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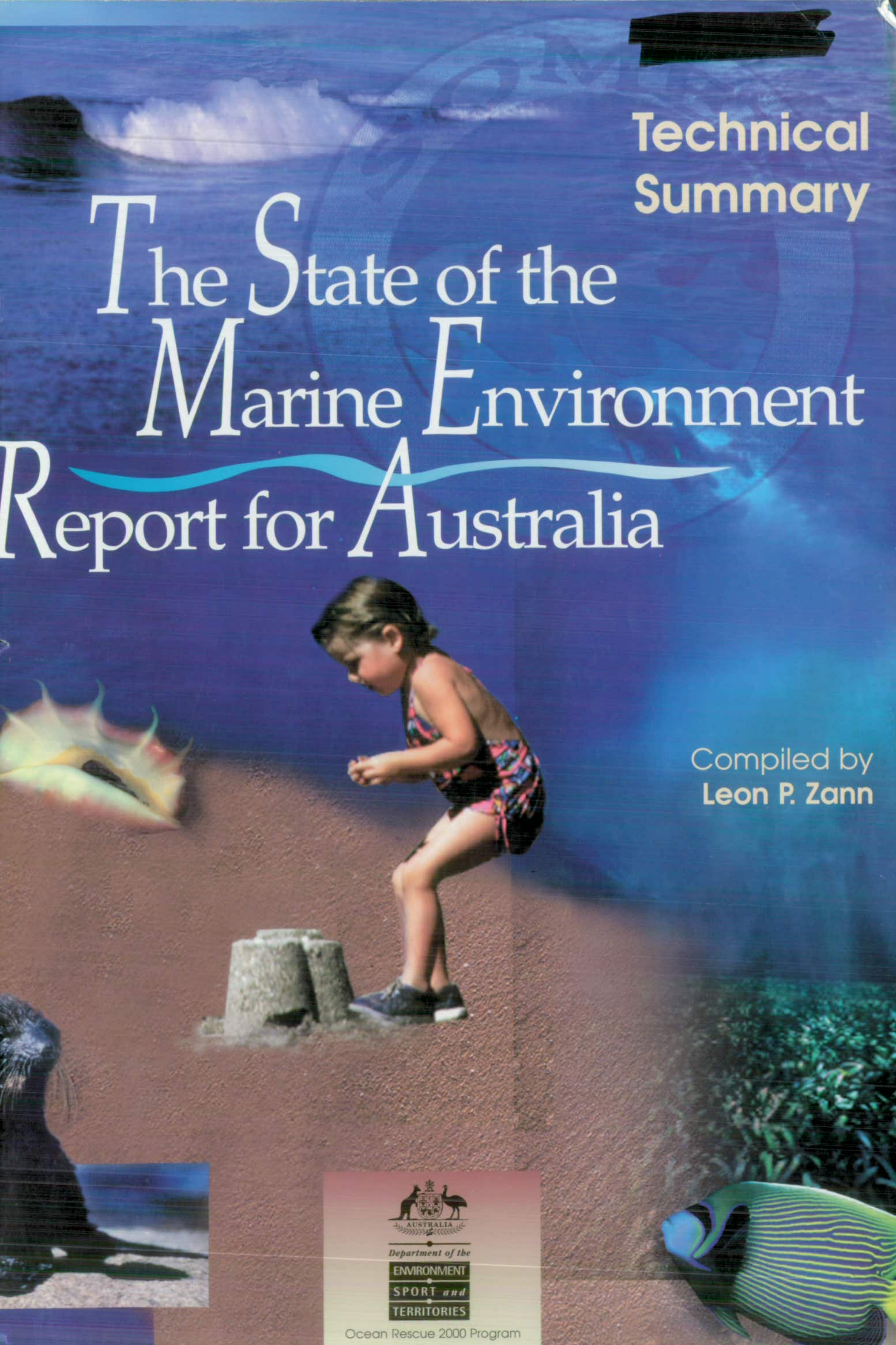


Technical Summary

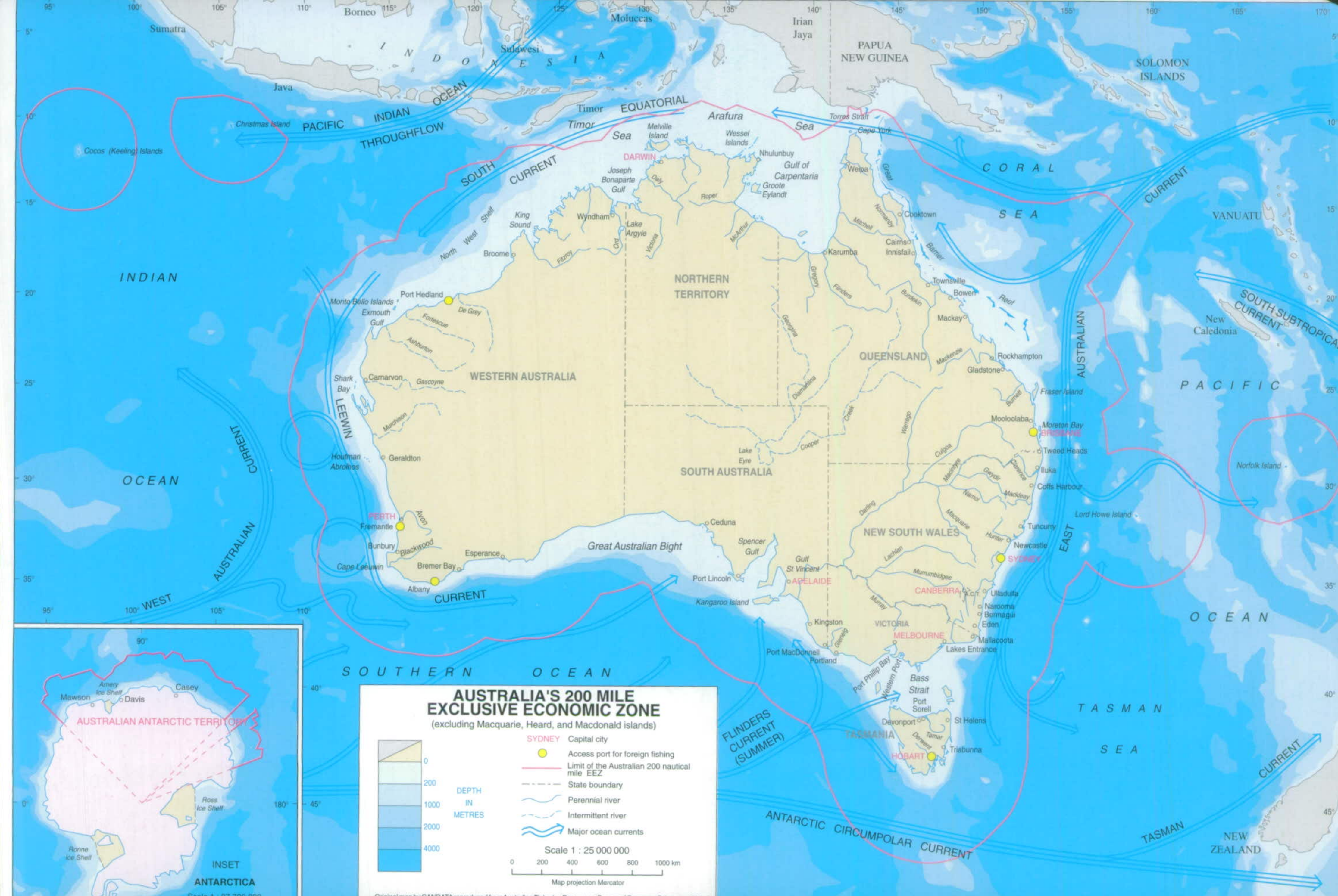
The State of the Marine Environment Report for Australia

Compiled by
Leon P. Zann

AUSTRALIA

Department of the
ENVIRONMENT
SPORT *and*
TERRITORIES

Ocean Rescue 2000 Program


AUSTRALIA'S 200 MILE
EXCLUSIVE ECONOMIC ZONE
(excluding Macquarie, Heard, and Macdonald islands)
SYDNEY Capital city
Access port for foreign fishing
Limit of the Australian 200 nautical mile EEZ
State boundary
Perennial river
Intermittent river
Major ocean currents
DEPTH IN METRES
0
200
1000
2000
4000
Scale 1 : 25 000 000
0 200 400 600 800 1000 km
Map projection Mercator
Original map by CANDATA reproduced from Australian Fisheries Resources, Bureau of Resource Sciences, 1993.
INSET
ANTARCTICA
Scale 1 : 87 700 000
AUSTRALIAN ANTARCTIC TERRITORY
Mawson
Davis
Casey
Amery Ice Shelf
Ross Ice Shelf
Ronne Ice Shelf
INDIAN
OCEAN
SOUTHERN OCEAN
PACIFIC
OCEAN
TASMAN
SEA
CORAL
SEA
Arafura Sea
Timor Sea
Great Australian Bight
INDONESIA
PAPUA NEW GUINEA
SOLOMON ISLANDS
VANUATU
New Caledonia
NEW ZEALAND
Sumatra
Java
Borneo
Sulawesi
Moluccas
Timor
Irian Jaya
Christmas Island
Cocos (Keeling) Islands
Norfolk Island
Lord Howe Island
INDIAN OCEAN PACIFIC THROUGHFLOW
EQUATORIAL
SOUTH CURRENT
LEEUWIN
CURRENT
WEST AUSTRALIAN CURRENT
EAST AUSTRALIAN CURRENT
SOUTH SUBTROPICAL CURRENT
TASMAN CURRENT
ANTARCTIC CIRCUMPOLAR CURRENT
FLINDERS CURRENT (SUMMER)
WESTERN AUSTRALIA
NORTHERN TERRITORY
SOUTH AUSTRALIA
QUEENSLAND
NEW SOUTH WALES
VICTORIA
TASMANIA
DARWIN
PERTH
ADELAIDE
MELBOURNE
HOBART
CANBERRA
SYDNEY
BRISBANE

Jo. Johnson

State of the Marine Environment Report for Australia

Technical Summary

Compiled by Leon P. Zann

Great Barrier Reef Marine Park Authority
Townsville, Queensland, Australia

Ocean Rescue 2000
Department of the Environment, Sport and Territories, Canberra

Published by

GREAT BARRIER REEF
MARINE PARK AUTHORITY

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Introduction

Australia is an island continent and the sea is very important to Australians. A quarter of our population lives within three kilometres of the coast, some 86% live in coastal catchments, and two-thirds reside in our coastal towns and cities.

Australia's sea area is much larger than our land area. Our 200 nautical mile Exclusive Economic Zone (EEZ) is over 11 million square kilometres in area, and is one of the largest in the world. Our mainland coastline, including Tasmania, is almost 70,000 kilometres long. Our seas span 33° of latitude (58° including the Antarctic Territory), and encompass all five oceanographic climate zones.

The sea remains important for the sustenance and spirit of coastal Aboriginal peoples and Torres Strait Islanders. It is of great social and cultural importance for the general population, and 'the beach' has become a national icon.

The sea is also of great economic value to Australia. Coastal and marine tourism, fisheries, marine transport and offshore petroleum are estimated to be worth around $17 billion per annum.

Our view of the sea has changed greatly over the past 40 years. In the 1950s the sea was regarded as the last frontier. In the 1960s it was seen as the solution to the growing world population and increased resource depletion on land. However, by the 1970s there were early concerns about the vulnerability of coastal waters. During the 1980s these concerns deepened as some fisheries and marine ecosystems began to decline.

In 1990 the Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP), reporting to the United Nations on the health of the world's oceans, concluded that *chemical contamination and litter can be observed from the poles to the tropics and from beaches to abyssal depths, and if allowed to go unchecked, this would lead to global deterioration in the quality and productivity of the marine environment.... We fear, especially in view of the continuing growth of human populations, that the marine environment could deteriorate significantly in the next decade unless strong, coordinated national and international action is taken (GESAMP 1990).*

Ocean Rescue 2000 program

Because of growing concerns in Australia on the state of Australia's marine environment, the Commonwealth Government established the Ocean Rescue 2000 program in 1991 to promote the conservation and sustainable use of the marine and coastal environment. Ocean Rescue 2000 builds on existing marine conservation and management programs and is part of the national strategy for Ecologically Sustainable Development.

The principal objective of the program is to develop and implement a marine conservation plan to guide the sustainable use and management of Australia's marine resources. Other objectives include ensuring adequate baseline and monitoring information on the marine environment, activities and management, and ensuring its accessibility to decision-makers and managers; fostering an educated, informed and involved community; and developing and implementing a national representative system of marine protected areas.

The program consists of the following elements:

- National Representative System of Marine Protected Areas;
- Australian Marine Conservation Plan;
- State of the Marine Environment Report for Australia (SOMER);
- National Marine Education Program;
- National Marine Information System; and
- Marine and Coastal Community Network.

State of the Marine Environment Report

The State of the Marine Environment Report (SOMER) is the first comprehensive, scientific description of Australia's marine environment. It was undertaken primarily to provide baseline information for the proposed Australian Marine Conservation Plan. It has also provided information for the Commonwealth government's new national State of the Environment reporting program which will first report in late 1995.

The Commonwealth Department of the Environment, Sport and Territories commissioned the Great Barrier Reef Marine Park Authority to prepare SOMER. The Authority has over 15 years experience in research and management of the Great Barrier Reef, the world's largest multi-use marine protected area, and its expertise is being increasingly sought for marine environmental management, both nationally and internationally.

SOMER describes in detail the major marine ecosystems and their status; the major uses of the marine environment and their effects; the general issues and threats affecting the marine environment; the condition or health of the marine environment; and marine environmental management and conservation. While SOMER examines habitats and communities from the shore to the ocean depths, its major focus is the coastal waters around the continent.

The SOMER process

The production of SOMER was a major challenge. Australia's marine environment is vast and covers a great range of climates, ecosystems, habitats and human influences. More significantly, it is very incompletely known. Long-term scientific information on the marine environment, which is essential to accurately assess its environmental condition, is very scattered, or lacking altogether in many areas.

The subjects to be covered in SOMER were initially identified by a workshop of experts from marine science, resource management and industry. A senior marine scientist was appointed to coordinate the project and produce the report, with the assistance of an expert Advisory Committee. Experts in each subject area were identified and invited to write scientific reviews on the subject, to identify major issues, and to assess, if possible, the extent of any problems. These reviews were then subject to a process of open scientific peer review involving at least two other experts in that area. The 83 technical papers thus produced provided the source material for SOMER.

Because of the great volume of information obtained and the technical nature of many of the reviews, the technical papers were abridged and simplified where necessary, and the major conclusions and the management implications were defined. The abridged papers were checked with the original author(s) and the SOMER Advisory Committee to ensure that accuracy was maintained, and drafts were sent to relevant Commonwealth, State and Northern Territory environmental agencies for comment and input.

SOMER publications

The abridged papers have been compiled to create this document, *The State of the Marine Environment Report for Australia: Technical Summary*. Written in a semi-technical style, this is intended for marine environmental managers, environmental scientists, conservationists, teachers, university students and others with specialist interests in the marine environment. The final chapter, *Conclusions: general issues and pressures affecting Australia's marine environment*, was produced from the SOMER

SOMER process

topics identified by workshop

expert scientists commissioned to produce technical papers

papers peer reviewed

Selected papers published:
SOMER Technical Annexes 1 & 2

technical papers, condensed & management implications identified

reviewed by authors, SOMER Advisory Committee and relevant government agencies

combined to produce technical report:
SOMER Technical Summary

major findings and issues identified & collated

reviewed by SOMER Advisory Committee and relevant government agencies

published as non-technical report:
Our Sea, Our Future. Major findings of SOMER

major findings summarised in brochure:
Our Sea, Our Future. Summary of SOMER

applications of SOMER:

- ***Australian Marine Conservation Plan***
- ***National Marine Education Program***
- ***Marine Environment Conference (Uni. Queensland, 1995)***
- ***National State of the Environment Report (1995)***

Advisory Committee's prioritisation of the issues identified in the SOMER Process.

The overview report, *Our Sea, Our Future: Major Findings of the State of the Marine Environment Report for Australia,* was produced from this document and contains the major findings of SOMER. It is written in a non-technical style for general readership.

Several volumes of the unabridged technical papers have been published as *The State of the Marine Environment Report for Australia: Technical Annexes.* All material published to date is currently available on the Internet. It is hoped that all material will also become available in electronic form, on CD ROM.

Leon Zann
SOMER Coordinator
Great Barrier Reef Marine Park Authority

Acknowledgments:
SOMER is the result of the efforts of 134 scientists and technical experts, 14 members of the Advisory Committee, and around 160 external reviewers. Authors and reviewers are noted in each chapter.

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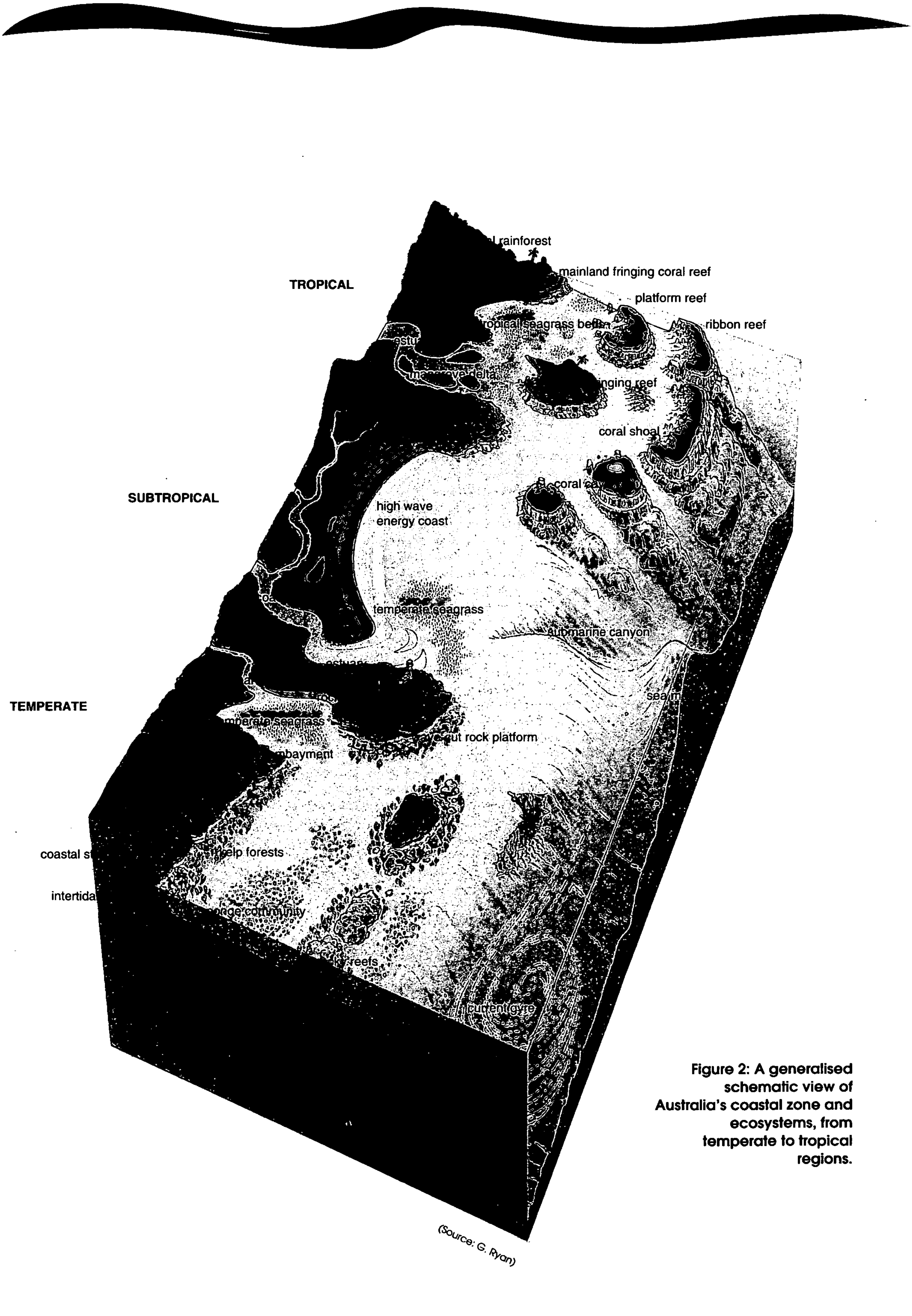

Figure 2: A generalised schematic view of Australia's coastal zone and ecosystems, from temperate to tropical regions.

Part 1
The Physical Environment

Australia's marine domain covers some 60 degrees latitude, from Torres Strait to Heard and Macquarie Islands, and 75 degrees longitude, from Cocos (Keeling) Islands to Norfolk Island. Australia's 200 nautical mile Exclusive Economic Zone is over 11 million square kilometres and is one of the largest in the world. It spans a great range of climates, and geographic, geologic and oceanographic features. The coastline of the mainland and larger islands is around 70,000 kilometres in length. It includes 12,000 islands and many thousands of coral reefs.

Australia is an island continent. It is encircled by the Pacific and Indian Oceans to the east and west, and the circumpolar Southern Ocean to the south. Subsidiary seas include the Tasman and Coral Seas to the east, and the Timor and Arafura Seas to the north. Australia's nearest neighbours are Papua New Guinea and the islands of Indonesia to the north, and New Zealand to the east. Antarctica, to which Australia was once joined, lies 2,500 kilometres to the south. Apart from the northern shelf connections, Australia is geographically very isolated.

Australia's External Territories greatly extend its 200 nautical mile Exclusive Economic Zone. These are Heard and McDonald Islands in the southern Indian Ocean; the Australian Antarctic Territory; Cocos (Keeling) Islands in the Indian Ocean; Christmas Island in the Indian Ocean; the Coral Sea Islands off Queensland; and Ashmore and Cartier Islands, west of Darwin.

Australia's marine environment extends from the coastal strip (commonly defined as extending 3 kilometres inland from the shoreline) to the edge of its territorial waters, usually 200 nautical miles from land. Functionally, the landward margin extends inland to include the catchments, since the freshwater input is highly relevant to coastal waters. The seaward margin really has no limits, for it is part of the world ocean.

Surprisingly, no detailed account of the Australian marine environment has been compiled, although a growing number of reviews cover specific topics or geographic areas.

This first part of this report provides a brief overview of physical aspects of the marine environment. It describes the geography and geomorphology of the coastal zone, the characteristics of the sea floor of the continental shelf, and the ocean and its circulation. It particularly focuses on the interface between the land and sea, an area where many environmental problems occur.

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Chapter 1. The coastal zone: an introduction[1]

The land and sea are functionally connected in the coastal zone. Effects of disturbances to catchments flow on to estuaries and the sea. Australia's terrestrial environment has been extensively modified since European colonisation. Around half the forest and woodlands have been cleared, and more than half of the agricultural and pastoral lands are now considered degraded. There are no major river catchments and few minor catchments in which the natural vegetation has not been altered. Erosion, fertilisers, animal wastes, sewage and industrial discharges have contaminated many inland waterways. The situation has reached crisis point in some river systems where blooms of toxic algae have become frequent occurrences.

Increasing degradation of the more densely inhabited coastal strips in the south-west and east south-east has been a major national concern in recent decades. Since 1980 alone there have been no fewer than 30 government inquiries and reports into aspects of the coastal zone. These tell of poorly planned coastal development, of urban sprawl, declining water quality, increasing conflicts amongst users, and fragmented, duplicated and uncoordinated management at the Commonwealth, State and local government levels.

These problems do not just affect coastal lands: degradation of catchments, declining inland water quality and rapid and poorly planned urbanisation of the coastal lands are major threats to Australia's marine environment.

The state of the terrestrial environment has been examined in various national and State government reports (DAHE 1986, DASET 1991, Castles 1992, Govt WA 1992, EPA NSW 1993 a&b) while the state of the coastal zone has been the focus of the recent Report of the House of Representatives Standing Committee on Environment, Recreation and the Arts 'The Injured Coastline' (HORSCERA 1991) and the Resource Assessment Commission's Coastal Zone Inquiry (RAC 1993).

This chapter briefly describes the terrestrial part of Australia's coastal zone, and the land uses and management practices within it which affect catchments and the marine environment.

Coast, coastal strip and coastal zone? Some definitions

Difficulties of coastal management start with the terminology and definitions of boundaries. Approaches include administrative ones (e.g. local government boundaries and offshore legislative boundaries), linear (e.g. based on arbitrary distances from a reference point), and biophysical (e.g. based on river drainage or ecosystems).

In New South Wales the 'coast' has been defined as the area one kilometre landward from the high-water mark and three kilometres to sea.

The boundaries of the 'coastal zone' are more flexibly defined, according to the issue. CSIRO defines it as extending seawards 12 nautical miles offshore or to the 100 metre depth, whichever is furthest, (except where overriding legislation is involved), and extends landwards to include all coastal lands, at least to the limit of local government areas adjoining tidal waters (HORSCERA 1991).

The Resource Assessment Commission adopted the even broader definition of the coastal zone by the OECD Environment Directorate. This defines the marine boundary as extending 200 nautical miles seaward from the low-water mark, and the landward boundaries as either the existing local government administrative areas abutting the coast, or natural drainage basins abutting the coast (RAC 1993). However, RAC largely confined its inquiry to a much narrower area of land along the coast.

To emphasise the connection of land and sea, RAC's broad definition of the coastal zone is adopted in this report. The land component of the coastal zone is referred to as 'coastal lands'. The narrow strip of coastal land under the influence of the sea is referred to as the 'coastal strip'. While this distance varies greatly, a linear boundary of three kilometres from the high tide mark is adopted here so as to be comparable with the inventory of 'coastal land forms' by Galloway (1981), and the area included in CSIRO's CAMRIS Database.

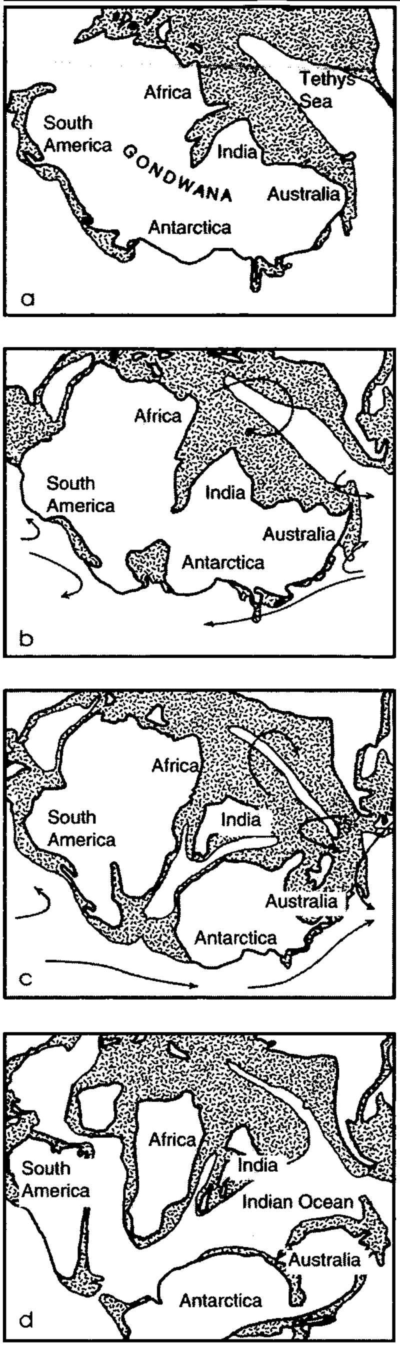
The dynamic coast

Formation

The shape of the Australian continent is the result of the break up of the larger supercontinent of Gondwana, and several mountain-building episodes occurring over many millions of years. Locally, sea level changes during the past few million years have changed the continental outline.

[1]By Dr L. Zann, SOMER Coordinator.

(Source: G. Poore)



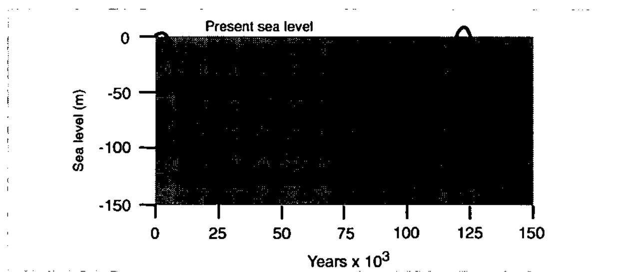
Throughout this period, rivers and ice have eroded away the mountains and moved sediments towards the continental margins where sedimentary layers kilometres thick have accumulated, and within which Australia's major oil and gas fields are located. The surface sediments of the coastal zone have been modified by processes related to sea level history, rate and type of sediment supply and energy available to erode, rework and disperse sediments.

Sea level change

The present position of sea level is relatively high compared with that of the last several hundred thousand years. For much of that period the coastline would have occupied positions within the present outer continental shelf. Over the last 150,000 years the location of the shore has oscillated between about 5 metres above present sea level and 130 metres below it, but most of the time between 20 metres and 70 metres below the present level.

During the last glacial episode about 40,000 years ago the sea level was at least 130 metres lower than the present. The most recent sea level rise began around 19,000 years ago, reaching a maximum rate of about two centimetres per year between 11,000 and 12,000 years ago. Isostatic and tectonic changes have had limited impact in this region, as the earth's crust in the Australian region is very stable compared with other areas.

Figure 1.2: Sea level curve showing eustatic changes over the last 140,000 years. Sea level rise (transgression) and fall (regression) in a coastal area results from the melting or formation of the polar ice caps causing a change in the ocean's volume (eustatic changes); and sinking or uplift of the surface because of the weight of sediments, water or ice (isostatic changes), or from collision or rifting of continental plates (tectonic changes).



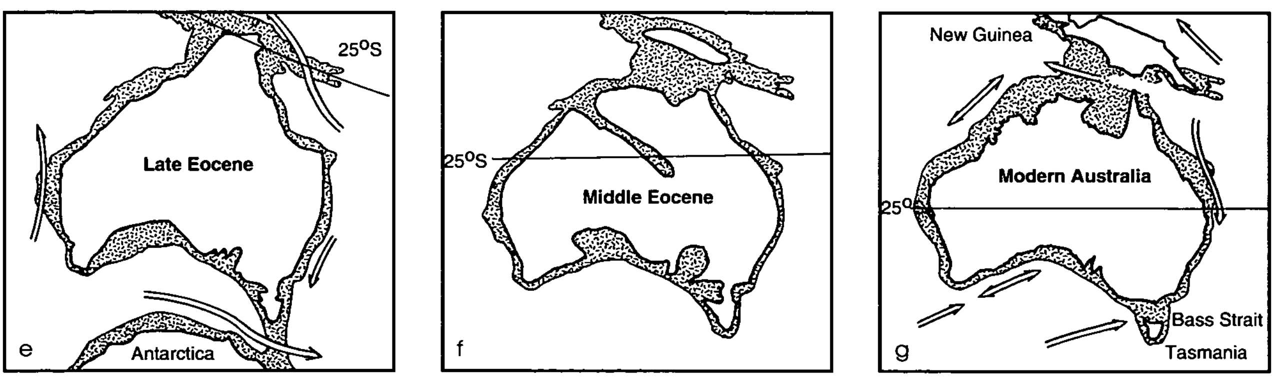


Figure 1.1: The origin of Australia's coastline and marine life. Australia-Antarctica separated from Gondwana around 100 million years ago and drifted away to the east, carrying coastal fauna and flora with it (a - d). After the split from Antarctica, Australia drifted northwards, colliding with South-East Asia forming Papua New Guinea, linking the two regions' marine life (e - g). As a result, marine life in northern Australia is mainly tropical Indo-Pacific in origin. Marine life in the climatically isolated temperate south is ancient Tethyan and Palaeoaustral in origin, and has a very high proportion of endemic species.

The marine transgression that took place in late Pleistocene to early Holocene times (to 6,000 years ago) cut back cliffs on steep parts of the coast, and formed estuaries at river mouths; drowned valleys such as at Port Jackson, and submerged lowlands such as at Jervis Bay, Corner Inlet, Western Port, Port Phillip Bay and Shark Bay. Subsequent erosion and deposition have produced existing features such as cliffs, beaches and dunes, estuaries and lagoons, saltmarshes and mangroves.

Except during the warm periods of the Pleistocene interglacials, the mainland was joined to Papua New Guinea and Tasmania by 'land bridges' which facilitated the migration of biota, including humans, but isolated marine species. Large fresh to brackish lakes and lagoons probably occupied the lower parts or basins of Bass Strait, Gulf of Carpentaria and Bonaparte Gulf at these times. During the ice ages the climate of Australia was colder and windier, and rainfall was lower, creating significant changes in vegetation cover. Vast dust storms swept terrestrial clays into the adjacent oceans, and assisted in the formation of coastal dune fields.

Characteristics of Australia's coastal strip

Length of the coastline

Estimates of the length of the coastline vary according to the scales adopted. Galloway and Bahr (1979) estimated the mainland coastline, plus nearby islands greater than 12 hectares in area, to be 69,630 kilometres using 0.1-kilometre intercepts which take in finer-scale coastal features, or 30,270 kilometres using 10-kilometre intercepts.

Table 1.1: Estimates of lengths of coastlines (using 10 km intercept)

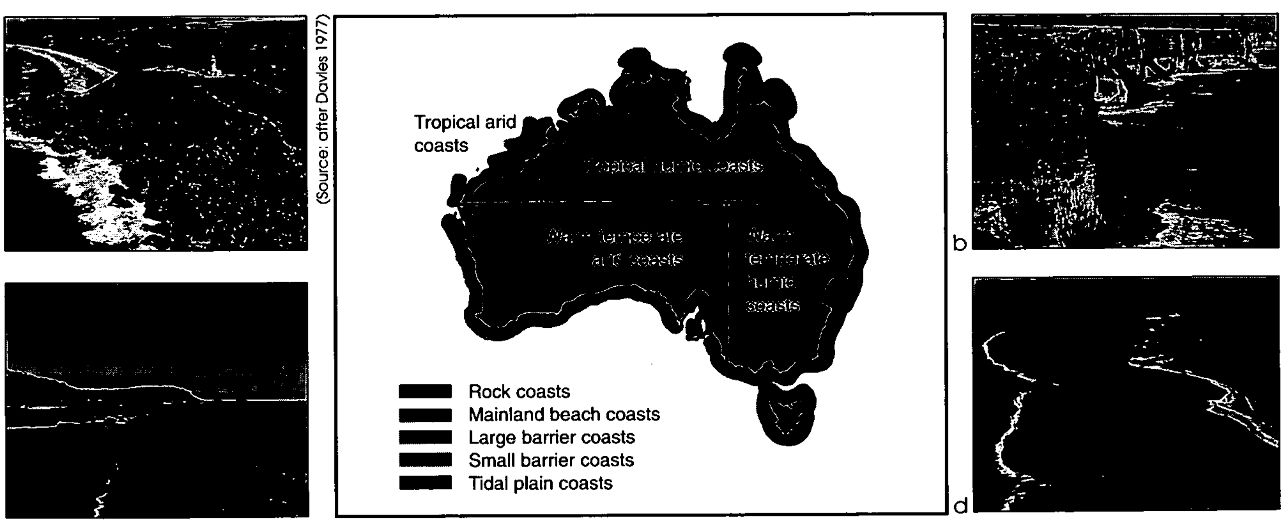
Queensland	6,080 km
New South Wales	1,740 km
Victoria	1,720 km
Tasmania	2,230 km
South Australia	3,270 km
Western Australia	10,100 km
Northern Territory	5,030 km
Total Australia	30,270 km

(Source: Galloway and Bahr 1979)

Major regions and features

The major coastal features are the result of the interaction of geology, surface processes, and climate. Four basic regions are commonly recognised: Warm Temperate Humid Coasts; Warm Temperate Arid Coasts; Tropical Arid Coasts; and Tropical Humid Coasts (Davies 1977). A number of other classifications are based on sediment types, and biotic and geological characteristics.

In the north, wave energy is generally low, particularly in the Gulf of Carpentaria and Great Barrier Reef coast. Tropical cyclones bring occasional episodes of high wind and wave energy and storm



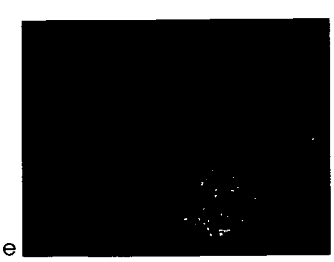


Figure 1.3: Australian shores are varied and picturesque. (a) Warm temperate humid coastlines in the south-east are noted for their rocky headlands and long sandy beaches. Cape Byron (NSW). (b) Warm temperate arid coastline. The spectacular Nullarbor Cliffs stretch unbroken for around 180 kilometres of the Great Australian Bight (SA). (c) Arid Shark Bay coast (WA). (d) Tropical arid coastline. Fringing coral reefs off Ningaloo (WA). (e) Tropical humid coastline. The wide, macrotidal shore near Hope Islet (NT).

surges in summer. Mean spring-tide ranges are generally small, less than two metres, but are much greater in the north-west between Port Hedland and Darwin (up to 10.5 metres at Collier Bay), and in the Mackay area of central Queensland. In the south, wave energy is higher and calcareous beach and dune sediments have been deposited along the western and southern coasts.

Around 10% of the coastal zone is high, rocky terrain, and 18% is cliff above two metres high. The rest of the coast is low-lying dunes and beaches (23%), low rocky terrain (9%), tertiary sands (9%), supra- and intertidal muds (30%), alluvium (8%) and estuaries and lagoons (8%). The proportions of these vary greatly among States (Table 1.2).

Catchment uses and environmental effects

The major land uses in Australia are agriculture (67%), forestry (2%) and nature conservation (3.5%). Urban and transport uses occupy only 1.3% of the land area. Around 26% is desert or inaccessible mountainous terrain.

Agriculture

Over 200 years Australia has become one of the world's leading agricultural nations. It is the largest exporter of wool, the largest supplier to the free market of sugar, the second largest exporter of meat, the fourth largest exporter of wheat and a major supplier of dairy produce, fruits, grains, cotton and other commodities. Of agricultural lands, 91% is used for grazing, 6% pastures and 3% cropping.

Major environmental issues in the industry include drought; soil erosion; loss of soil fertility, structure, and increasing acidity; utilisation of marginal lands; increasing salinity; effects of agricultural chemicals; and feral and native animal pests.

Forestry

About 30% of forest is managed primarily for wood production. Timber production in 1989-90 was around 16.5 million cubic metres (63% native hardwoods and 37% exotic softwoods) and was worth $548 million.

Major environmental issues include conservation of forest biodiversity; loss of rainforests; and clear-felling for wood chip. The last destroys vegetation cover and wildlife habitat, increases erosion, affects water quality, compacts soil and removes nutrients.

(Source: GBRMPA)

Figure 1.4: Australia's coastal landforms include dunes, sandy beaches, soft and rocky shores and estuaries. Queensland coastline.

Table 1.2: Areas of major coastal landforms (sq km) and % of total coastline

Landform	Qld	NSW	Vic	Tas	SA	WA	NT	Total
Dunes, beaches etc	5,109	1,236	1,653	984	5,613	12,057	1,242	27,897
(%)	(18.8)	(16.3)	(28.0)	(13.8)	(53.4)	(33.4)	(5.5)	(23.8%)
Low rocky terrain	1,407	1,938	724	1,974	969	2,832	390	10,234
(%)	(5.5)	(25.6)	(12.3)	(27.7)	(9.2)	(7.8)	(1.7)	(8.7%)
High rocky terrain	2,198	1,365	432	2,247	279	5,142	552	12,215
(%)	(8.1)	(18.0)	(7.3)	(31.5)	(2.7)	(14.2)	(2.4)	(10.4%)
Tertiary sand, laterite	1,212	144	939	414	129	2,076	5,271	10,185
(%)	(4.4)	(1.9)	(15.9)	(5.8)	(1.2)	(5.7)	(23.3)	(8.7%)
Intertidal mud	4,527	117	150	33	459	5,643	5,742	16,671
(%)	(16.6)	(1.5)	(2.5)	(0.5)	(4.4)	(15.6)	(25.4)	(14.2%)
Supratidal mud*	8,522	117	198	57	558	4,218	6,675	20,345
Alluvium*	2,652	1,518	1,203	714	99	1,977	1,581	10,638
Water (estuaries)	1,596	1,128	597	705	1,503	2,187	1,146	8,862
(%)	(5.9)	(14.9)	(10.1)	(9.9)	(14.3)	(6.0)	(5.2)	(7.6%)
Cliffs >2 m (km)	4,875	565	465	664	1,023	1,950	548	
(% of coastline)	(8.0)	(33.0)	(27.0)	(27.0)	(29.0)	(18.0)	(10.0)	
Length of coastlines (km)	6,080	1,740	1,720	2,230	3,270	10,100	5,030	

* terrestrial landforms

(Source: Bunt, 1988, from Galloway database)

Mining

Australia is among the world's leading exporters of coal, gold, iron ore, bauxite, alumina, zinc, manganese, lead and mineral sand, with an annual value of around $22,000 million (1989-90).

Major environmental issues include access (26% of land has restricted access because of Aboriginal and conservation status); site disturbance; and air and water pollution.

Energy

Australia is largely self-sufficient in energy commodities. Major energy users are the transportation (38%) and manufacturing (33%) sectors. The sources of finally consumed energy are: petroleum (49%), natural gas (19%), electricity (16%) and coal (7%). Coal is the major energy export.

Major environmental issues include air pollution from coal burning stations, motor vehicles, smelters, and green house gas emissions, particularly carbon dioxide.

Urbanisation and industrial developments

Although Australia's population density is the lowest of any continent other than Antarctica, and the urban area is very small (0.1% total), the population is one of the most urbanised in the world with 85% living in large cities. The population is also highly concentrated on the south-eastern coast. Around 80% live in the coastal zone, 25% within three kilometres of the sea.

Key environmental issues include urban sprawl (poorly planned expansion into adjacent lands of agricultural and environmental value); access to open space (for recreational, environmental and aesthetic purposes); transportation management (high dependence on private road transport, with high gaseous emissions of carbon monoxide and nitrogen oxides); sewage and waste management (water quantity and quality problems); and air, noise and water pollution resulting from the above.

The problem of land degradation

Of about 226 million hectares of forest and woodland at the time of European settlement, only 135 million hectares remains in a close-to-original state. Almost half of Australia's rainforests have been cleared. Around 52% of agricultural and pastoral lands are considered degraded and in need of reclamation. Major types of degradation include soil erosion (sheet and rill, gully, wind); soil surface scalding; soil structure decline; soil compaction; soil acidity; nutrient decline; salinisation of dry land and irrigated land; waterlogging; and coastal degradation.

Recent major management initiatives include the Decade of Land Care, the National Soil Conservation Strategy, the Land and Water Resources Research and Development Corporation, and the One Billion Trees Program.

Inland waters

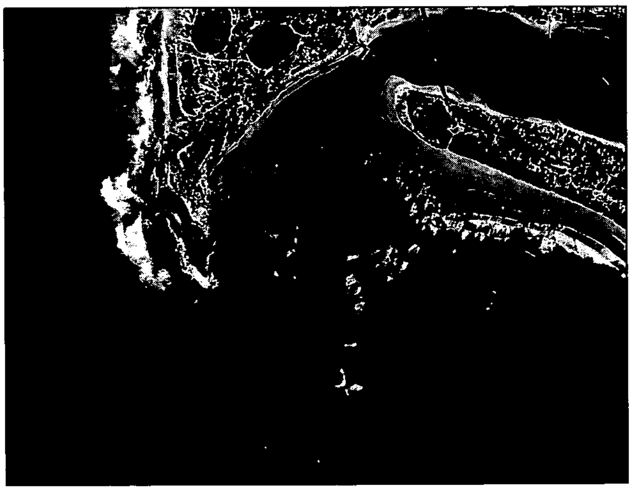
Australia's rainfall and run-off are less than those of other continents, and twice as variable. Floods and droughts are an integral feature of the climate and have moulded both the terrestrial and marine environments. Rainfall is concentrated on the coasts and with the exception of the Murray-Darling, Australian rivers are relatively short, draining directly into the ocean.

Drainage

Australia has a total of 245 rivers, with a total annual discharge of about 440,000 million cubic metres. This is very small compared with the other continents. Australia's total discharge is exceeded by the Fly River in Papua New Guinea, or the Mekong River in South East Asia. Vast areas of the arid and semiarid interior have no external discharge. Most run-off is into the Timor Sea and Gulf of Carpentaria (48%), and to the north-east (21%).

Inland water quality declining

The quality of Australia's lakes and inland waterways is declining. CSIRO's Institute of Natural Resources and Environment give the causes as overclearing and intensive irrigation raising watertables and increasing salinities; inappropriate cultivation practices contributing to soil erosion which increases turbidity and salinity; industrial wastes containing toxins, acids, oils, sediments, organic wastes, bacteria and viruses; sewage effluent containing nutrients, oils, fats, toxins, bacteria and viruses; urban run-off containing oils, detergents, toxins, organic wastes and litter; and agricultural run-off containing fertilisers, weedicides, defoliants and pesticides, viruses and bacteria.



(Source: Victorian Department of Conservation and Natural Resources)

Figure 1.5: Degradation of estuaries and bays in the south-east and south-west is a major concern. The Barwon River (Vic) carrying a heavy silt load after heavy rain in the catchment.

The most serious land use change affecting run-off in Australia is deforestation, either partial and temporary through forestry, or total and permanent when land is converted to agriculture, urban and industrial use.

Nutrient pollution is a severe problem, particularly in the inland rivers. The Murray-Darling Basin Commission estimates that about 70% of phosphorus and 40% of nitrogen entering that system originate from agriculture. The basin supports around 60 million sheep, six million cattle and one million pigs. Around 200 towns, with a combined population of one million, dispose of sewage into the system. So much water is pumped out that the river often flows backwards. In 1991 nutrient pollution led to the toxification of more than 1,000 kilometres of the Darling by blue-green algae.

Changes in the hydrological cycle

Inputs of fresh water from land masses are important in coastal lagoons, estuaries and enclosed waters, and may have significant impacts on oceanic waters near the coast. It is widely believed that human activity in river catchments since European settlement has significantly altered the discharge of fresh water into the sea by increasing or decreasing annual flow, and changing the magnitude and frequency of flooding. Changes in river discharges are generally inferred from geomorphological and sedimentological studies, but the long-term river-gauging records necessary to quantify these changes are lacking.

Effects of dams and irrigation

Alteration of river flow by dams and irrigation schemes has also significantly altered freshwater inputs into the sea. Australia has around 374 dams, of which over half are in the south-east. These greatly reduce downstream discharges, seasonality of flows, and the frequency and/or magnitude of smaller flood peaks. Attempts have been made in recent years to release water to maintain downstream riparian environments, particularly freshwater wetlands and fish habitats, but rarely are the needs of the marine end of the system considered.

Irrigation takes 74% of all water diverted from rivers and ground water, but uses this on less than 1% of agricultural lands. Irrigation-induced salinity and waterlogging threatens much of the irrigated land in temperate Australia, and many wetlands and river systems.

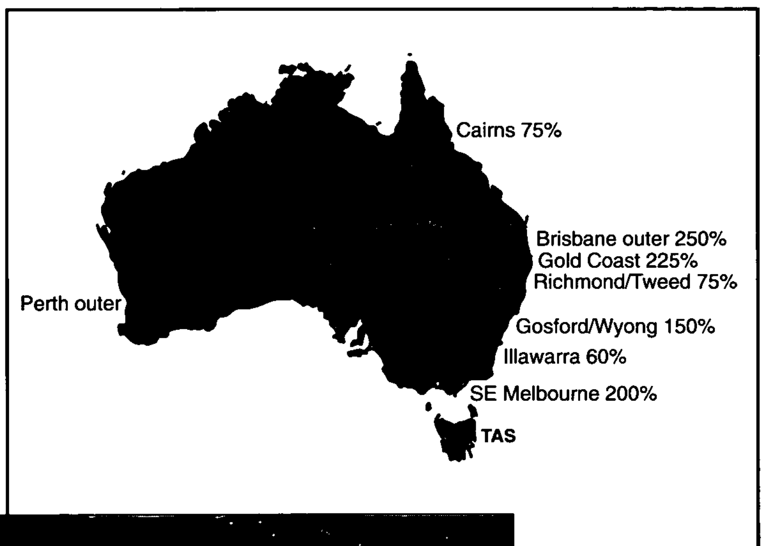
The coastal strip

The recent government inquiries on the coastal zone have highlighted the problems in the coastal strip in the south-east and south-west (HORSCERA 1991, RAC 1993).

Rapid demographic growth

The concentration of the population in a small part of Australia's coastal zone and the consequent environmental disturbances are emphasised throughout this report: 26% live within 3 kilometres of the sea and 67% within the coastal towns and cities. Australia's most severe marine environmental problems are adjacent to the 10% of the coastline which is urbanised or urbanising.

Australia's coastal zone is a desirable place to live. The RAC Coastal Zone Inquiry noted with concern the unprecedented growth of non-metropolitan areas in the coastal zone over the past 30 years. While the Australian population grew by 32% between 1971 and 1991 (from 12.6 million to 16.6 million), that in the



(Source: RAC 1993)

Figure 1.6: Coastal growth has been rapid in non-metropolitan areas over the past 20 years. Growth rates in coastal growth regions, 1971-91 (excluding capital cities).

(Source: I. Dutton)

Figure 1.7: Coastal strip development is a major issue from Hervey Bay in Queensland, to southern Victoria. The Byron Shire coast (NSW) is rapidly being urbanised. Foreshore development and beach erosion are serious issues in many places.

non-metropolitan coastal zone grew by 95% (from 2.1 million to 4.1 million). The growth has been most rapid in the coastal zone of Queensland (increasing from 33% to 46% of population), New South Wales (from 14% to 20%) and Western Australia (from 19% to 32%) (RAC 1993).

Fast growing regions in the coastal zone are beginning to merge. The fastest growing area, Gold Coast-Albert Shire (Qld) threatens to merge with the next fastest, Outer Brisbane, and the Sunshine Coast from the north, and Richmond-Tweed (NSW) from the south. In New South Wales fast growing Gosford-Wyong, Hunter and Illawarra threaten to merge with Sydney. In Victoria, South-East Melbourne is expanding along Port Phillip Bay and Western Port. In Western Australia Perth is expanding along the coast.

The value of new building in the coastal zone between 1983 and 1991 was around $70 billion: dwellings ($43 billion), commercial ($14 billion), tourism ($7 billion), community ($7 billion), and factories ($3 billion) (RAC 1993).

Summary and conclusions

1. Australia is an arid continent and the coastal lands, particularly in the south east, support the great majority of the population.

2. As a consequence the environment of Australia's coastal lands has been degraded in many areas. Pollution of rivers, lakes and shores, and urban sprawl have been identified as major problems by all recent government inquiries on the coastal zone.

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Chapter 2. The ocean[1]

The unresting ocean covers 70% of the earth's surface. It controls the earth's climate, and is the cradle of its life. Australia, the island continent, is surrounded by ocean. Australia's 200 nautical mile EEZ encompasses all the ocean temperature zones, from tropical to polar, and supports a vast variety of lifeforms.

An understanding of the physical processes that move the great ocean currents, and of the properties of the water bodies, is essential for an understanding of the patterns of marine life, and for their management.

The basic attributes of the sea which affect the marine biota are temperature, affecting metabolism; salinity, affecting osmoregulation, particularly in estuarine species; depth, affecting light absorption; currents, which disperse and mix water bodies, larvae and contaminants; and nutrients, which are necessary for plant production.

This chapter briefly describes the oceanography of Australian waters as a setting. It focuses in particular on patterns of ocean circulation around Australia, and their effects on ocean and coastal productivity.

Temperature and salinity

Australia's ocean domain covers all five of the ocean temperature zones: tropical (25-31°C); subtropical (15-27°C); temperate (10-25oC); subpolar (5-10°C); and polar (-2°C to 5°C). Mainland and Tasmanian shores cover tropical, subtropical and temperate zones, while Heard, McDonald and Macquarie Islands are subpolar, and the Australian Antarctic Territory is polar. The major temperature zones tend to be characterised by distinctive marine biota: the shallow tropics by coral reefs and mangroves; temperate waters by macroalgae; and polar waters by seasonally very high planktonic productivity.

Surface temperatures in shallow northern tropical waters may reach 32°C during summer, while those off southern Tasmania may drop to 9°C in late winter. Off Antarctica, the annual range is around -1.5°C to 4°C.

In the tropical Indian and eastern Pacific Oceans, surface temperatures often exceed 28°C, but gradually decrease towards higher latitudes because of reduced solar radiation. More rapid reductions occur at the Subtropical Convergence (40-45°S) and at the Antarctic Convergence (55-60°S). Seasonal changes in tropical surface temperature are small. Changes in other areas are greater, around 5°C.

In summer, sea surface temperatures over the continental shelf produce pools of warm water such as that forming the Leeuwin Current off Western Australia. Surface salinities in the tropics and at latitudes over 40°S are 34-35 psu (practical salinity units), and 35-36 psu at mid-latitudes.

Temperature and salinity of the upper ocean

The properties of the upper ocean are controlled by incoming and reflected radiation; rainfall, river flow and evaporation; sea ice formation and melting; and winds, currents and tides. Heat and fresh water raise the surface temperature and lower the salinity, and therefore the density, making the water column strongly layered and stable.

The main thermocline - the depth at which the temperature changes most rapidly - is around 500 metres while a seasonal (summer) thermocline exists at around 100 metres depth in all except antarctic waters.

The upper 100 metres or so is well mixed by winds and waves, but where water masses meet (ocean convergences), deeper mixing occurs. Mixing also occurs when the surface becomes cold and more dense than that below, upsetting the stability of the water column (convective mixing).

Ocean circulation

The ocean is in constant motion because of differential heating and cooling, the winds, and the spinning of the earth. The circulation patterns of the ocean basins are relatively fixed, but closer to the land they are influenced by local weather conditions and are more variable.

Large-scale ocean circulation

The prevailing westerly winds in the mid-latitudes and easterly winds in the tropics drive the ocean currents in the major ocean basins in large, closed circulation patterns or gyres. Because of the earth's

[1]Based on a paper by Professor J.H. Middleton, Centre for Marine Sciences, University of NSW, Sydney, New South Wales; and other sources.

(Source: CSIRO Division of Oceanography)

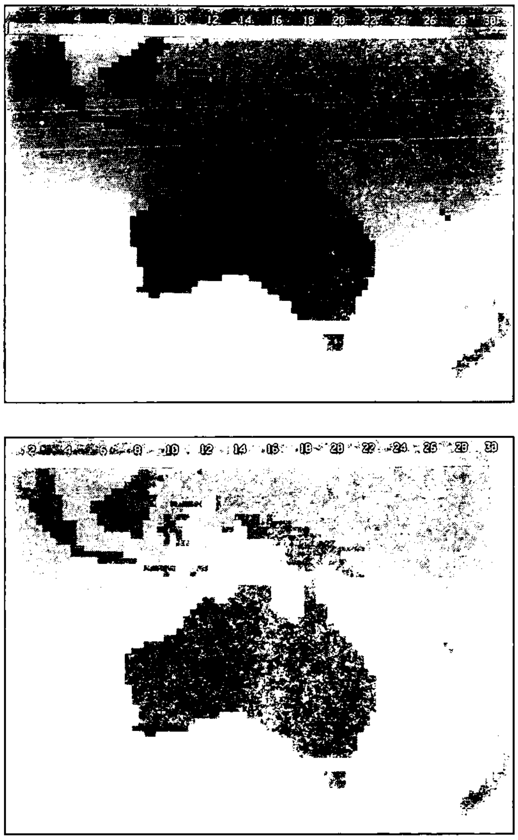

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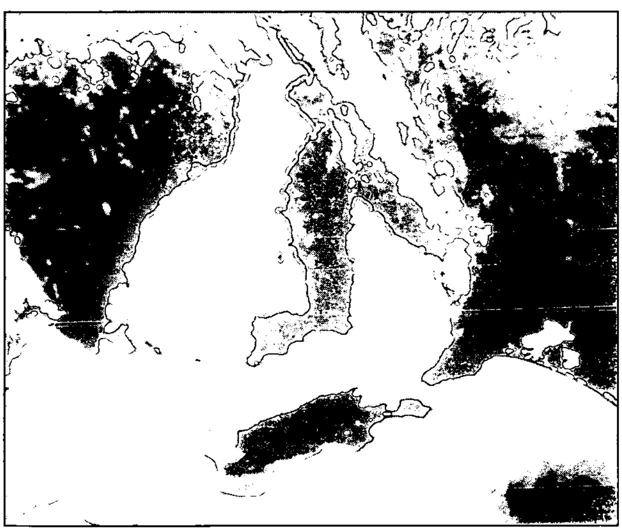
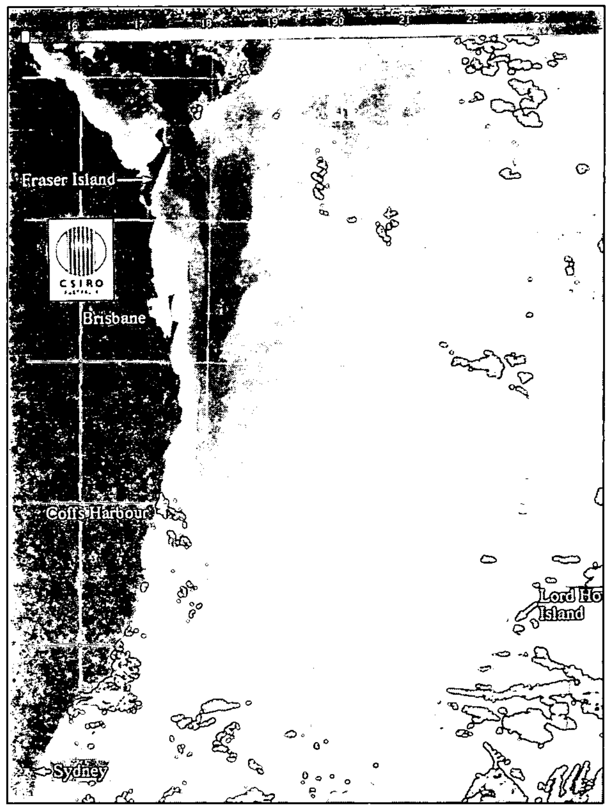
Figure 2.1: Australia's waters encompass all five of the ocean's climate zones. These images, produced from satellite data, show average surface sea temperatures for summer (a) and winter (b) between 1982 and 1988.



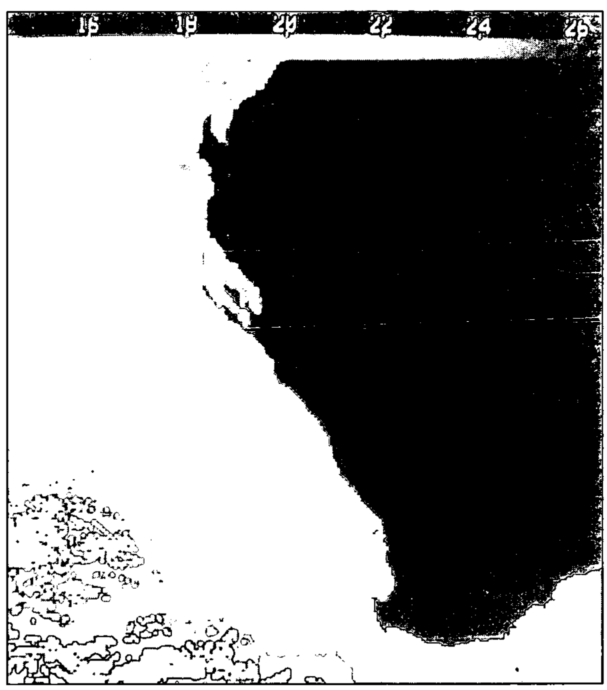
(Source: CSIRO Division of Oceanography)

Figure 2.2: Satellite image of South Australia's gulfs showing marked changes in surface sea temperatures. The gulfs are 'reverse estuaries' which become warm and more salty in their upper reaches.



(Source: CSIRO Division of Oceanography)

Figure 2.3: Satellite image of eastern Australia showing the meandering East Australian Current. This current brings warm equatorial and Coral Sea water down Australia's eastern coast. Around the Sydney area it turns east into the Tasman Sea where it forms giant loops and eddies.



(Source: CSIRO Division of Oceanography)

Figure 2.4: Satellite image of Western Australia showing the Leeuwin Current. This current brings warm, low salinity water masses from the North West Shelf region down the western and south-western coasts. It sometimes reaches the Eyre Peninsula in South Australia.

rotation, these intensify towards the western boundary of the ocean basins. The western boundary current of the Pacific basin which flows southward down the eastern coast is called the East Australian Current (EAC) (Figure 2.3). The EAC is relatively weak because it is blocked by a myriad of reefs and islands in the Coral Sea. The EAC flows southwards along the continental slope until central New South Wales where it tends to turn offshore. Once or twice a year, loops (200-300 kilometres in diameter and 1,500-2,000 metres deep) detach from the EAC and become warm eddies in the Tasman Sea off New South Wales.

Circulation in the Indian Ocean off the west coast is highly variable, probably because of a westward flow from the Pacific through the Indonesian Archipelago. The prevailing Leeuwin Current (Figure 2.4) is largely driven by very warm water which comes from the region of the North West Shelf in summer. It is seasonal but highly variable, and flows southward in the deeper waters off the Western Australian coast, reaching its maximum strength around midyear.

In southern Australia the Flinders Current flows at depth northwards past western Tasmania, western Bass Strait and along the Victorian and South Australian coasts. In the Southern Ocean south of Tasmania the prevailing strong westerly winds drive the Antarctic Circumpolar Current eastwards around Antarctica.

Ocean water masses

Below the surface waters to about 800 metres, and extending from the equator to the Subantarctic Convergence, lies the South Pacific Central Water in the east, and the Indian Central Water in the west. The low-salinity, cold antarctic surface waters meet subantarctic waters at the Antarctic Convergence, and the resulting mixture sinks, flowing below the Central Water at a depth of around 1,000 metres. Below this, and flowing southwards at a depth of 1,000-3,000 metres, lies the Pacific Deep Water which is of Atlantic and Antarctic origin.

Continental shelf circulation

Wind-driven circulation

In the shallow continental shelf waters the wind can generate substantial currents in a day or so. The winds change direction seasonally and with shorter-term weather changes, accelerating shelf currents. The current pulses which result from wind reversals travel in a wavelike manner and are known as continental shelf waves or coastal trapped waves. The currents produced may move at 0.1-0.2 metres/second, and move particles several hundred kilometres along the shelf in two weeks.

Wind-driven continental shelf waves are the primary source of current variability in practically all

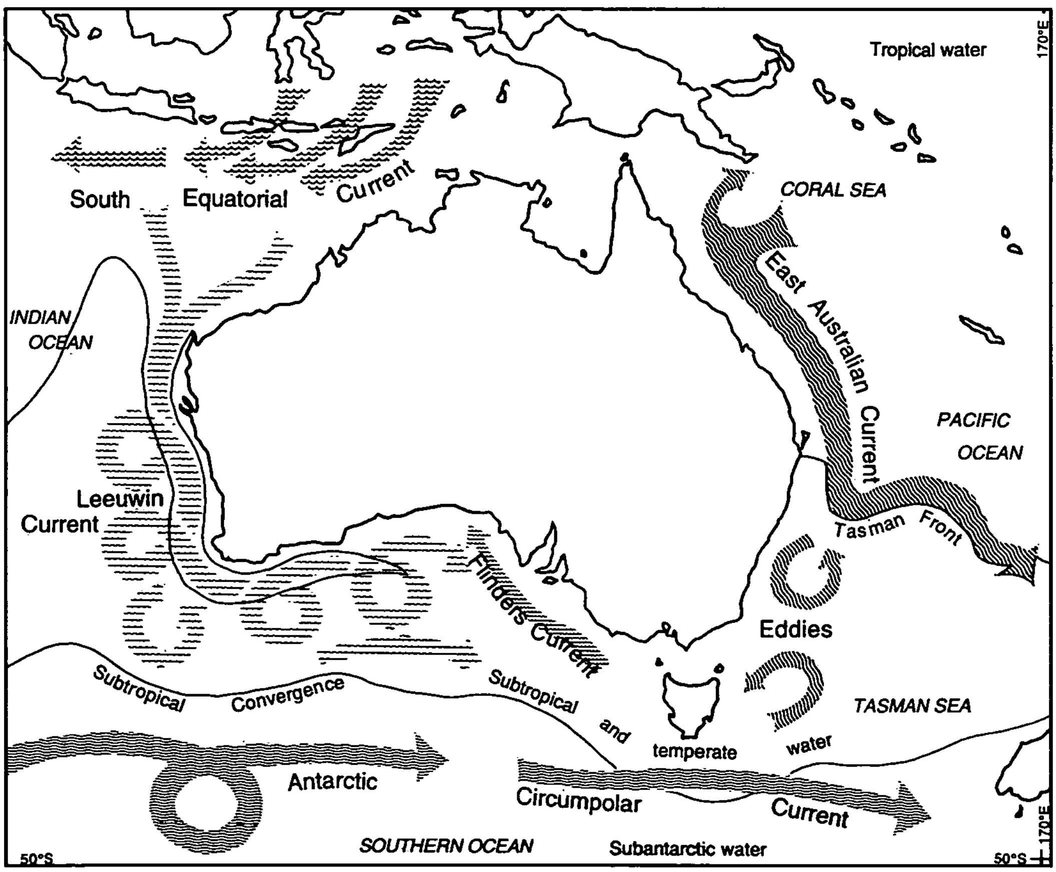


Figure 2.5: Ocean currents around Australia. (from various sources)

Australian shelf waters, the Great Barrier Reef, New South Wales Shelf, Bass Strait, the Great Australian Bight, and North West Shelf. At times they may be strong enough to bring an upwelling of nutrient-rich deeper waters into the photic zone, increasing planktonic productivity. Between November and May, tropical cyclones are a common feature of tropical waters, and may generate strong currents and high mean sea levels.

Deep ocean effects

In many cases the offshore deep ocean currents flow in the opposite direction to the local wind-driven continental shelf currents, making current predictions difficult, particularly off New South Wales where the meandering East Australian Current drives coastal currents. The Leeuwin Current, primarily a deep ocean effect, also strongly affects shelf circulation along the western coastline.

Tidal circulation

The gravitational attraction of the sun and moon create variations in the sea level (tides) and associated ocean currents (tidal streams). Because of the presence of the continents, the tides cannot follow the celestial bodies around the rotating world, so the tides propagate in the ocean around places where the ocean surface does not vary (known as amphidromic points).

On narrow continental shelves such as that off New South Wales, the tidal ranges are similar to that of the deep ocean, around two metres. On wide shelves such as the North West Shelf and central Great Barrier Reef around Mackay, the tidal oscillation is near resonant and the spring tidal range is around 10 metres. In the complex reef passages off Mackay, tidal currents may reach 4 metres/second (8 knots).

Flows in embayments and gulfs

Topographic features on coastlines may deflect or interrupt the consistent, alongshore currents of the outer continental shelf, producing large eddies of local significance. Wind-driven flows in Bass Strait and the Gulf of Carpentaria are both extremely complex, and predictions have only been achieved through numerical computer models.

Embayments and gulfs may cut off water masses, and create distinctive conditions. Evaporation during the dry South Australian summer makes the upper reaches of the Spencer Gulf and Gulf St Vincent extremely salty, to 48 and 42 psu, respectively. The dense, salty and warm waters sink and flow along the bottom of the gulfs into deeper oceanic waters.

Ocean productivity

The primary production in the sea depends on a supply of nutrients (nitrates and phosphates, and to a lesser extent silicates and trace elements) to the upper layers, the photic zone, where sunlight enables plants to photosynthesise. The main source of nutrients in the ocean are the enriched waters below the thermocline, run-off from the land, and biological fixing of atmospheric nitrogen. The general status of nutrients and the productivity of Australian waters have been described by Bunt (1987) and Jeffrey et al. (1990).

The ocean around Australia is generally low in nutrients, especially nitrates and phosphates, and consequently has a low biological and fisheries productivity. The east and west are dominated by low-nutrient subtropical waters, while the south is largely isolated from the rich subantarctic waters.

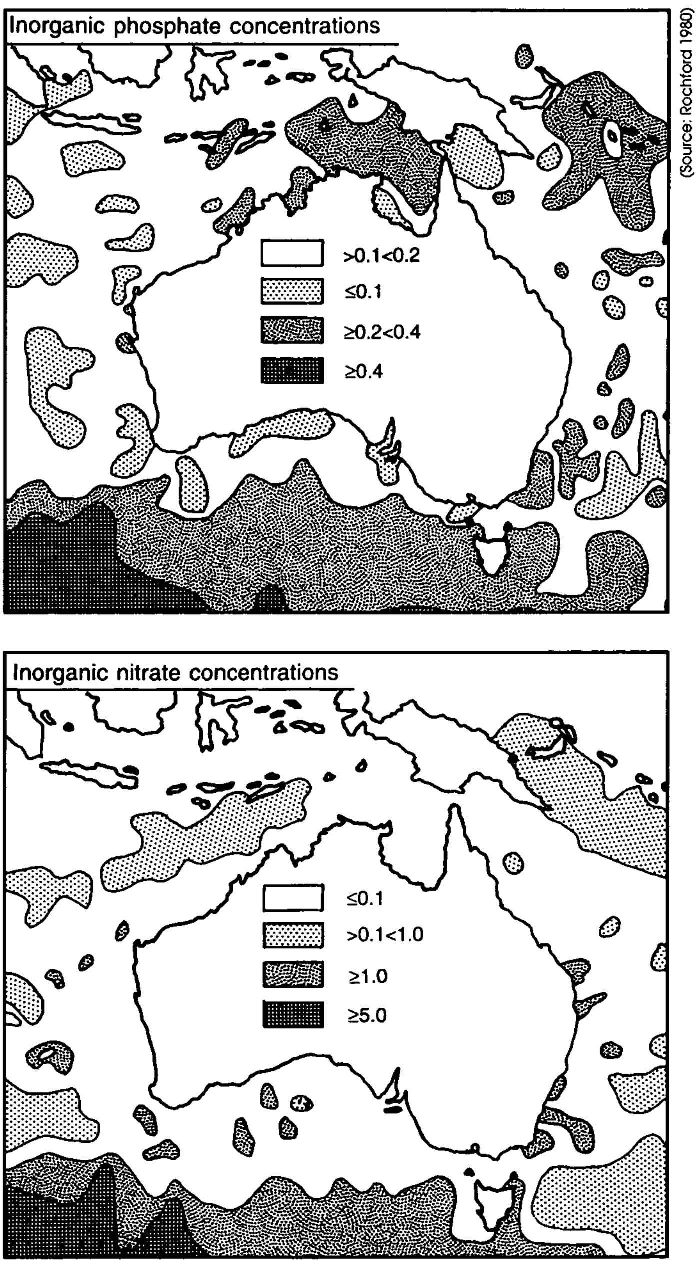


Figure 2.6: Nutrient concentrations (micrograms per litre) at the surface of the ocean around Australia.

Significant upwellings are also lacking. Nutrient inputs from land run-off are also limited because of the poor nutrient status of the continent's ancient, leached soils, and the low rainfall.

Large areas of the oceans around Australia are virtual deserts (<0.1 micromole/litre nitrate). Off most of the coastline, nutrient levels are low (>0.1-1.0 micromole/litre nitrate), and typical of subtropical belts of the world ocean. In isolated areas, for example off New South Wales, nutrient levels are higher because of localised upwellings from the East Australian Current. South of Tasmania at the Subtropical Convergence, nutrient levels are higher (1-5 micromoles/litre nitrate) but these are significantly lower than levels in the world's more productive waters, for example 20-25 micromoles/litre nitrate off south-west Africa.

Upwellings of nutrient-rich deep waters occur at various times of the year around Australia but have low nutrient levels compared with the world's richer upwellings. Upwellings occur in the outer margin of eddies in the western Tasman Sea and at the centre of eddies off eastern Tasmania. Seasonal upwellings occur off south-east South Australia. An autumn upwelling occurs off the Gippsland coast (Vic), but this contains nutrient-poor cold water from Bass Strait.

Intrusions of currents may also create minor upwellings. South of Sydney meanderings of the East Australian Current may take nutrient-rich deeper water upwards to where winds and internal waves may carry it to the surface. Similar intrusions also occur along the outer margin of the northern Great Barrier Reef.

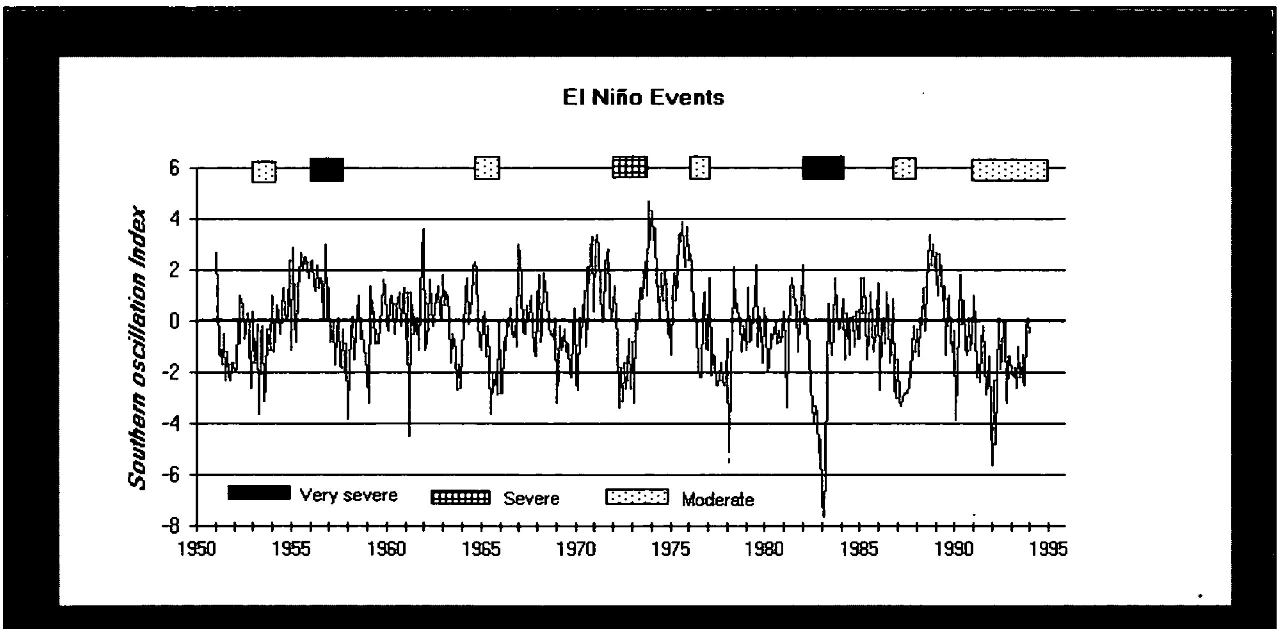
In Western Australia enriched tropical waters carried onto the North West Shelf in summer is then carried into coastal areas by tidal currents and tidal mixing. Because of the low nutrient status of Australia's waters, biological productivity is generally low, and fisheries are limited. However a number of locally enriched regions do support fisheries which are economically significant on a local or international basis. These include southern bluefin tuna, prawns, and rock lobster fisheries (Chapter 30).

On the other hand, the low nutrient status of coastal waters and low rainfall has contributed to the dominance of corals on much of Australia's tropical shelf. In temperate areas this has contributed to the dominance of seagrasses in many coastal areas. Both corals and seagrasses are sensitive to elevated nutrients and sediments (Chapters 9, 12, 42).

El Niño/Southern Oscillation (ENSO)

The positions of the low and high atmospheric pressure regions along the equatorial Pacific vary every few years. Known as the El Niño Southern Oscillation (ENSO) by meteorologists, this has ocean-wide effects on wind patterns, cyclone frequencies, and monsoons, and on ocean currents, temperatures and nutrients. It also has a profound influence on rainfall on the Australian continent.

In normal years warm ocean waters accumulate in the Equatorial Pacific Ocean, aiding the development of monsoonal rainfall over northern Australia. In the Eastern Pacific cold, nutrient-rich waters flow northwards along Peru in South America and fish and birds thrive. However, during years with a negative



(Source: CSIRO)

Figure 2.7: The Southern Oscillation Index. Prolonged negative values indicate ENSO events.

Southern Oscillation Index the wind patterns change and the warm equatorial waters spread eastward to accumulate off Peru, overriding the normal cold current. Known as the El Niño event, this has disastrous effects on fisheries and bird breeding. An eastward shift of the low-pressure, rain-forming region from northern Australia into the Central Pacific also occurs, causing droughts in eastern Australia. Recent ENSOs occurred in 1958-60, 1965, 1972-73, 1976, 1983-84, 1987, and 1991-1994.

The ENSO affects ocean currents around Australia, ocean temperatures, and probably ocean productivity and distributional and breeding patterns of certain species. ENSOs affect tuna landings in the Western Pacific, turtle breeding, and possibly cause coral 'bleaching' events (the large-scale loss of the symbiotic algae from corals, sometimes causing death to the corals).

Summary and conclusions

1. The waters surrounding Australia and its external territories are linked to three of the large ocean basins of the southern hemisphere, the Pacific, Indian and Southern Oceans. They include all of the ocean temperature zones (tropical, subtropical, temperate, subpolar and polar).

2. The major ocean current in the east is the East Australian Current, a western boundary current of warm Coral Sea water. The major current in the west is the Leeuwin Current, a surface stream of warm, low-salinity water. The major current in the south is the Antarctic Circumpolar Current.

3. Wind-driven, continental shelf waves affect currents in most shelf waters, including the Great Barrier Reef, New South Wales Shelf, Bass Strait, the Great Australian Bight, and North West Shelf.

4. Localised, seasonal upwellings of nutrient-rich waters occur in association with the East Australian Current, eddies in the Tasman Sea, tidally induced upwellings, continental shelf waves, and enrichment by tropical waters.

5. Australian waters have a low nutrient status and a low biotic productivity because of a lack of major boundary currents and a lack of the major upwellings, dominance by low nutrient subtropical waters, general isolation from the rich subantarctic waters, and low nutrient content in run-off from the land.

6. The low nutrient status of coastal waters has probably enabled corals to dominate much of the tropical shelf, and for seagrass to dominate temperate shallows.

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Chapter 3. The sea floor[1]

The continental shelf comprises the shallow (<200 metres) sea floor that surrounds Australia. It is relatively productive biologically as it receives land-based nutrients, and the shallows lie within the photic zone. It supports a rich and diverse biota, from tropical seagrass and coral reefs, to temperate kelp forests. It provides the great part of Australia's fish and petroleum. However changes in land use since European settlement have significantly increased river sediment loads and sedimentation on the inner shelf.

The major features of the sea floor around Australia are the relatively shallow continental shelf, the continental slope and rise, and the deep abyssal plain which extends into the ocean basins. Australia's continental margin includes three major terraces and four major plateaus off Western Australia, four terraces off the south and a number of troughs and plateaus off the north-east in the Coral Sea.

Characteristics of the continental shelf

The continental shelf is a continuous feature around Australia, ranging in width from 15 kilometres off the

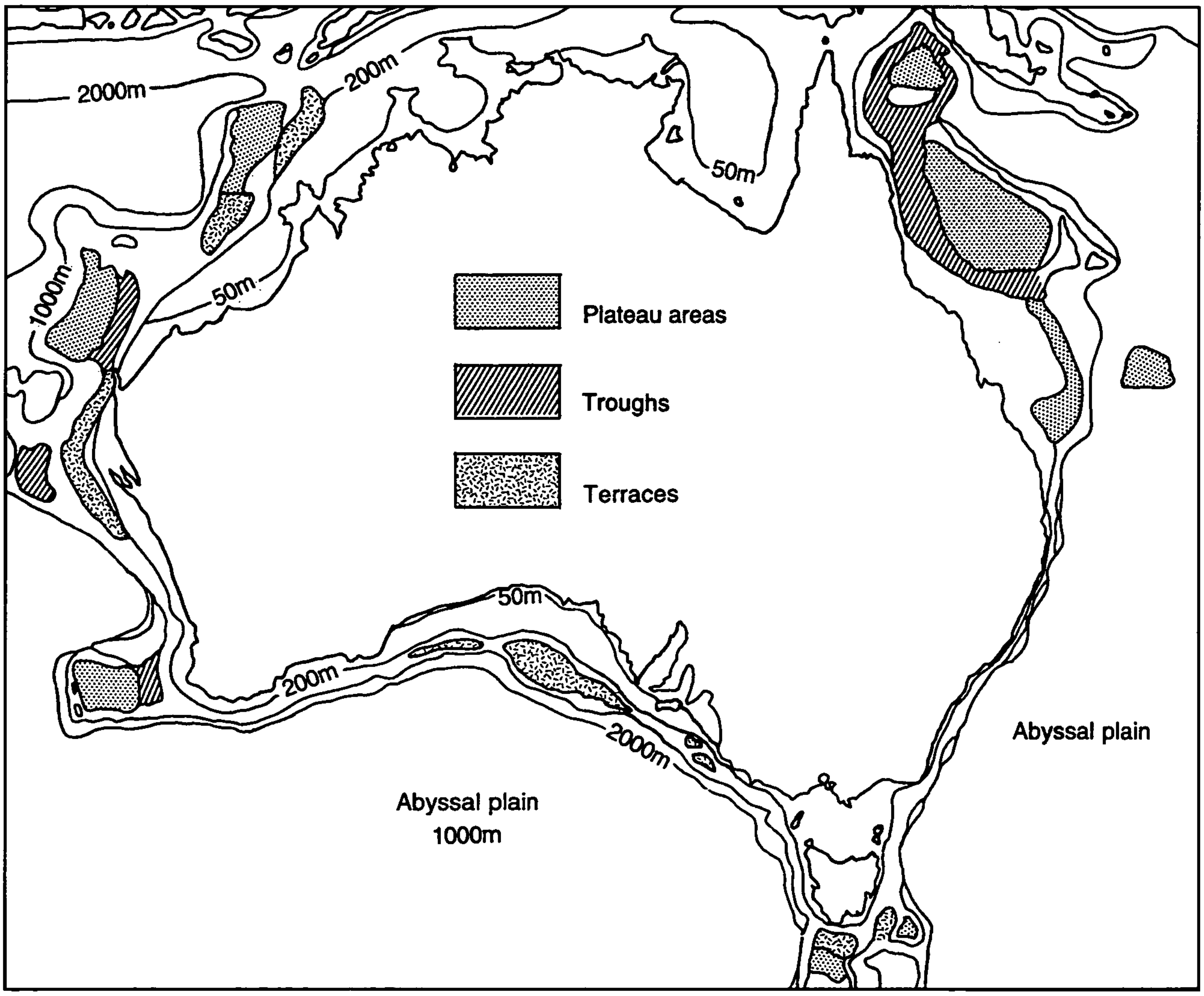


Figure 3.1: Regional bathymetry of Australian shelf areas. (Locations of major oil/gas fields are indicated as triangles.)

[1]Based on a paper by Dr P.T. Harris, Ocean Sciences Institute, University of Sydney, New South Wales.

south-east coasts, to 400 kilometres in the Timor Sea. It joins Australia with Papua New Guinea in the Torres Strait and Arafura Sea, and with Tasmania in Bass Strait. It is generally a featureless surface, broken by occasional reefs, old dunes and ridges, but may have a complex morphology, as in the north-east areas occupied by the Great Barrier Reef.

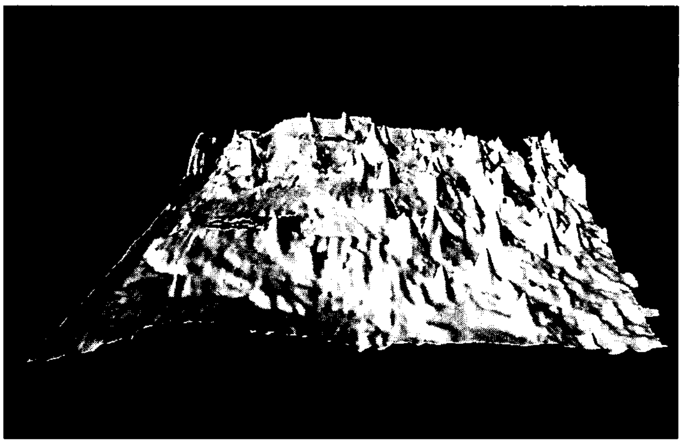
The continental shelf extends from the beach or foreshore, across the flat sea floor or shore face, and then begins to drop at the shelf break into the continental slope. Geologically, it is similar to the rest of the continent in that its foundation is composed of granitic crustal material, whereas the floor of the deep ocean abyss is underlain by basalt.

Table 3.1: Australia's sea floor area (in millions of square kilometres)

From coast to 50 m depth	1.298
From coast to shelf edge	2.505
From coast to abyssal edge	5.826
Terraces	0.249
Plateaus	0.476
Slope	1.514

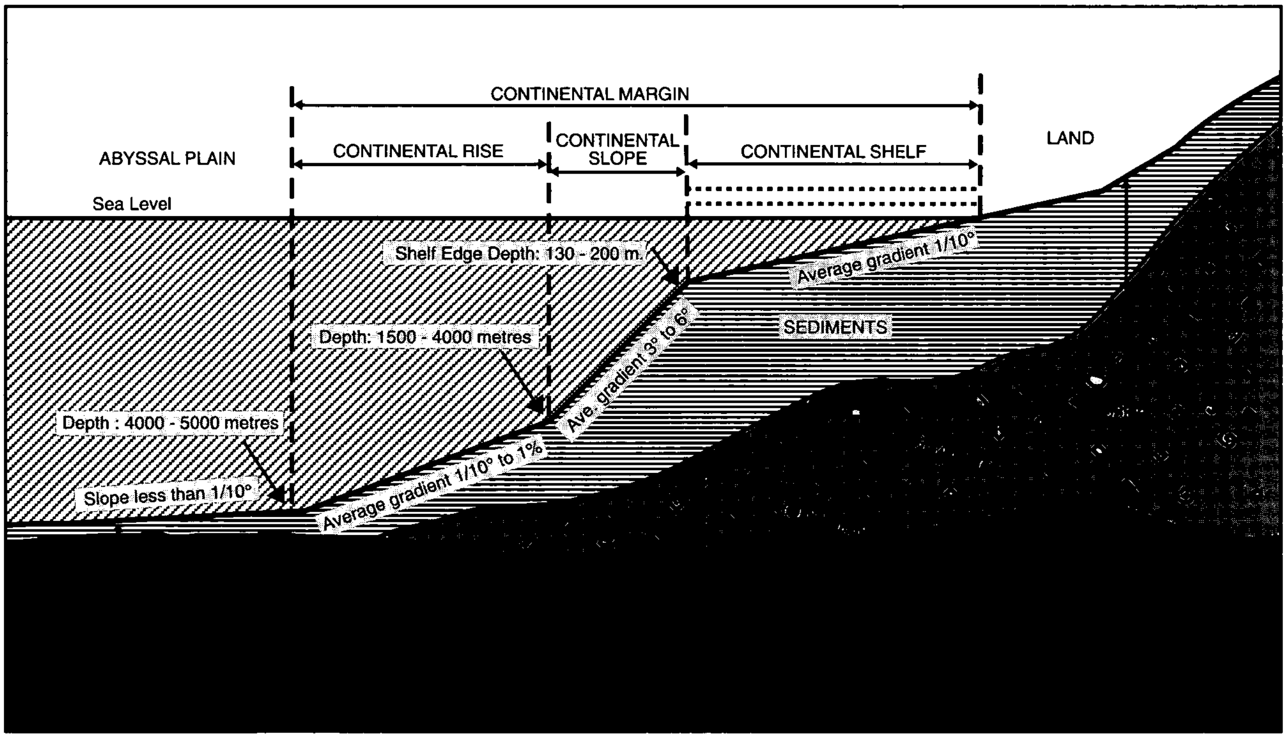
(Source: Bunt 1987)

Figure 3.2: Spectacular volcanic cones recently discovered around 100 kilometres south of Tasmania. The cones which lie in 1,000 metres of water and average 200 metres in height, are the fishing grounds for Tasmania's lucrative orange roughy fishery. This image, which covers an area of around 35 kilometres square, was produced by multibeam sonar in 1994.



(Source: N. Exon, AGSO)

Figure 3.3: Shelf areas where surface sediments contain greater than, or less than, 50% calcium carbonate. River catchment areas and estimated total sediment loads supplied to the coastal zone are indicated.



Shelf sediments

The sediments on today's shelf are primarily detrital, from rivers, glaciers and winds; and organic such as biologically produced shells. They also include locally important relic sediments such as beach ridges and river deltas from a time of lower sea level, and palimpsest, or reworked sediments.

Depositional rates

The current rates of detrital deposition are not well known. The central portion of Australia (47% of the surface) is desert and has no drainage into the sea. Around 40% is wind-blown sand which may enter the sea during dust storms. River sediment supply rates

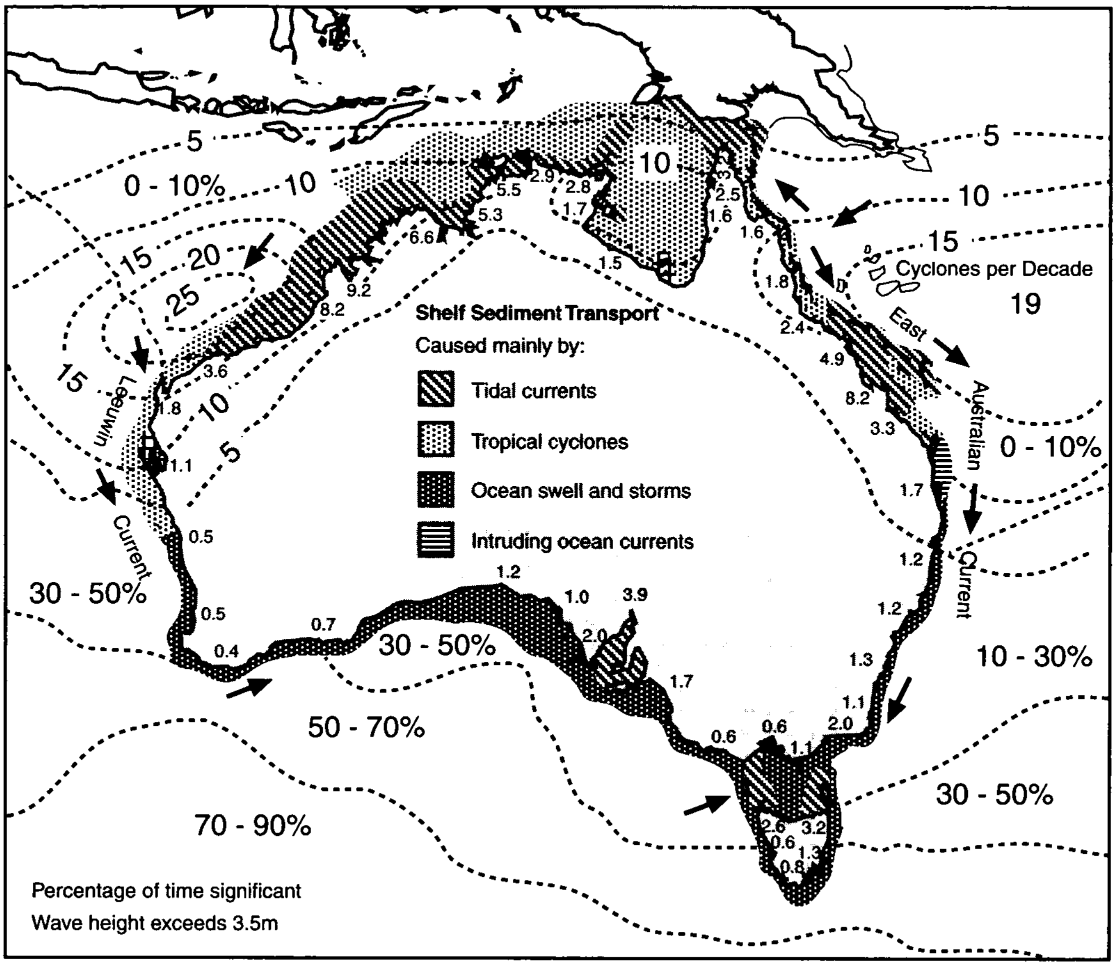


Figure 3.4: Sediment transport regions: tidal currents (17.4%), tropical cyclones (53.8%), ocean swell and storms (28.2%) and intruding ocean currents (0.6%). Frequency of cyclones and mean tidal range are also shown.

are best known for north-east Queensland and the Murray River, and for smaller catchments where dams have been constructed, such as the Ord and Snowy Rivers. These studies indicate that, in Australia, river sediment loads are affected by extreme rainfall episodes. Sediment discharged into the sea during a single major flood may greatly exceed that over several 'normal' years. This necessitates monitoring over decades to accurately determine trends.

In general, coarse sand-size sediments do not escape from any estuary on the southern coast, from New South Wales to Western Australia. All of the Murray River's coarser sediments and most of the finer sediments are trapped in estuarine Lake Alexandrina. Sediment yields in the wet north are much higher (around 100-300 tonnes per square kilometre per year) than in the south (around 10-30 tonnes per square kilometre per year).

It is estimated that the total discharge of sediments to Australia's continental shelf is around 150 million tonnes a year. This is very low compared with other continents, for example, 530 million tonnes per year from Africa, and 1800 million tonnes per year from South America. Overgrazing by cattle and sheep since European settlement has greatly increased erosion in Australia. For example, the present discharge from the Ord catchment is around 35 million tonnes per year, compared with a pre-European discharge of 3.5 million tonnes per year.

Sediment types

The distribution of sediments has been mapped for about 70% of Australia's shelf. Carbonates exceed 50% of the outer shelf, whereas non-carbonates exceed 50% of inner-shelf sediments. In southern Australia the non-calcareous inner-shelf sediments such as those off Rottnest, Lacepede and New South Wales, are generally coarse-grained relic or palimpsest quartz sands, while in northern Australia they are commonly terrigenous silts and clays supplied by rivers. Outer-shelf, carbonate-rich sediments are also commonly relic. On the Great Barrier Reef, Holocene reefal carbonates range from 10 to 30 metres in thickness. The sources of organic sediments vary with latitude: north of 24°S they are corals and the alga *Halimeda*; south of this (and particularly south of 38°S) they are bryozoa.

The rate of accumulation of sediments varies. Sediment cores and seismic profiles indicate typical thicknesses of around 100 centimetres have accumulated over the past 6,500 years, the present Holocene sea level stand. The detrital river input and biogenic carbonate input has been roughly equivalent in terms of gross supply to the shelf (around 150 million tonnes per year).

Shelf energy regimes

Shelf sediments are moved or reworked by swell waves and ocean currents, and are turned over by burrowing organisms, a process known as bioturbation. Currents produced by tropical cyclones and temperate storm events dominate the erosion and transport of sediments over 82% of the Australian shelf. The energy expended and the amount of sediment transported during a storm event may equal many months or years of non-storm background processes, even on highly dynamic, tidally influenced shelves. Storm-dominated shelves consist of three characteristic zones: inner shelf, mid-shelf and outer shelf.

Tropical cyclones are the greatest influence on northern shelves. The North West Shelf experiences up to 25 cyclones per decade, and the Great Barrier Reef experiences up to 15 cyclones per 100 kilometres length of coastline per decade. One cyclone in the Great Barrier Reef eroded a sediment layer averaging 6.9 centimetres from a mid-shelf sea floor, and transported sediments over 15 kilometre distances.

Tidal currents dominate sediment transport on around 17% of Australia's shelf in the macrotidal areas where tidal ranges exceed four metres, for example, between Port Hedland and Darwin, and Broad Sound on the Great Barrier Reef. They are important in mesotidal areas where the tidal range is two to four metres in range, such as Torres Strait, Bass Strait and Moreton Bay. Intrusive ocean currents dominate sediment transport in around 1% of the shelf, especially off Fraser Island in southern Queensland where the southwards flowing East Australian Current intrudes on the shelf. The Leeuwin Current may create a similar effect in the west.

Effects of humans on shelf sediments and sedimentation rates

In some areas there have been tenfold increases in river sediment loads since European settlement because of widespread overgrazing by cattle and sheep. Various estuary, harbour and beach engineering projects have also altered natural sedimentary processes, particularly in the south (Chapter 40).

Localised impacts include offshore dumping of dredge spoil, sand mining and aggregate extraction, urban sewage outfalls, laying of oil pipes and construction of oil drilling platforms, and oil spills. Benthic trawl fisheries are undertaken over large areas of the Australian shelf and may have a potentially significant effect on erosion and reworking of shelf sediments.

Monitoring of shelf sediments

There are relatively few programs monitoring shelf sediments. The Torres Strait baseline study (conducted by the Great Barrier Reef Marine Park Authority) and the Sydney Water Board ocean outfalls project are the only ones involving repeated shelf-sediment sampling.

Indicators

The use of shelf sediments as a record of prehistoric environmental conditions may prove to be a tool of fundamental importance to environmental management agencies, as such changes are related to river discharge of sediments (total load, sediment composition and nutrients). In order for sediments to provide a useful record of short-term environmental changes (that is, over years), rapid deposition (more than one centimetre per year) and minimal reworking (bioturbation) must occur. Variations in sedimentation and concentrations of heavy metals such as copper and zinc have been thus detected off the Fly River Delta in Papua New Guinea, and may be detectable off Moreton Bay and Port Phillip Bay. Sediments accumulating over longer periods (that is, over hundreds to thousands of years) may be used as environmental indicators. Carbon dioxide and oxygen isotopes in coral and bivalve shells are used to estimate past ocean temperature and global ice volumes.

Changes in sedimentation rates may also be used to assess the impacts of changing land use. Recent studies on loss of soil as a result of logging suggest that sediment loads may increase by a factor of 10 to 100 or more.

Massive corals reveal climate secrets

Important studies at the Australian Institute of Marine Science have found that corals exhibit seasonal density banding which is observed in drill cores. The banding shows seasonal variations in [illegible] rings, and appears related to water temperature, light intensity and nutrient [illegible]

Summary and conclusions

1. Australia's continental shelf is around two million square kilometres in area. It has a complex geological history. Sediments presently found on the shelf were deposited in the Pleistocene during lower sea level, and during the present high sea level stand. Deposition rates are low compared with other continents.

2. Sediments on 70% of Australia's continental shelf have been mapped. The river and biogenic sediment supplies have not been accurately estimated.

3. The mobility of shelf sediments is controlled by swell waves and storms (28% shelf), tropical cyclones (54%), tidal currents (17.4%) and by ocean currents (0.6%).

4. Major human impacts are the increase in sedimentation following erosion from overgrazing (by a factor of 10), benthic trawling, and localised effects of sea dumping, coastal engineering works, sewage discharges and other influences.

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Chapter 4. The land-sea interface[1]

The biological productivity of the diverse coastal ecosystems encompassed in Australia's enormous latitudinal range depends on nutrients delivered, removed and recycled by geochemical and biological processes which are strongly coupled to the physical oceanographic environment. An understanding of coastal oceanography is also particularly important in assessing the impacts and fates of land-based pollutants from either point sources or in run-off.

This chapter focuses on the sensitive land-sea interface. It describes key systems and processes relevant to nutrient inputs, cycling and oceanographic controls on the productivity of coastal waters, and also to terrestrial inputs such as wastes and pollutants.

Riverine run-off and nutrient inputs

Most of the nutrients and sediments washed from the land into coastal waters are transported by rivers. Australia is a dry continent and reliable, year-round rainfall is largely restricted to discrete zones along the eastern and southern margins of the continent. Australia has no major river systems, and with the exception of the Murray-Darling River system, most are relatively short. Because of the small size of most catchments, flood events are usually of short duration, often only a few days long. In monsoonal northern Australia, significant river flow and nutrient discharge is restricted to the summer wet season, but is highly variable between and within years as major flood events are related to the activity of monsoonal depressions or tropical cyclones.

In Australia's river systems, concentrations of suspended sediments and dissolved materials in river waters vary with flow rates and times of flooding. After prolonged dry periods, the first flood event of the season frequently contains high concentrations of nutrient materials which have built up within the watershed or are stored with sediments in upper reaches of individual streams.

Estuaries

Estuaries are zones where fresh and salt waters mix. Because nutrient delivery is concentrated within the estuarine mixing zone, estuaries usually have a higher biological productivity than adjoining coastal and continental shelf waters. Many of Australia's fisheries are either based within estuaries or are dependent upon estuarine productivity at some time in the organism's life cycle.

Mixing processes

Mixing processes within estuaries are related to the density difference between fresh water and seawater. Where estuaries occur within coastal embayments or drowned river valleys, the fresh water floats upon a wedge of salt water which intrudes landward along the bottom of the estuary. Mixing occurs when winds and tides cause the layers to mix, in most cases producing a gradient of salinities at the surface which ranges from pure sea water outside of the mouth of the estuary, to pure fresh water at the head of the estuary. The transition between fresh and salt depends on the freshwater discharge rate, the size and depth profile of the estuary, the tidal range and wind stress. Salinity, nutrients and plankton populations within estuaries are therefore rarely stable. Under flood conditions, the volume of fresh water may be so high that sea water cannot intrude into the estuary and mixing occurs within the flood plume on the adjacent continental shelf.

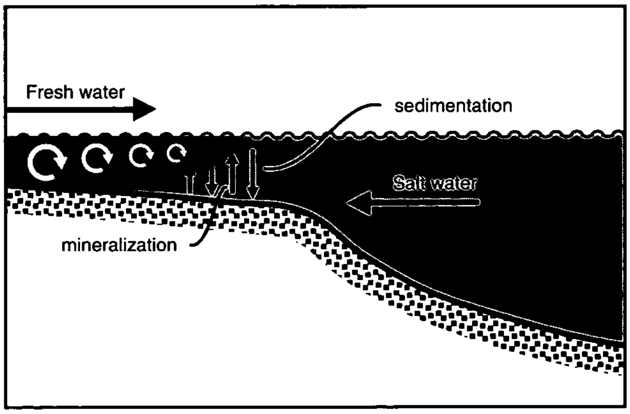

Figure 4.1: Time-averaged water flows, mixing patterns and major nutrient fluxes in a partially mixed salt-wedge estuarine system.

[1]Based on a paper by Dr M. J. Furnas, Australian Institute of Marine Science, Townsville, Queensland.

Arid coastlines

On arid coastlines, high evaporation rates from shallow embayments without significant freshwater inflows and restricted tidal exchange can create situations where salinities exceed those in normal sea water (inverse estuaries). These may be permanent, such as in Shark Bay, or seasonal, in the monsoonal regions. The productivity of inverse estuaries is related to tide and wind-driven exchanges of materials with the neighbouring ocean, nitrogen fixation and to recycling within the ecosystem.

Supratidal mud flats are found along a number of arid and dry-tropical coastlines, for example, the southern Gulf of Carpentaria. These flats concentrate salt and nutrients for extended periods following tidal inundations, sheet run-off, rainfall and ground water intrusions, then release salty, nutrient-laden water into the coastal zone following dissolution during spring tides.

Chemical processes in estuaries

A wide variety of interconnected geochemical and biological processes operate in the estuarine environment to alter the concentration and speciation of biologically important nutrient materials, metals and other materials. Some chemicals are actively taken up or released into solution, for example, soluble iron transported by rivers is precipitated in or near the estuary. The solubility of copper and many other trace metals is strongly dependent upon the concentration of organic chelating agents in fresh and salt waters. Much of the phosphorus transported by river systems is bound to soil particles. When the river particles mix with saline waters in the estuary, soluble phosphorus is released, increasing phosphate concentrations in estuarine waters.

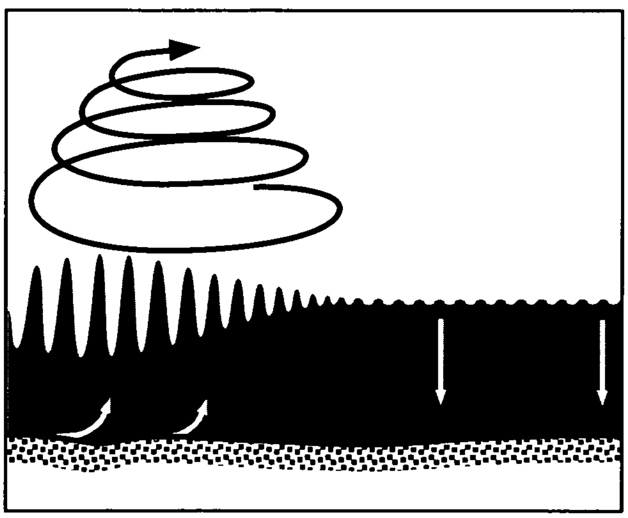

Figure 4.2: Mixing dynamics and significant nutrient fluxes associated with cyclonic storms moving over the continental shelf.

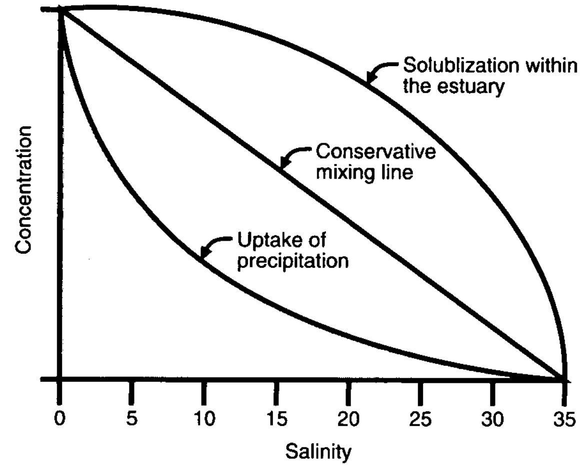

Figure 4.3: Schematic depiction of solute: salinity relationships in estuaries for materials not affected by estuarine processes, materials removed or solublized within the estuary.

Nitrogen undergoes a number of biologically mediated transformations in estuarine systems. Around half the organic nitrogen which falls to the bottom in estuaries may be removed from the ecosystem by denitrifying bacteria. Rates of nitrification and denitrification are in turn directly coupled to the degree of nutrient loading.

Estuarine productivity

The productivity of plankton communities in estuaries is dependent upon several factors including the rate of nutrient supply, usually through freshwater inputs, the amount of physical mixing within the ecosystem and the residence time of water within the estuary. Where nutrient input rates are high and residence times are long relative to the growth rates of algae, pronounced algal blooms can develop (Chapter 42). Residence times for water and plankton is determined by freshwater input, the shape of the estuary (for example, long and narrow versus short and wide), the presence of adjoining wetlands and the volume of the estuary relative to the tidally exchanged volume.

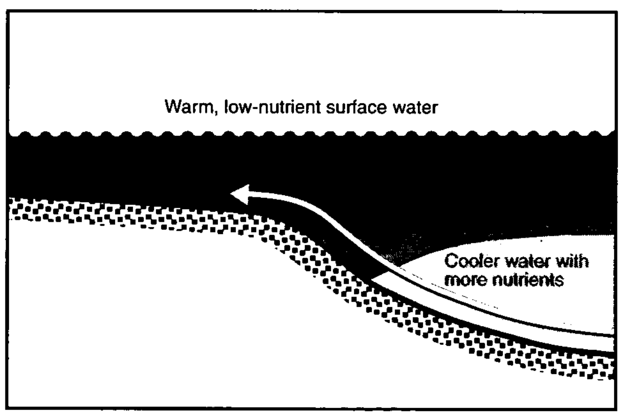

Figure 4.4: Temperature section through intrusive upwelling.

Coastal mixing

Once past the estuary, fresh waters and nutrient materials do not disperse haphazardly into the adjoining ocean. Buoyant layers of river water generally flow along the coastline and terrestrial sediments, nutrient materials and contaminants are usually deposited along the coast. Much of this material can be trapped within the shallow nearshore zone for extended periods. In the Gulf of Carpentaria, annual prawn catches are directly correlated with the level of terrestrial run-off into the Gulf. Shelfbreak upwellings, tidally induced mixing and frontal zones are also major contributors to coastal nutrients off New South Wales (Chapter 2).

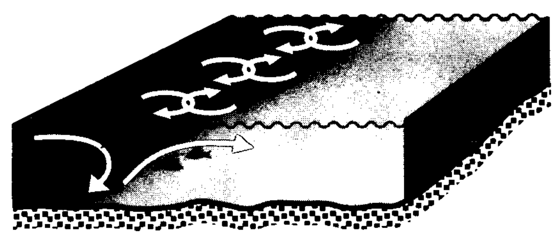

Figure 4.5: Water movements and mixing processes within a frontal zone.

(Source: GBRMPA)

Figure 4.6: Coastal water bodies, showing mixing. LANDSAT image sowing depth/turbidity, Curtis Coast (Qld).

Summary and conclusions

1. There is still very little quantitative information on the interaction between physical and biological processes, and longer-term climatic effects.

2. This lack stems from the immense area to be covered, the belated development of significant scientific programs aimed at understanding how large and medium-scale marine ecosystems operate.

3. The quality of water in Australia's estuaries and coastal zone and the productivity of the fisheries are ultimately tied to the oceanographic processes responsible for delivering nutrients to the ecosystem(s) in question.

4. Variability in biological processes, for example primary productivity and recruitment, are directly or indirectly linked to system-scale physical variability. Any effort to responsibly manage water quality and Australian fisheries must be based on an understanding of the limitations posed by the underlying environmental and oceanographic processes.

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Part 2
Marine Biodiversity

Australia's marine environment traverses a great range of climatic, geomorphological and oceanographic zones. These create a variety of habitats and support many different marine communities comprising a myriad plant and animal species, from minute plankton to giant blue whales.

Biodiversity is the variety of life forms, the different plants, animals and micro-organisms, the genes they contain and ecosystems they form. The concept particularly emphasises the interrelated nature of the living world and its processes. Biodiversity is the result of hundreds of millions of years of evolution and is the material for future evolution. Biodiversity exists at three different levels: genetic, species, and ecosystem.

Marine biodiversity is quite distinct in structure and function from that of the land, necessitating different approaches to management. Although the sea has a generally lower species diversity than the land, it has a much higher phylogenetic diversity. Of 33 animal phyla, 28 occur in the sea, and 13 are exclusively marine. Eleven phyla occur on land, and only one is exclusively terrestrial.

At the habitat level, there are fundamental differences with land. The medium of sea organisms is buoyant, viscous and mobile, and has a three dimensional structure.

Trends in organisms' sizes, life spans and trophic levels also differ in the sea. For example, the largest and most long-lived animals are carnivores, not herbivores as on land. The major primary producers in the sea are microscopic plankton, while on the land they are the large trees and grasses.

In the sea, reproductive cycles generally involve larval and juvenile phases, which rely on currents for dispersal, and annual recruitment is often highly variable.

Australia's marine biodiversity

No comprehensive description of Australia's marine ecology and biota exists, and very little is known of their biological status and threats. This is not unexpected: our EEZ is vast in area; the marine zones, ecosystems and communities are diverse and complex; and marine species number in the tens of thousands. Marine studies are young in Australia and large geographic areas and groups of marine organisms, and ecological processes are not well known. The sea is also a hostile, alien, and very expensive environment in which to work.

While a substantial body of scientific literature does exist in some areas, the majority of this is descriptive in approach rather than experimental or quantitative, reflecting the early state of marine ecological research in this country. Much of the research is *ad hoc* or piecemeal in nature, and covers a small geographic area, and a short time span.

More surprisingly, there have been few attempts to synthesise this scattered, patchy information to achieve an overview of geographic areas of special interest, or to assess the state of understanding of certain ecosystems or subjects, or to identify the gaps in knowledge in order to develop systematic research priorities. This largely reflects the increasingly

Classification of the marine environment

Oceanographic zones
The size, continuity and complexity of the marine environment make it difficult to classify. Its landward margins extend from the backshore, splash zone and the tidal shores and estuaries, but the terrestrial coastal strip (3 kilometres landward) and smaller offshore islands and coastal lakes are often broadly included in the marine domain. The major ocean zones are the light-influenced (photic) and dark (aphotic) zones. The major sea floor (benthic) divisions are the inner (shallow and lit) and outer continental shelf (deeper, dark); the continental slope (bathyal zone) and the deep ocean floor (abyssal zone). The ocean water column (pelagic division) is divided into the continental shelf waters (neritic province) and the waters in the deep ocean (oceanic province).

Biological zones
Marine animals and plants (biota) are broadly classified according to the zones they occupy: those living in or on the sea floor are termed benthos; these living on the surface are epifauna; and those living in the sediments are infauna. In the water column, the large, actively swimming animals are termed nekton. The smaller, drifting biota are the plankton: the plants are phytoplankton, the animals are zooplankton.

specialised nature of modern sciences, the limited spatial or geographic interests of most researchers, and the lack of an integrated, strategic approach to marine studies.

Management of marine biodiversity

A detailed knowledge of marine ecology and wildlife biology, and of impacts and threats, is necessary for large marine ecosystem management, and is fundamental to the development of the Australian Marine Conservation Plan, and the Representative Network of Marine Protected Areas. It is also fundamental to the concept of ecologically sustainable development (Chapter 61).

Description of this part

Part 2 of this report describes major marine ecosystems and habitats, and marine groups of special interest. It is based on technical papers prepared by some of the foremost researchers in their respective fields. For each subject area they have outlined the major human impacts and threats and management programs, and identified information and data sets which might be useful for monitoring. Given the constraints of limited knowledge and time, and limited space in this report, these reviews are far from complete. However, most are unique in that this is the first attempt to describe them at a national scale, and from the perspective of environmental status and management.

The first chapter in this part (Chapter 5) provides a background description of the biogeography of Australia's marine biota, and examines patterns of endemism. The next nine chapters (Chapters 6-14) then describe major ecosystems and habitats along a cross shelf transect, extending from the saltmarshes and mangroves that fringe the land, to offshore plankton and benthic communities. Where possible, the status of these ecosystems, communities and habitats are assessed, and the major issues affecting them are described.

The remaining chapters (Chapters 15-18) examine the status of marine species, although in very few cases is this known with any confidence. Chapter 15 provides an important discussion on the considerations in the conservation of marine species, for unlike the land species, the conservation biology of marine species remains little studied. Chapter 16 examines the conservation status of invertebrates and lower vertebrates, in so far as this is known. The conservation status of the rather better-known higher vertebrates - seabirds, reptiles and mammals is described in Chapters 17 and 18.

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Chapter 5. Biogeography of Australia's marine biota[1]

The Australian continent's shallow-water marine biota, though less well known than our unique terrestrial flora and fauna, is notable for its high level of endemicity and for groups of animals and plants shared only with other Southern Hemisphere continents. The reasons for this are only now emerging after nearly two centuries of taxonomic and biogeographic research.

Although the present biota of Australia's coast and shelf can be explained in part by reference to modern conditions, it is also the result of a long history in a changing environment. Since the 1960s the theories of Continental Drift and Plate Tectonics have been applied to the interpretation of the biogeography of Australia's marine biota.

Geological history of Australian marine biota

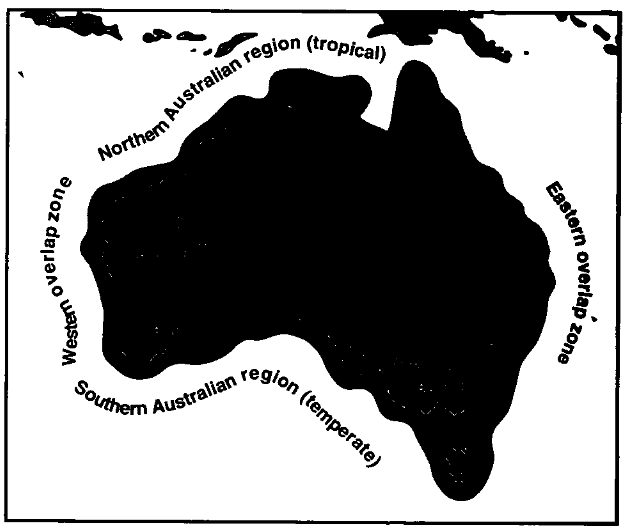
Most marine phyla originated in ancient Cambrian times, 600 million years ago, but new classes continued to appear until the Lower Carboniferous, 300 million years ago. During the late Palaeozoic, the marine biota of Gondwana (of which Australia was part) fluctuated from Palaeoaustral (cool-temperate) to Tethyan (warm-temperate) in composition.

The history of Australia's modern marine biota began in the Mesozoic (Chapter 1). Australia-Antarctica separated from Gondwana around 100 million years ago and New Zealand split from Australia around 80 million years ago. Australia and Antarctica separated during the Tertiary (around 40 million years ago), resulting in the meeting of Australia's eastern marine biota (originally part of the Weddellian Province which had been connected to Chile) and the south and west (which had been tropical Teuthan). During the Miocene (about 20 million years ago) Australia collided with South-East Asia forming Papua New Guinea, and linking the two regions' biota. The major oceanographic features which affect Australia's marine biogeography, the Antarctic Convergence and the Subtropical Convergence, also commenced during the Miocene.

By the Quaternary (2 million years ago) the arrangement of land and sea in the south-western Pacific had assumed its present state, although the shape and size of the Australian coastline continued to change, and the Torres and Bass Straits opened and closed many times because of sea level fluctuations of over 200 metres. These changes to the shelf size, coastlines, estuaries and coastal lakes, and changing latitudes of the passages between the east coast and the rest of the mainland, have greatly affected the continuity of their biotas.

Distribution patterns

The biogeography of Australia's fish, molluscs, echinoderms and corals are relatively well known and illustrates the major biogeographic trends.



(Source: Wilson and Allen 1987)

Figure 5.1: Major faunal regions of the Australian coast.

Fish

Of 3,400 species of fish occurring around Australia, around 900 are pelagic or wide-ranging, and 2,500 occur on the shelf and nearshore. The greatest number, around 1,900 species, in 600 genera and 120 families, are found in the tropics. Most of these species (87%) are shared with the Indo-West Pacific region. A moderate level of endemicity (13% of species) has occurred because of isolation by the prevailing southwards movement of tropical East Australian and Leeuwin Currents.

[1] Based on a paper by Dr G.C.B. Poore, Museum of Victoria, South Melbourne, Victoria.

The southern, temperate fish fauna is less diverse, around 600 species, and the long isolation of species has resulted in very high endemicity (85% of species). Of the remaining species, 11% are shared with New Zealand. A few families with low dispersability such as viviparous clinids, brooding syngnathids (pipefish and seahorses) and nesting gobiescocids (gobies) account for much of the endemicity.

Molluscs

The biogeography of Australian molluscs is similar to that of the fish although many more species are present. In the north, 10% of species are endemic and the remainder are widely distributed in the Indo-West Pacific. By contrast, in the south there is 95% endemicity. Several endemic genera (Trigoniidae, Campanilidae, Diastomatidae) are relicts of the ancient Tethyan fauna and others are relicts of the ancient Palaeoaustral fauna.

Echinoderms

The starfish and their kin also repeat the biogeographic patterns of the fishes and molluscs, with 13% endemics in the tropics and 90% in the temperate region.

Corals

Corals, essentially tropical in their distribution, differ from the above trends. The Australian fauna is essentially a subset of the Indo-West Pacific corals, and is largely confined to the Great Barrier Reef and north Western Australian reefs. There is a rather abrupt depletion of species at the southern end of the Great Barrier Reef and at the Abrolhos Islands (Chapter 12).

Other taxa

Other marine animals are less well known. Most are more diverse in the tropics. Of the crustaceans: crabs, hermit crabs, lobsters, shrimps and prawns are more diverse in warmer waters, but the smaller amphipods and isopods are less diverse.

Biogeographic provinces

The biogeographer Ekman has placed Australia's tropical and subtropical marine environments in the Indo-West Pacific region, the world's 'greatest wealth of animal life'. Southern Australia was considered separate and was included in the warm-temperate fauna of the Southern Hemisphere.

The distribution patterns in Australia today are the result of the contributions of two different early Tertiary biotas. The Pan-Pacific Tethyan biota (and its successor, the Indo-West Pacific biota) has dominated the northern coast since the beginning of the Tertiary, and contributed to the temperate biotas. Barriers to interchange of coastal and shelf biotas with South-East Asia are only slight. Southern limits of the Tethyan element is limited by the latitudinal temperature gradient (18-20^{o}C).

The temperate Palaeoaustral fauna has dominated south-eastern Australian coasts since the Tertiary. Its high level of endemicity results from isolation by ocean basins from other southern continents, and from a latitudinal gradient to the north.

While the division into tropical and temperate regions is widely accepted, the further subdivision into a number of marine provinces (as many as three tropical and four temperate zones have been proposed, Figure 5.3) has been debated because boundaries are doubtful and not quantitatively defined. Two transition zones, one in the west and one in the east, are more commonly accepted.

Further subdivisions are based more on ecological divisions than on biogeographic ones. The tropical region has been separated into areas subject to high, summer monsoonal rainfall, such as Queensland, Northern Territory, north Western Australia, and those subject to low, irregular rainfall and occasional cyclonic disturbances, such as north-western Western Australia. Queensland has been further separated into coastal (inshore), and Great Barrier Reef (offshore).

Species diversity

The number of different species in a particular habitat is also important in understanding ecological and biogeographic trends, and in identifying areas of particular conservation value.

Few quantitative attempts have been made in Australia to assess diversity, largely because of the poor state of taxonomic knowledge of marine biota. Rarely are more than 40% of the species found in an area known to science.

Management implications

Biogeography

'Biogeographic zonation' is an important criterion in the selection of an area for protection, the implication being that areas within zones have similar biotas, and the area selected should be 'representative' of the zone. While the division of Australia into northern tropical and southern temperate regions with broad transitional zones is clearly inadequate for most management decisions, a finer classification has not yet been achieved.

The Australian Committee for the International Union for the Conservation of Nature (IUCN) has adopted in its policy for protection of marine and estuarine areas a classification of Australian habitats and coastline comprising 14 coastal (<200 metres depth) geographic zones, plus 18 oceanic zones and external territories. While this has been used as an interim basis for the

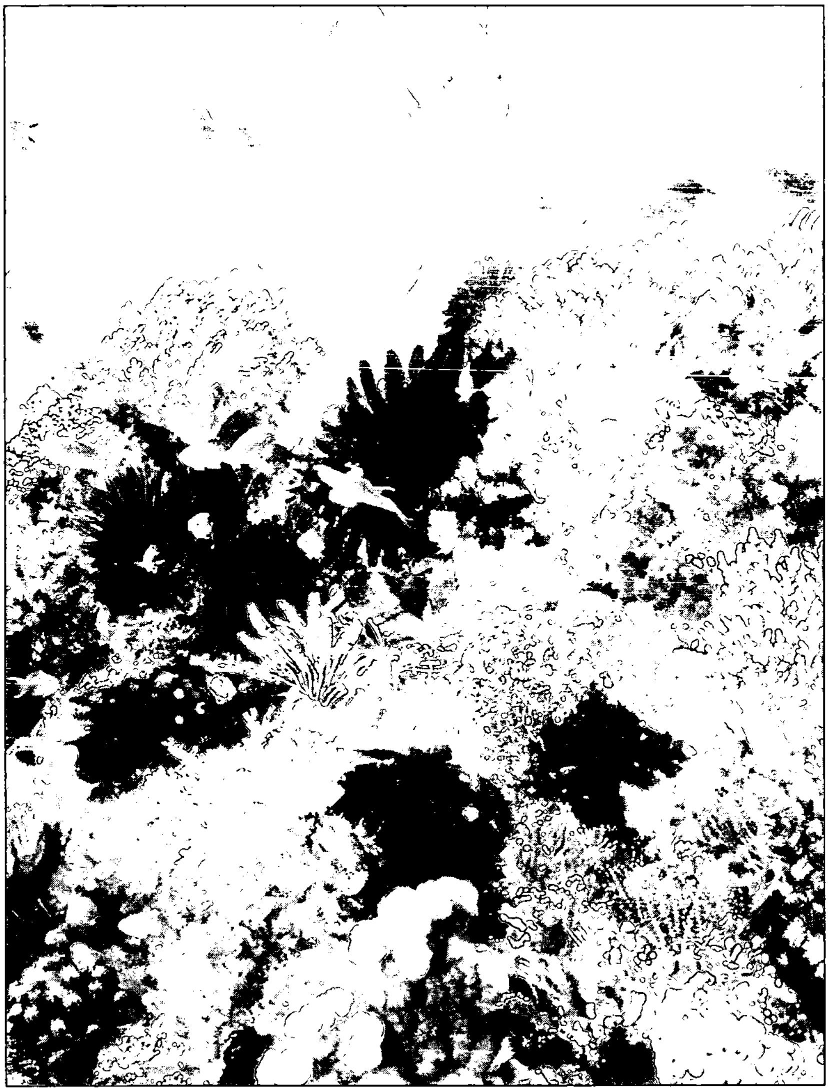
Ocean Rescue 2000 program, the zones do not well coincide with suspected biogeographic boundaries, and the geographic categories are inappropriate for environmental management. The development of a bioregional classification based on biogeographical, ecological and other criteria is now a priority in the Ocean Rescue 2000 program (Chapter 68). Endemism is a valuable criterion for selection of marine protected areas. It is the southern coast of Australia which has the greatest endemicity and is under the greatest threat from human disturbances. In contrast, northern ecosystems, such as the Great Barrier Reef, share most of their fauna with other places in the Indo-West Pacific and rank lowly by this criterion.

Biodiversity

With the exception of certain large species of particular conservation importance, management of the marine environment should be geared to the management of communities rather than species.

'High biodiversity' is regarded as an important attribute for protection. Species diversity tends to be higher in the tropics and coral reefs are said to be of special conservation value because of their great diversity, but many of Australia's other marine environments (for example Bass Strait) are also inhabited by communities rich in species. Australia's coastal, shelf and slope communities remain poorly described, while the taxonomic knowledge of Australia's biota is incomplete. Only 10 to 50% of most macrofauna, depending on the group, has been described.

While 'high biodiversity' and 'representativeness' are important criteria for the identification of protected areas, communities of low diversity may have important ecological, commercial and conservation value. In addition, concentration on the protection of 'representative' areas of 'high biodiversity' may overly focus on specific areas while overlooking the maintenance of water quality, of 'ecosystem function', and of sustainable human use.

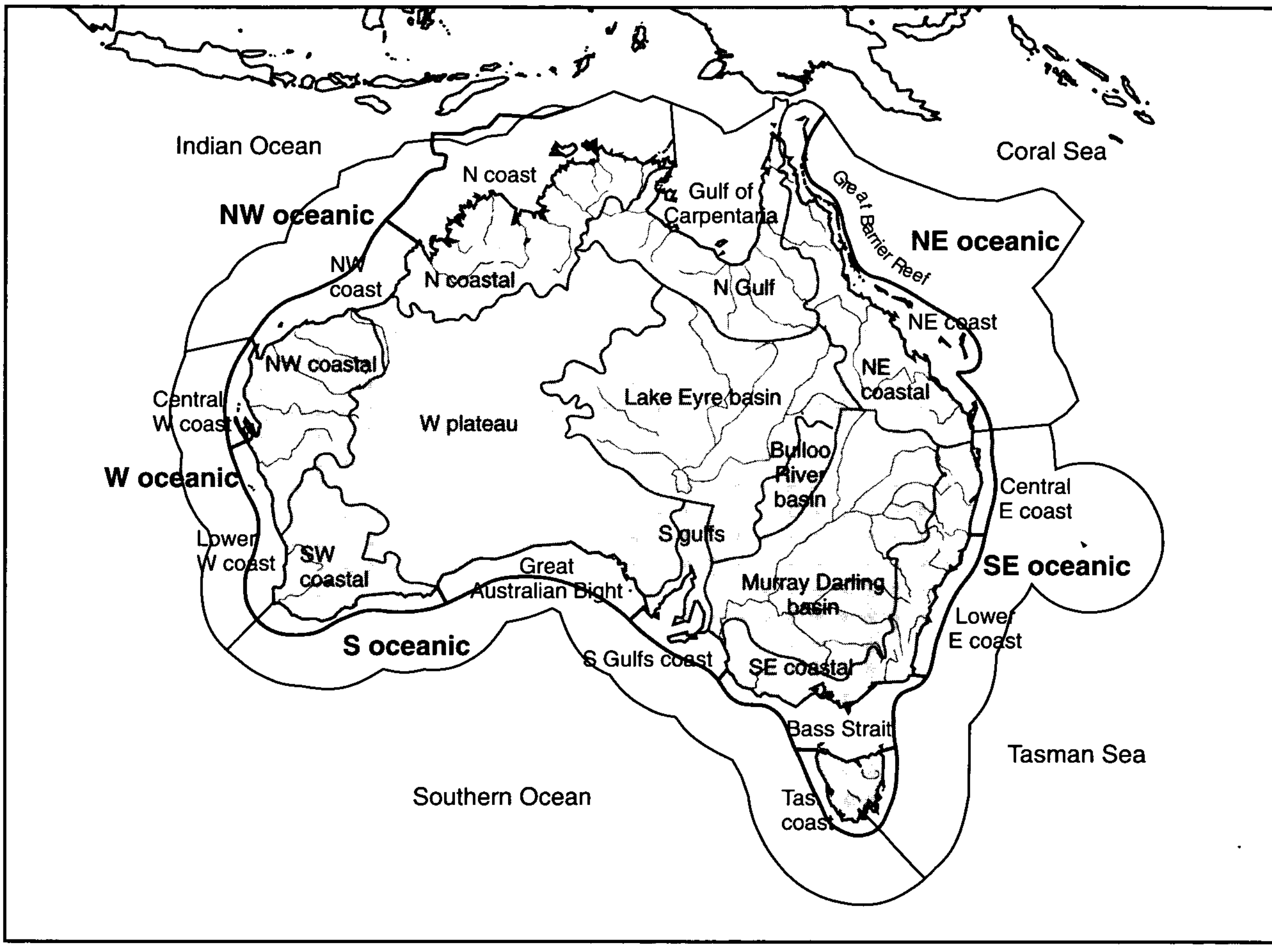


(Source: GBRMPA)

Figure 5.2: Coral reefs have a very high species diversity.

Table 5.1: Some estimates of species diversity from different marine habitats in Australia

Great Barrier Reef lagoon	103 echinoderms 196 molluscs
North West Shelf (WA)	308 decapod crustaceans
Port Phillip Bay (Vic)	713 macrobenthic spp.
Western Port (Vic)	572 macrobenthic spp.
Bass Strait	800 spp.



(Source: AIUCN)

Figure 5.3: Regionalisation within the 200 metre isobath and the 200 nautical mile zone, adopted by the Committee for IUCN (1986).

Summary and conclusions

1. Australia's marine biota is the result of the contributions of two different early Tertiary biotas, the subsequent geological history, and the present climatic conditions.

2. Two distinct marine biogeographic provinces exist. The biota of tropical northern Australia is typically Indo-West Pacific of Pan-Pacific Tethyan origin and has a low level of endemicity (ca 10%). That of temperate southern Australia is temperate Palaeoaustral in origin, and has a very high level of endemicity (80-90%). Overlaps exist in the west and east. Further subdivision on biogeographic grounds is not yet possible.

3. Research is required to develop a sound biogeographic, ecological and geographic framework upon which marine environmental management might be based.

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Acknowledgments:
The technical paper by Dr G.C.B. Poore was reviewed by Dr G. Ross, Australian Biological Resources Study, Canberra, ACT; and Dr D. Brunckhorst, Australian Nature Conservation Agency, Canberra, ACT.

Chapter 6. Estuaries and enclosed waters[1]

Estuaries are unique places where fresh water from rivers enters the sea. Characterised by extremes in salinity, they are harsh environments inhabited by a rather limited number of specialised species. Estuarine sediments and waters are very rich in nutrients from the land, and estuaries are amongst the most productive places on earth. Saltmarshes and mangroves line their shores, and seagrass pastures and algal beds flourish in their shallows. Estuaries have also been the focus of urban and industrial development and are amongst the most polluted places in the ocean.

Australia's estuaries formed over the past 18,000 years as the rising sea invaded lowlands and river valleys and, in the south, glacier valleys. Because of our generally arid climate and highly seasonal rainfall, they are limited in number and development.

All of the State capitals and most of the coastal cities and towns are situated on estuaries. Historically, many Australian estuaries became focal points of human settlement because of their importance as natural ports for ocean and river shipping, proximity to fertile coastal plains and productive fishing grounds, and permanent fresh water. Settlements grew as infrastructure for storage, processing and supply of commodities were established. Industrial development, and urbanisation followed in many areas.

Estuaries where larger urban centres have developed have been severely disturbed by clearing and reclamation of shores and wetlands for ports, roads, and urban and industrial sites; clearing of catchments for agriculture, forestry and mining; disposal of domestic and industrial wastes; commercial and recreational fisheries; power stations; recreation and other uses.

Table 6.1: Number of estuaries and enclosed waters by State/Territory, bioregion* and climate

State/ Territory	No.	Bioregion	No.
Qld	307	Gulf of Carpentaria	136
NSW	81	North East Coast	192
Vic	35	Central East Coast	34
Tas	63	Lower East Coast	66
SA	15	Bass Strait	57
WA	145	Tasmanian Coast	41
NT	137	South Gulfs Coast	9
		Great Australian Bight	6
		South West Coast	13
Climate		Lower West Coast	6
		Central West Cost	2
Tropical	415	North West Coast	42
Subtropical	170	North Coast	179
Temperate	198	Total	783
Total	783		

(* See ACIUCN classification, Fig. 5.3)

Table 6.2: Distribution and areas (sq km) of estuarine habitat types

State/ Territory	Open water*	Intertidal flats	** Mangroves	Seagrasses	Saltmarshes	Total
NSW	1,323	na	107	153	57	1,487
Vic	2,682	444	41	346	125	3,292
Qld	4,093	1,574	3,424	68	5,322	14,413
WA	17,825	2,891	1,561	11	2,965	25,241
SA	760	219	111	na	84	1,173
Tas	1,825	274	na	na	37	2,136
NT	5,187	821	2,952	23	5,005	13,966
Total	33,694	6,223	8,195	601	13,595	61,707

* includes subtidal seagrass beds
** includes intertidal seagrass beds
*** probably much higher

[1]Based on a paper by Professor P. Saenger, Southern Cross University, Lismore, New South Wales.

Characteristics of Australian estuaries

The characteristics of Australian estuaries are relatively well known following a survey of 783 estuaries by Bucher and Saenger (1989 and 1991) with the support of the Australian National Parks and Wildlife Service (now Australian Nature Conservation Agency), and the Sport Fishing Confederation of Australia.

Distribution and size

Australian estuaries occur over a very wide range of geological and climatic conditions and consequently display a great variety in form. Australia's largest estuary is 1,120 square kilometres in area. The smallest is only a few hectares.

Most Australian estuaries are found in the wet tropics, the majority in the Gulf of Carpentaria and North East Coast biogeographic zones of Queensland. The fewest are found in the South Gulf Coast and Great Australian Bight of South Australia (Table 6.1).

Ecology

Estuarine open water and tidal habitats are very diverse, and are primarily dominated by seagrasses, mangroves and saltmarshes. Around 70.5% of Australia's total area of mangroves (11,617 square kilometres) is associated with estuaries. The Northern Territory and Queensland support most of Australia's mangroves and saltmarshes (around 76% and 77%, respectively). Western Australia has the largest area of intertidal flats because of its very high tidal range. Victoria has the most extensive seagrass beds (Table 6.2).

(Source: L. Zann)

Figure 6.1: Tropical estuary dominated by mangrove and saltmarsh communities.

Importance of estuaries

Estuaries are ecologically very productive. Their shores are lined by saltmarshes and mangroves and seagrass pastures and algal beds flourish in their shallows (Chapters 7-9). They are important for fisheries and mariculture. A high proportion of commercially important fish species in Australia are estuarine-dependent for at least some stage of their life cycle. For example, 60% by weight of the New South Wales catch is estuarine.

Estuaries may have particular conservation value because of the presence of rare or endangered species or communities, and for their potential use as scientific study or reference areas, and as educational resources. They also provide essential feeding areas for migratory shorebirds.

Estuaries and embayments are important foci of urban and industrial development in Australia, particularly in the south, where historically they were settled as sea and river ports. All of the State capitals and most of the coastal cities and towns are situated on estuaries.

Today, estuaries are also important recreational areas for amateur fishers, bathers, skiers and windsurfers, and users of small sailing and motor craft.

Status of estuaries and major threats

Catchment clearance

Australian estuaries have been affected to varying extents by human activities. The clearance of catchments is widespread, particularly in South Australia, Victoria, New South Wales and central coastal Queensland. Developments within catchments may affect water quality by increasing erosion and silt loads. More than half the catchment has been cleared in 37% of New South Wales estuaries; 60% of Victoria's; 86% of South Australia's; and 3% of Western Australia's; and 0% of Northern Territory estuaries. Insufficient information is available for Queensland and Tasmania.

Water quality

Information on water quality is available for relatively few Australian estuaries. Bucher and Saenger (1991) rated water quality as either 'fair' or 'poor' in seven Queensland estuaries (149 rated 'excellent'; 151 unknown status); 14 in New South Wales (none 'excellent'; 67 unknown); nine in Victoria (five 'excellent'; 26 unknown); two in Tasmania (16 'excellent'; 45 unknown); six in Western Australia (121 'excellent'; 18 unknown); and none in the Northern Territory (424 'excellent'; three unknown). Insufficient information was available for South Australia.

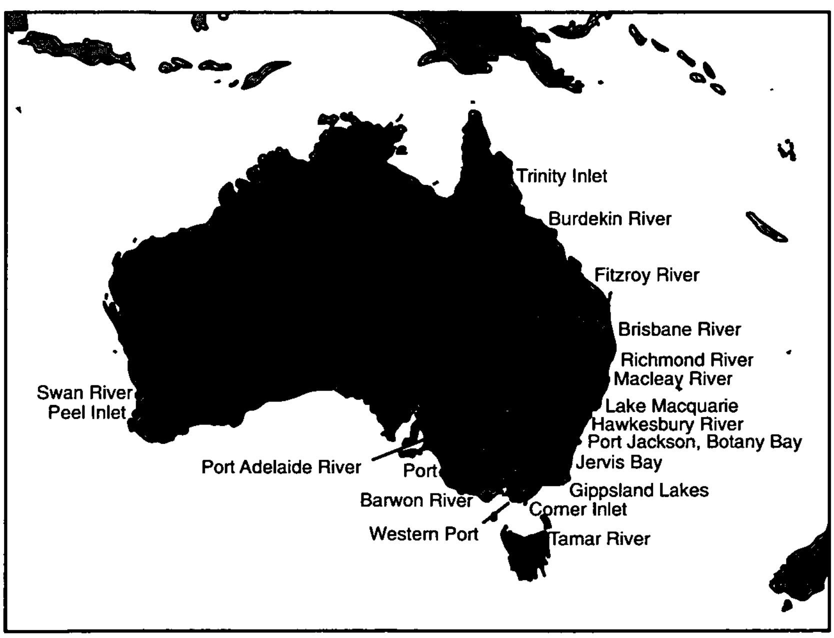
Table 6.3: Overview of Australia's estuaries (% of estuaries with ...)

State/ Territory	Uncleared catchments	Excellent water quality	High fisheries value	High conservation value	Threats to conservation value	Adequate state of knowledge
NSW	24.7	0.0	24.7	16.0	21.0	100.0
Vic	22.9	14.3	14.3	48.6	22.9	31.4
Qld	55.4	48.5	18.9	21.8	2.3	11.1
WA	86.2	83.4	7.6	7.6	2.8	7.6
SA	0.0	0.0	6.7	20.0	6.7	13.3
Tas	27.0	25.4	0.0	6.3	4.8	6.3
NT	99.3	97.1	17.5	22.6	0.7	5.1
Overall	60.8	54.2	15.2	18.6	5.2	19.2

Fisheries

According to Bucher and Saenger (1991) 20 of New South Wales' estuaries have a high fisheries value; 5 of Victoria's; 58 of Queensland's; 11 of Western Australia's; 1 of South Australia's; none of Tasmania's; and 24 of the Northern Territory's estuaries.

Threats to estuarine fisheries have come from pollution; catchment clearance; wetland reclamation; engineering works such as dredging, training walls, marinas, flood mitigation and dams; overfishing; weed infestations; litter and other factors. Bucher and Saenger found 'real' threats existed to fisheries in 21% of New South Wales estuaries; 23% of Victoria's; 3% of South Australia's; 7% of South Australia's; 5% of Tasmania's and 1% of the Northern Territory's estuaries.



(Source: Saenger)

Figure 6.2: Threatened estuaries and enclosed marine waters of high conservation or fisheries value.

Conservation and management

Bucher and Saenger rated 13 of New South Wales estuaries of 'high' conservation value; 17 of Victoria's; 67 of Queensland's; 11 of Western Australia's; 3 of South Australia's; 4 of Tasmania's; and 31 of the Northern Territory's estuaries.

The conservation value was threatened in 21% of New South Wales estuaries; 23% of Victoria's; 2% of Queensland's; 2% of Western Australia's; 6.6% of South Australia's; 3% of Tasmania's; and 1% of the Northern Territory's estuaries.

At present 62% of Australian estuaries are subject to some form of administrative classification which restricts their uses, and 28% have some form of conservation designation such as marine park, national park, game reserve and flora/fauna reserve. The reservations vary in name and intent from State/Territory to State/Territory, and are under the controls of a range of different administrative bodies within each State/Territory because of jurisdictional and administrative fragmentation. In few cases do these classifications apply to a significant proportion of the estuary, and rarely do they cover an entire estuary.

Generally the protection reflects local interests and cannot be construed to constitute a national system of estuarine reserves. The level of surveillance and enforcement is likewise highly variable.

Status of knowledge and monitoring programs

The characteristics and status of Australian estuaries are moderately well known. The database of 783 estuaries compiled by Bucher and Saenger (1989 and 1991) highlighted major information gaps. Water quality data is particularly lacking for most estuaries, and there have been few systematic studies. Although it is descriptive in nature and far from complete, the Australian estuary database (from which this chapter was compiled) is the only systematic attempt to assess the status of any marine ecosystem in this country.

(Source: L. Zann)

Figure 6.3: Estuaries in Australia are the focus for fishing and other activities and have high conservation values.

Summary and conclusions

1. Many estuaries in eastern and southern Australia have suffered from catchment clearance, have a lower water quality and face real threats to their fisheries and conservation values. Those in northern and western Australia have been relatively unaffected by human activities.

2. Nationally, 18.6% of estuaries retain a high conservation value. Representative and important features of these should be considered in a national system of estuarine reserves.

3. Further research is required on individual catchment characteristics, water quality, and assessment of fisheries and conservation values, and baseline studies of biota.

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Chapter 7. Coastal saltmarshes[1]

For most of the period since European settlement, mangroves and saltmarshes have been thought of as wastelands and breeding places for troublesome mosquitos and sandflies, suited only for garbage and waste disposal, or for 'improvement' by draining, reclamation or excavation.

Coastal saltmarshes are an intertidal plant community complex dominated by herbs and low shrubs. They are structurally distinct from mangroves, which are dominated by trees.

Australia has around 13,595 square kilometres of estuarine saltmarshes (Chapter 6). They are found in the estuaries of all States and the Northern Territory, but are most extensive in the tropical north. Where mangroves also occur, they are found at higher elevations. Along arid and semiarid coasts, the coastal marshes merge with the inland saline habitats, and on cliffs and headlands saltmarsh species are found in areas exposed to salt spray.

Characteristics

Composition

Saltmarsh plant communities are typically low in species diversity and are frequently dominated by a single species. Species richness increases with latitude. A northern Australian saltmarsh, although extensive in area, generally has fewer than 10 species, whereas a smaller Victorian or Tasmanian one may have more than 30 species.

Saltmarshes characteristically show a clear zonation from low to high elevations, across the shore. For example, in New South Wales the order is *Sarcocornia quinqueflora - Sporobolus virginicus - Juncus kraussii*. Brackish areas in upper estuaries or on the shores of some coastal lagoons support floristically different communities, and saltmarshes may grade upwards into scrubland or forest, characteristically dominated by *Casuarina, Melaleuca* or *Eucalyptus* species.

Biogeography

Two biogeographically distinct saltmarsh types exist in southern Australia. Arid or seasonally arid (Mediterranean climate) marshes are characterised by a diversity of succulent, shrubby members of the family Chenopodiaceae, with more open vegetation towards the upper tidal limit. On temperate coasts with a higher rainfall, vegetation is denser and more grassland and sedgeland communities are present. On the east coast there is a gradual transition from these to the more species-poor subtropical marshes which are often dominated by *Sporobolus virginicus*.

Although there is a high degree of endemism in the Australian saltmarsh flora, at the generic level there is a strong similarity with those elsewhere in the southern hemisphere, and linkages with floras in the northern hemisphere. The saltmarsh flora are not as unique as the various terrestrial communities of the Australian continent.

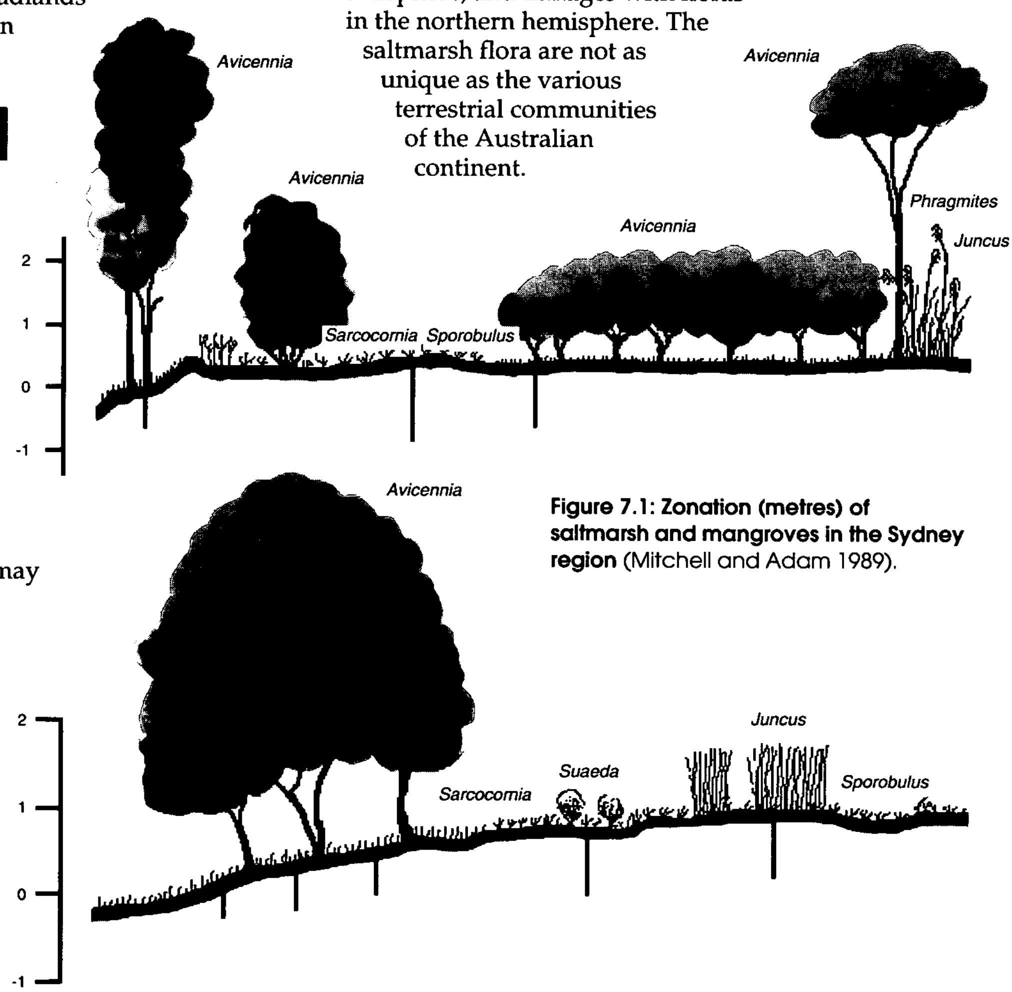

Figure 7.1: Zonation (metres) of saltmarsh and mangroves in the Sydney region (Mitchell and Adam 1989).

[1]Based on a paper by Associate Professor P. Adam, University of New South Wales, Sydney, New South Wales.

(Source: P Adam)

Figure 7.2: Saltmarsh at Wallis Lake (NSW). Extensive *Sarcocornia quinqueflora* and scattered mangroves *Avicennia marina*, tussocky *Juncus kraussii* and *Sporobulus virginicus* (left).

Importance of saltmarshes

Saltmarshes are commonly regarded as highly productive, key habitats. For example, *Spartina* saltmarshes on the east coast of the United States are amongst the most productive natural communities on earth. Although few studies have been undertaken, the standing crop and productivity of Australian saltmarshes appear to be on the lower end of the ranges found in the northern hemisphere.

Saltmarshes support numerous organisms, of both terrestrial and marine origin, including birds. They provide roosting sites for many migratory wading birds, breeding sites for species such as the white-fronted chat, and habitat for certain endangered species. A large part of the population of the rare orange-bellied parrot overwinters on Victorian saltmarshes, feeding on seeds of chenopods.

Major threats to saltmarshes

Reclamation

In urban and tourist areas saltmarshes have been reclaimed for port, industrial and housing development; parks and sports fields; and marinas, resorts and canal estates. In rural areas they are used for solar salt production ponds, aquaculture ponds, and agriculture.

Compared with the total area of Australia's saltmarsh, the net losses have not been great. However, losses have been concentrated in the south-east, where the initial area was small, and where species diversity is highest, the losses are likely to be significant both nationally and regionally in terms of biodiversity, and significant regionally in terms of loss of habitat.

Degradation

A much larger area of saltmarsh has been lost by habitat degradation. Around settled areas they have been altered by rubbish dumps, drains, powerlines and other services. Vehicular use by 4-wheel drives and trail bikes alters the microtopography and drainage, leading to vegetation changes. Stormwater drains frequently discharge into marshes, introducing gross pollutants, nutrients and weed seeds, causing erosion and altering salinity. As depositional sinks, saltmarshes may accumulate pollutants. In rural areas many saltmarshes are heavily grazed by cattle.

Weed invasion

A number of significant invasive weeds threaten the natural biodiversity and community structure of our saltmarshes. In Tasmania and Victoria the cord grass *(Spartina anglica)*, introduced early this century, has

(Source: P. Adam)

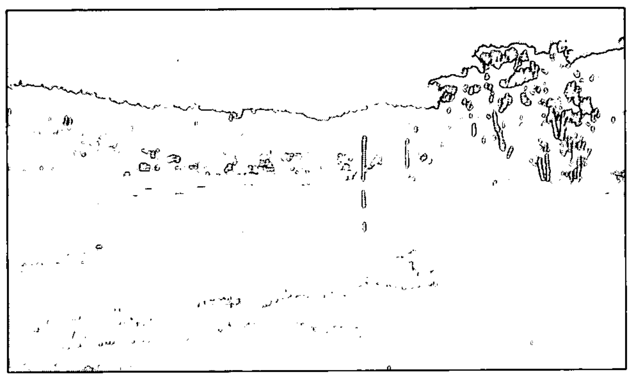

Figure 7.3: Introduced cord grass, *Spartina anglica*, dominating a saltmarsh on the Tamar estuary (Tas).

grown vigorously in the low marsh, advancing seaward of the grey mangrove *Avicennia marina* in areas. In the south, pampas grass *(Cotaderia selloana)* has invaded some saltmarshes and the introduced rush *(Juncus actus)* has displaced the native rush *(J. krausii)* in areas. The groundsel bush *(Baccharis halimifolia)*, a native of the United States, has become a major weed in coastal southern Queensland and northern New South Wales and is spreading southwards.

Insect control

Saltmarshes harbour large numbers of mosquitos and sandflies which are nuisances for adjacent residents and tourists and a potential health risk by spreading diseases. Control of these through use of insecticides and/or drainage of wetlands probably affects the ecology of saltmarshes.

Sea level rise

Intertidal wetlands, adapted to the present sea level and tidal regime, would be affected by sea level rises which may result from global warming. As the level rises, the seaward boundary of the wetlands would regress, and the landward boundary would extend inland where the topography and land use permitted. Changes in rainfall would also affect the composition of vegetation.

Conservation and management

A number of significant saltmarshes are included within coastal national parks. Several have been placed on the list of 'Internationally Significant Wetlands' under the Ramsar convention. The Towra Point Nature Reserve was purchased by the Commonwealth to meet obligations under the Japan-Australia Migratory Birds Agreement.

The majority of saltmarshes lack formal protection. However an increasing concern regarding loss of wetlands over the past decade has resulted in planning authorities taking an increasingly sympathetic view towards protection at the local council level, and States are developing guidelines and more formal policies. For example, since 1985 New South Wales' State Environmental Planning Policy 14 (Coastal Wetlands)' makes any proposals which would have impacts on wetlands a 'designated development' which requires production of an Environmental Impact Statement.

Status of knowledge and monitoring programs

There are relatively few detailed studies of saltmarshes in Australia, and very few quantitative studies of their productivity. The most complete species list at the national scale is that of Saenger et al. (1977), but criteria for inclusion of upper saltmarsh species were inconsistently applied. Detailed lists have been developed for particular areas of the coast such as southern Australia, New South Wales and Tasmania. Saltmarshes are associated with estuaries identified in the Australian estuarine database by Bucher and Saenger (1991) (Chapter 6).

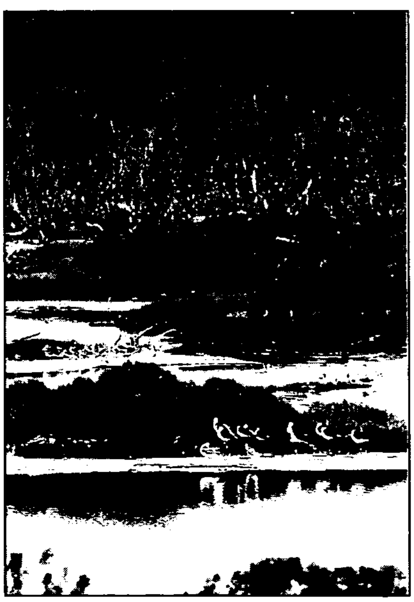

Figure 7.4: St Kilda saltmarsh community near Adelaide. This sanctuary lies within ICI's saltworks and is managed by that company.

(Source: G. Abraham)

Summary and conclusions

1. Although Australia has large areas of undisturbed saltmarshes, important areas in the densely populated south-east have been seriously degraded or lost.

2. In order to slow saltmarsh degradation it will be important to implement catchment management regimes which address the inputs of stormwater, nutrients and pollutants into estuaries.

3. Research is required on the fauna and flora of saltmarshes; on ecosystem productivity, energy and nutrient flows; on the effects of insect controls, pollutants and on control of invasive weeds; and on rehabilitation of damaged marshes.

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Acknowledgments:
The technical paper by Associate Professor P. Adam was reviewed by Dr A. Robertson, Australian Institute of Marine Science, Townsville, Qld.

Chapter 8. Mangrove systems[1]

Mangrove forests are composed of unique trees and shrubs which have adapted to the extreme saline conditions between the tides. They are of major ecological and economic importance in tropical and subtropical areas. Mangroves provide habitats and nurseries for fish, including many of commercial and recreational importance. They buffer estuaries from sediments and coastlines from storm waves, are natural nutrient filters, and are critical habitats for many birds and other wildlife.

Australia's mangroves are of world significance. They are among the richest in species diversity, and rank third largest in area. Mangrove forests are also vulnerable worldwide: around 1% of the world's mangrove habitat is cleared or reclaimed each year.

Table 8.1: Area (sq km) of mangrove forests in Australian states and their islands

Queensland	4,602
tropics	*4,117*
subtropics	*485*
New South Wales	99
Victoria	12
South Australia	211
Western Australia	2,517
tropics	*2,507*
subtropics	*10*
Northern Territory	4,119
Tasmania	0
Total	11,558

(after Galloway 1982)

Characteristics of mangroves

Mangroves are a diverse group of largely tropical trees, shrubs, palms and ferns which have adapted for life between the tides on sheltered shores, estuaries and tidal creeks.

(Source: GBRMPA)

Figure 8.1: Mangroves are highly productive communities, are important nurseries for fish, and protect the coastline during storms. These mangroves are off eastern Cape York (Qld).

Specialisations include exposed breathing roots, support roots and buttresses, salt-excreting leaves, and viviparous, water-dispersed propagules. Some 69 species from 20 diverse families occur in the world's tropics and subtropics, with the greatest diversity in the Indonesian-Malay archipelago.

(Source: Robertson and Alongi 1992)

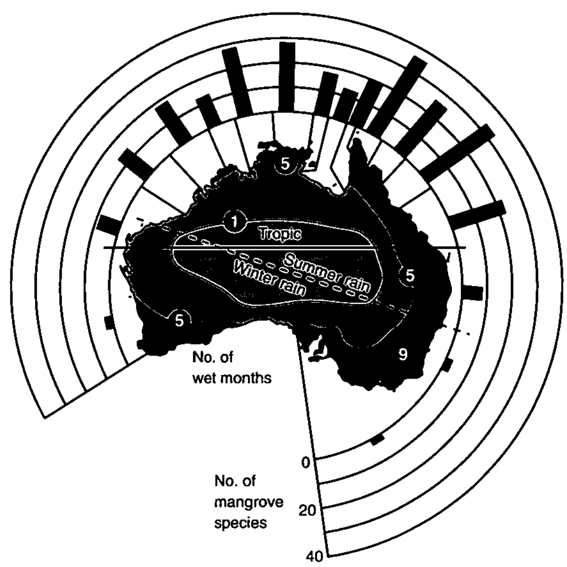


Figure 8.2: Mangrove plant richness around Australia. There are far more species in the wet tropics. The aridity (shown here as number of wet months) affects species richness in north Western Australia.

Australia's mangroves

Australia has 39 mangrove species, of which only one species, the newly discovered *Avicennia integra*, appears endemic. They are most diverse in the wet tropics, with 35 species in some estuaries on Cape York. They are less diverse in the arid tropics, subtropics and temperate shores. Only one species, *A. marina*, occurs along the southern coastline.

[1]Based on a paper by Dr A. I. Robertson and Dr D. M. Alongi, the Australian Institute of Marine Science, Townsville, Queensland.

The composition of mangrove communities varies with temperature, rainfall, river run-off, sediment type, tidal amplitude and geomorphology of the coast. In wet north-eastern Queensland there is a very high species diversity, the forests are very tall, to 30 metres, with closed canopies, and they are highly productive.

In the arid north-west, where water and salinity stress is great, there is a lower species diversity, e.g. seven species in the Pilbara coast. Here they form open canopy woodlands, or low scrub (1-5 metres high) of low diversity and low productivity. Communities are dominated by *A. marina* along the waters edge, giving way to zones of *Rhizophora stylosa* and *Ceriops australis*.

Below latitude 30°S, open woodlands of a single species, *A. marina*, dominate mangrove habitats. Trees become stunted (<5 metres) in colder waters around 38°S, e.g. at Corner Inlet, Victoria.

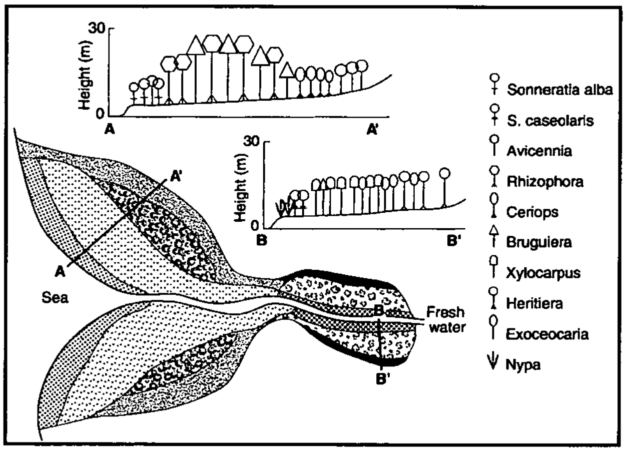


Figure 8.3: Idealised distribution of mangrove types from upstream (low salinity) to downstream (sea) in a high rainfall Queensland estuary.

Ecosystem structure and function

Hydrodynamic studies in northern Australia indicate water flow is important in mangrove ecosystems. Strong tidal flows and good exchange occur in downstream creeks, and ebb tides scour deep tidal channels. Dispersion is weak in upstream creeks and in forests, and materials may be trapped for several weeks, during which oxygen concentrations may become very low. Mangrove materials washed into the sea are often entrained in the nearshore coastal boundary layer.

Recent studies of associated flora and fauna have found that bacterial standing stocks in mangrove sediments are very high (e.g. 3.6×10^{11} cells/g) and are very productive. The meiobenthos (small bottom-living lifeforms) is dominated by low densities of nematode worms and harpacticoid copepods. The macrobenthos (larger bottom-dwelling animals) are dominated by crabs and molluscs. In the tropics a major role is played in the food chain by species of the grapsid crab *Sesarma*, which consume or bury up to 80% of the annual litter fall from mangroves, retaining litter nutrients in the system. Wood-boring molluscs are likewise important in breaking down tree trunks. Zooplankton, especially copepods and the larvae of crabs, are particularly abundant in mangrove waterways.

Mangroves provide important habitats for baitfish such as families Ambassidae, Clupeidae, Engraulidae, Gobiidae and Leignathidae, and predators such as Sparidae, Pomadasyidae, Lutjanidae, Carangidae, Charcharinidae. Around 197 fish species have been recorded from northern Australian mangroves, 65 from Brisbane mangroves, and 46 from Sydney mangroves.

In tropical estuaries, mangrove leaf detritus is the major source of energy, and microbial breakdown is the first step in the food chain leading to higher consumers. A carbon budget calculated for a *Rhizophora* community in north Queensland found around 30% of the leaf litter fall was consumed by sesarmid crabs and the remainder was exported by tidal action to creeks. The annual turnover of wood by teredo borers was equally important in forest food chains. Bacterial biomass and turnover in the sediment was very high. Phytoplankton production was low, and zooplankton, particularly crab larvae and copepods, were a major food source of juvenile fish.

Importance of mangroves

Fisheries

Some of Australia's most important single-species commercial fisheries are directly or indirectly linked to mangroves. The early life cycle of the banana prawn, *Penaeus merguiensis*, is confined to mangrove-lined estuaries. In the Gulf of Carpentaria, greatest catches of banana prawns are made in areas with highest concentrations of mangroves. Bait prawns *(Metapenaeus* spp*)*, mud crabs *(Scylla serrata)* and barramundi *(Lates calcarifer)* are directly dependent on mangroves. Juvenile tiger prawns *(Penaeus esculentus)* come from seagrass meadows adjacent to mangroves. Baitfish such as the Clupidae and Engraulidae which spend their juvenile stages in mangroves, mature and move out to sea where they become important food for mackerel and billfish.

Many fish targeted by Australian recreational fishermen live in tropical and subtropical mangroves, including bream *(Acanthopagus australia, A. berda)*; grunter *(Pomadasys kakaan)*; mangrove jack *(Lutjanus argentimaculatus)*; and barramundi.

Habitats for birds

Other fauna of high conservation value are dependent on Australia's mangroves. This is particularly so in the arid and semiarid tropics where mangroves form the only closed-canopy forest available for birds. A recent study found that 22 species in northern Western Australia were confined to mangroves for at least part of their range.

Coastal protection

Mangroves line around one third of the Queensland and Northern Territory coastlines, protecting the soft sediments and low-lying farmlands and towns from destructive cyclone-driven waves and storm surges. From overseas experience, clearing of mangroves has seriously increased coastal inundation and erosion by destructive seas. Mangroves also trap and stabilise sediments derived from river catchments with their dense tangles of prop roots, protecting adjacent marine habitats from sedimentation.

Nutrient filtering

Because of their position in estuaries between river systems and receiving marine waters, mangrove forests are likely to filter nutrients and other human-derived contaminants from catchments. In experimental conditions, mangroves, naturally limited by nitrogen and phosphorus, took up substantial quantities of added nutrients. Mangroves may be particularly important in north Queensland by removing agricultural nutrients entering into waters of the Great Barrier Reef.

Status of mangroves and major threats

Clearing and reclamation

Localised clearing and reclamation of mangroves in Australia has occurred near coastal cities such as Sydney, Newcastle, Brisbane and Cairns, but some regrowth has occurred in some of these areas. Many temperate estuaries have been extensively modified by breakwaters, channel dredging, flood mitigation and other engineering works, adversely affecting mangrove communities.

Significant areas of mangroves in south-east Queensland, near Gladstone, near Cairns and in Darwin Harbour are under direct threat from a variety of development projects. Concern has been expressed by commercial fisherers and conservation groups on the effects of reclamations, marinas and canal estates on mangroves and fisheries, particularly in Moreton Bay and on the Queensland coast.

(Source: N. Coleman)

Figure 8.4: Significant areas of mangroves have been cleared or killed around metropolitan areas of Australia. About 20% of the mangroves in Moreton Bay near Brisbane have been cleared.

However, by comparison with other countries, the losses of mangroves in Australia have been negligible. Clearing and reclamation of mangroves is occurring at around 1% per annum in the Philippines, Thailand, Malaysia and Ecuador. If this trend continues, Australia will have the Indo-Pacific region's - and possibly the world's - least disturbed mangrove forests.

Pollution

Oil spills have been responsible for mortality of mangroves adjacent to some ports, such as Botany Bay and Adelaide, but areas affected are relatively small in area.

High nutrient levels from domestic sewage and urban run-off are a problem in localised areas of mangrove-dominated estuaries in many parts of the country, particularly near Adelaide and Cairns.

Conservation and management

Around 8% of Australia's mangrove forest have some level of protection. Almost two-thirds of this area is in Queensland which has the most extensive reserve system. Relative to other nations, Australia has a good record in mangrove conservation, mainly through protection afforded by their remoteness and a lack of population and development pressures.

Significant areas lacking adequate protection include mangrove wetlands abutting the Great Barrier Reef and the Wet Tropics Rainforest World Heritage Areas, and the arid zone communities of the Pilbara region which are some of the best representative areas of undisturbed arid zone mangroves in the world.

The main problems facing future conservation and management of mangroves include the lack of coordination and overlapping responsibilities of State/Territory and Commonwealth government departments and agencies; alteration of the hydrology of catchments; and lack of knowledge on most mangrove systems in Australia.

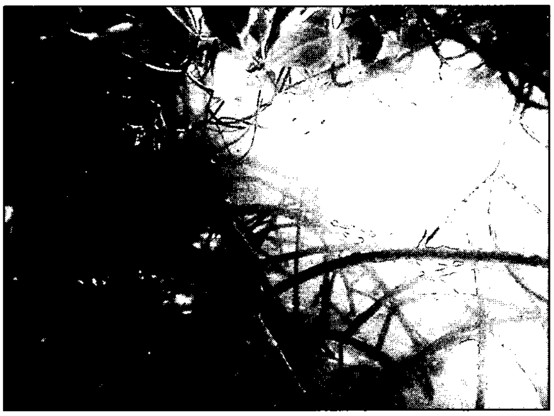
Status of knowledge and monitoring

The distribution of Australian mangroves is relatively well known. Early studies were concerned largely with southern *Avicennia* communities but important advances have been made in the understanding of northern Australian mangroves through research at

Table 8.2: Australian mangrove forests in conservation reserves of various types

	No. sites reserved	Area (km)	% total mangrove
Queensland	54	600	13
New South Wales	8	5	5
Victoria	2	3	23
South Australia	7	113	56
Western Australia *	-	-	0
Northern Territory	2	282	7
TOTAL	73	1,003	

(* note zero loss protection in WA)
(from Arthington and Hegerl 1988 and McComb and Lake 1988)



(Source: W. Gladstone, GBRMPA)

Figure 8.5: Tangled prop roots of *Rhizophora* at high tide.

the Australian Institute of Marine Science in Townsville.

Areas of mangroves in each State (and the Northern Territory) have been estimated by Galloway (1982). Areas have also been accurately mapped and placed on coastal land use maps and inventories, e.g. Victoria Land Conservation Council's Marine and Coastal Descriptive Report (1993), and on computerised geographic information systems, e.g. Queensland Department of Environment and Heritage.

Summary and conclusions

1. Australia has the third largest area of mangroves in the world. The northern communities are amongst the most diverse in the world. They are economically valuable habitats and nurseries for many fisheries, provide protection from storm waves and are sediment traps.

2. Localised disturbance historically occurred around coastal cities and towns, but has been reduced in recent decades. Degradation is negligible compared with other countries.

3. Only 8% by area of Australia's mangroves has some level of protection. Globally important areas in north Queensland and northern Western Australia are not protected.

4. The most serious problems in their conservation and management are local clearing and development; overlapping jurisdictions; changes in catchments; and inadequate scientific knowledge. Only north Queensland mangroves are adequately studied.

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Acknowledgments:
The technical paper by Dr A.I. Robertson and Dr D. M. Alongi was reviewed by Dr P. Adam, University of NSW, NSW; and Professor A.J. McComb, Murdoch University, Perth, WA.

Chapter 9. Seagrasses[1]

Australia has the largest number of seagrass species, and some of the largest and most diverse seagrass beds in the world. Seagrasses are ecologically critical for the long-term sustainability of Australia's coastal zone because of their high productivity and their ability to trap sediments. They are also essential for many recreational and commercial fisheries, and are critical habitats for a wide range of species, including endangered turtles and dugongs.

Australia's unique and important seagrasses are under serious threat, particularly in many temperate and subtropical bays and estuaries. Large die-backs have occurred in recent decades, probably because of increased sedimentation and nutrient enrichment. Recovery, even when conditions return to normal, has either not occurred or been extremely slow. The loss of temperate and subtropical seagrass is undoubtedly one of the most serious issues in the conservation of Australia's marine environment today.

The seagrasses are true grasses (rhizomateous angiosperms) adapted to life in shallow, sheltered coastal environments. They are ecologically very important because of their high primary production and associated detrital food chains, their ability to trap sediments and organic nutrients and to supply and fix biogenic calcium carbonate. They also act as substrata for attached plants and animals, as nurseries for many species, and as habitats for mobile species.

This chapter describes the commercial and conservation value of Australian seagrass communities, and their distribution, status and management.

Commercial and conservation value of seagrasses

Seagrass communities are important habitats for many commercially important species of fish and crustaceans, providing shelter from predators and strong currents, and playing a vital role in the food cycle of coastal ecosystems. They are the major nursery grounds for juvenile tiger, and endeavour prawns, the catch of which was worth around $80 million in exports earnings in 1993. They are also critical in the life cycle of western and tropical rock lobsters, worth $217 million and $4.5 million respectively, in 1993.

A wide range of commercial fish also depend directly or indirectly on seagrass. For example, Botany Bay *Zostera* and *Posidonia* beds support a large diversity of juvenile fish species, at least five commercially important species are associated with *Zostera* alone. Seagrass is the principal food of the dugong, the only herbivorous mammal which is strictly marine. The dugong is listed as vulnerable to extinction by the International Union of the Conservation of Nature. Seagrass is also a major food for the endangered green turtle (Chapter 18).

(Source: J.L. Young)

Figure 9.1: Australia has the largest area and highest diversity of temperate seagrass in the world. Seagrass communities are highly productive, are important nurseries for fish, and protect shores during storms. This diver is surveying beds in South Australia where large areas have suffered die-back.

Distribution and status of seagrasses

Based on species composition and distribution, Australia's seagrasses can be broadly divided into tropical and temperate communities. A transition zone occurs around 30°S on the east coast, and 25°S on the west coast. There are five major seagrass bioregions around Australia.

[1]Based on a paper by Dr I. Poiner and C. Peterken, CSIRO Division of Fisheries, Cleveland, Queensland.

Seagrasses of south-eastern Australia

(from the Tweed River in NSW, to Corner Inlet in Vic)

Seven species of seagrass are found in the warm temperate south-east. *Zostera* is the most common genus and occurs across a range of habitats. *Z. capricorni* occurs from the Tweed River south to Mallacoota where it is replaced by *Z. mulleri*. *Heterozostera tasmanica* occurs south of Port Stephens. Three species of *Halophila* are also present in a wide range of habitats but appear to be seasonal in growth and occur in small patches. *Posidonia australis*, present south of Wallis Lake, occupies fewer habitats than the others.

Because of the high energy of this coast, seagrass communities are confined to estuaries, coastal lagoons and embayments. They are most common in estuaries, where communities differ with the estuary type and age, and the catchment area and its stability. Seagrass beds are generally most developed seawards from the river mouth, although *Zostera* grows further upstream. Seagrass communities in the coastal lagoons are more variable in time, depending on the frequency with which the lagoon entrance is breached by the sea.

In 1985 there was a total of about 155 square kilometres of seagrass along the New South Wales coast. The largest beds were Lake Wallis (30.8 sq km); Clarence River (19.1 sq km) and Lake Macquarie (13.4 sq km). Little information is available from eastern

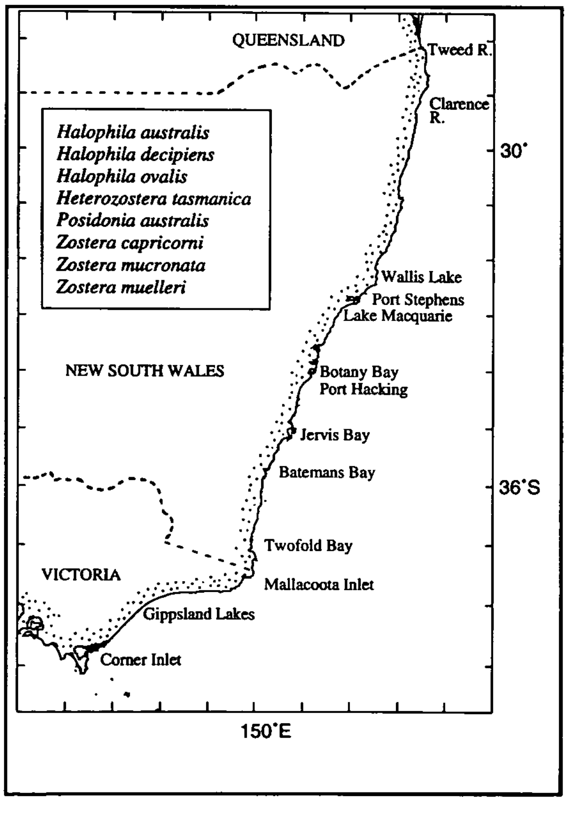


Figure 9.2: Seagrasses of south-east Australia.

Victoria but large beds are known to exist in Mallacoota Inlet, Gippsland Lakes and Corner Inlet. In 1965 it was estimated that Corner Inlet had 119 square kilometres of *Posidonia*.

Declines in south-eastern seagrasses

Major declines have been reported in many seagrass beds in the south-east. Seagrass in Lake Macquarie declined by 44% between 1953 and 1985, possibly because of increased turbidity. *Posidonia* beds in Botany Bay declined by 58% between 1942 and 1986. This has been attributed to increased wave action and erosion because of dredging, major storms in 1974 and 1975, eutrophication due to sewage discharges, and grazing by sea urchins. It has been estimated that there has been a general loss of 50% of *Zostera capricorni* in New South Wales river estuaries. Losses of 60% of the seagrass in the Tweed and Clarence estuaries have been attributed to increased turbidity associated with a general decline in water quality (Chapter 42). There have been reports of major losses of seagrasses in eastern Victoria but these have not been quantified.

Seagrasses of southern Australia

(from the Head of the Great Australian Bight east to Bass Strait)

Southern Australia has extensive areas of seagrass. These are characterised by warm temperate species of *Posidonia* and *Amphibolis*, which decline in number from west to east; temperate *Halophila australis*, which is widely distributed; and intermediate species of *Heterozostera* and *Zostera*.

Distribution of species is a function of coastal topography and environment. Seagrass beds are largely confined to more protected areas but some are found in exposed coasts protected by offshore reefs.

The major beds, dominated by *Posidonia*, are found in Spencer Gulf (3,700 sq km) and Gulf St Vincent (1,530 sq km). In South Australia seagrasses are also found in the small, scattered coastal lagoons (e.g. West Lakes, The Coorong), and at considerable depths of between 25-30 m in the exceptionally clear waters of the Great Australian Bight, and off Eyre Peninsula where they are unaffected by swells.

In Bass Strait seagrasses are patchy and largely restricted to sheltered areas behind reefs and islands. Distributions and cover of seagrasses in Victoria and Tasmania are not well documented. Tasmania has extensive areas of *Heterozostera* and *Halophila australis* in more sheltered waters, and large *Posidonia* meadows along the north coast and around Flinders Island.

Declines in southern seagrasses

Seagrass beds have declined in many areas in southern Australia. Overall losses of seagrass in Gulf St Vincent are estimated to be around 5,000 hectares

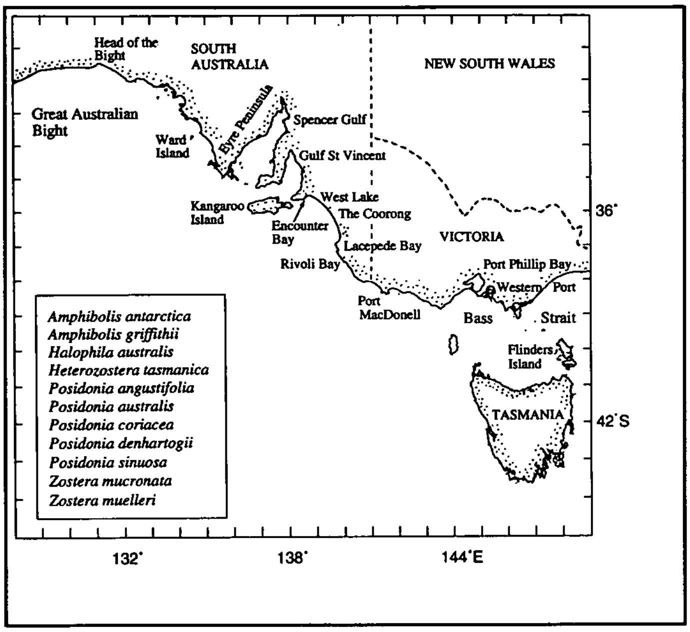


Figure 9.3: Seagrasses of southern Australia.

Over 900 hectares was lost in the construction of Outer Harbour in 1949. Seagrass die-back began immediately sewage discharge started at the Bolivar outfall in 1967. Around the Port Adelaide outfall, 50% of the *Posidonia* was lost between 1978 and 1981.

Major losses have also occurred in Port Phillip Bay and Western Port in Victoria. Most of Western Port, which has an area of 680 square kilometres, supported extensive beds when it was first explored in 1899. By the early 1970s, 250 square kilometres, about 37% of the area, supported seagrass and macroalgae. By 1984 the area was only 72 square kilometres. The biomass of the surviving beds had declined by 50%, giving an 85% decline in the bay's standing crop. The decline is attributed to an increase in fine silt entering the bay from river run-off which adheres to leaves and blocks off the light. Initial losses of seagrass from mud banks has further increased siltation.

Seagrasses of Western Australia

(Western Australia, from 12^{o}S to 35^{o}S)

The western coastline has the highest diversity of seagrasses in the world, 10 genera with 25 species. The distribution and abundance of seagrasses are also very wide, reflecting the abundance of suitable habitat. The north includes a number of tropical species, while the south is dominated by two complexes of *Posidonia*: *'ostenfordi'* in more exposed areas; and *'australis'* in more sheltered places. Eight species of *Posidonia* are found off the south-west.

Seagrasses are well developed in limestone reef lagoons near Perth, in Cockburn Sound, and the Swan-Canning basin. Progressing northwards, at Dongara, there is a natural, seasonal fluctuation in the areas of beds of up to 80%, and at sheltered Cliff Head there is a 50 square kilometres meadow of dense *Posidonia*. This is an important nursery for the western rock lobster.

Shark Bay, 13,000 square kilometres in area, has some of the largest and most diverse seagrass meadows in the world, and is the site of an overlap of temperate and tropical species. The high diversity here is thought to be the result of moderate disturbance and occasional cyclones. The Bay has restricted ocean exchange and high evaporation, and the eastern parts have become hypersaline because of the build-up of barrier banks caused by the great mass of seagrass. The hypersaline conditions favour the growth of the Bay's well known stromatolites. The most abundant seagrass in Shark Bay is *Amphibolis antarctica*, here at the northern limit of its range, which covers an area of 3,676 square kilometres, or 85% of the total seagrass beds. *Halodule uninervis* is the next most abundant plant and an important food for the Bay's dugongs.

Little is known of the extent of seagrasses north of Shark Bay. The major habitats for seagrasses are atoll coral reefs, offshore islands and sand cays, inshore islands and banks, and extensive intertidal flats.

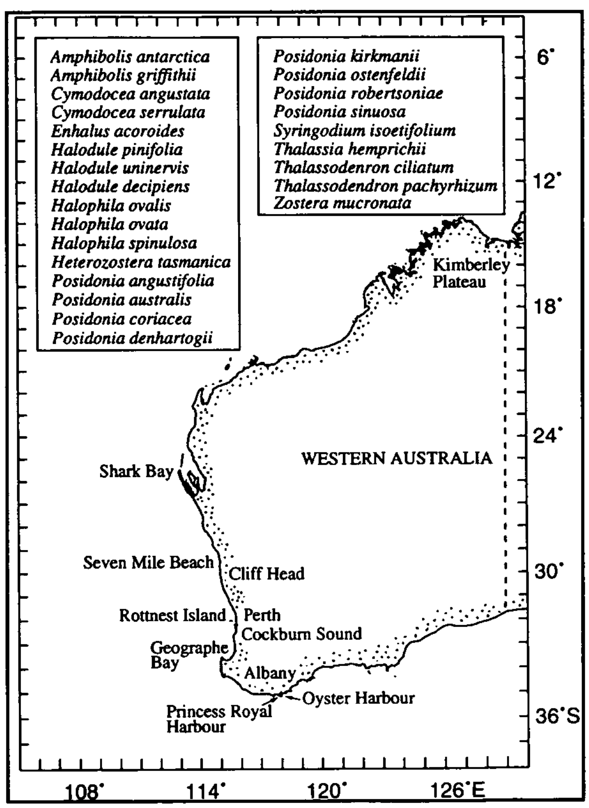


Figure 9.4: Seagrasses of Western Australia.

Declines in western seagrasses

Significant losses of seagrasses have occurred in south-western areas. In Cockburn Sound there was a loss of 97% of the seagrass (3,300 ha of the original 3,400 ha) between the 1950s and 1978. This was attributed to elevated nutrients giving rise to an explosion of epiphytes (attached algae) which caused an overall reduction by 63% to the light reaching the seagrass. Waste water controls have helped to arrest the decline and there is evidence of slow regrowth. A 66% loss in seagrass has occurred in Princess Royal Harbour, and a 46% loss in Oyster Harbour.

Seagrasses of tropical northern Australia

(from Cape Leveque in the west, to Torres Strait in the east)

The tropical north, encompassing the north-western coasts of Western Australia and the Northern Territory, the Gulf of Carpentaria, and Torres Strait, has 12 species of seagrass from seven genera. This is the highest species diversity in the Indo-Pacific. Tropical seagrass species tend to occur in mixed stands.

The north-western region is the least known. Eleven species are reported from tropical Western Australia but the 1,500 kilometres of coastline, and the 5,000 kilometres of the Northern Territory's coast west of the Gulf of Carpentaria have not been surveyed for seagrass. Aerial photographs indicate that beds are present along much of the Kimberley coast but more detailed studies are required for mapping.

The Gulf of Carpentaria, a shallow embayment with a variety of offshore and coastal features, has 906 square kilometres of seagrass habitat, along 671 kilometres of coastline. Around 74% of seagrass is found along open coastline, 10% on reef flats, and 13% is associated with river mouths.

Torres Strait, a shallow area strewn with islands and coral reefs, has 13 species and 17,500 square

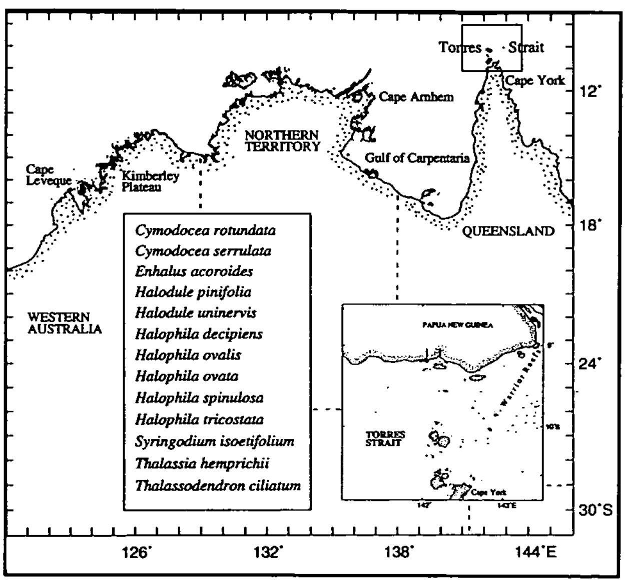


Figure 9.5: Seagrasses of northern Australia.

kilometres of seagrass habitat. Its diverse seagrass communities include mixed species reef-flat communities, mixed species open ocean communities, and subtidal *Halophila* communities. The open ocean communities in the central and western areas are unique and extensive in area.

Declines in northern seagrasses

The status of these seagrasses is not well known because of sparse human populations and coastal developments. It is known that cyclones can cause extensive, long-term seagrass losses. In the Gulf of Carpentaria in 1985, cyclone Sandy removed, undermined or smothered 151 square kilometres of a 183 square kilometres area of seagrass, representing around 20% of the entire Gulf's seagrass area. Recovery has been slow.

In 1991-92 several hundred square kilometres of seagrass disappeared from Torres Strait, possibly because of high turbidities resulting from flooding of the Mai River in Papua New Guinea.

Seagrasses of north-eastern Australia

(eastern coast of Queensland)

The north-east of Australia has a total of 14 species from nine genera. Much of the coastline is sheltered and represents potential seagrass habitat. The total area of seagrass is estimated to be 4,300 square kilometres. Major areas include Moreton Bay (267 sq km), Hervey Bay (1,026 sq km) and the area between Barrow Point and Lookout Point (1,566 sq km). *Halodule uninervis* is probably the most widespread species, and *Halophila ovalis* and *H. spinulosa* are also widespread. *Zostera capricorni* is only found south of 16°S.

Declines in north-eastern seagrasses

During the early 1970s some species in Moreton Bay experienced a decline, or disappeared completely. At Toorbul Point, a stand of *Syringodium isoetifolium* disappeared completely, and *Zostera capricornia* declined. At Jumpinpin in the south a bed of *Cymodocea serrulata* was lost in 1972-73 and has never recovered.

Around 900 square kilometres of seagrass was lost in Hervey Bay in 1992-93, possibly because of high turbidities resulting from flooding of the Mary and Burrum Rivers, and run-off and turbulence from cyclone Fran three weeks later.

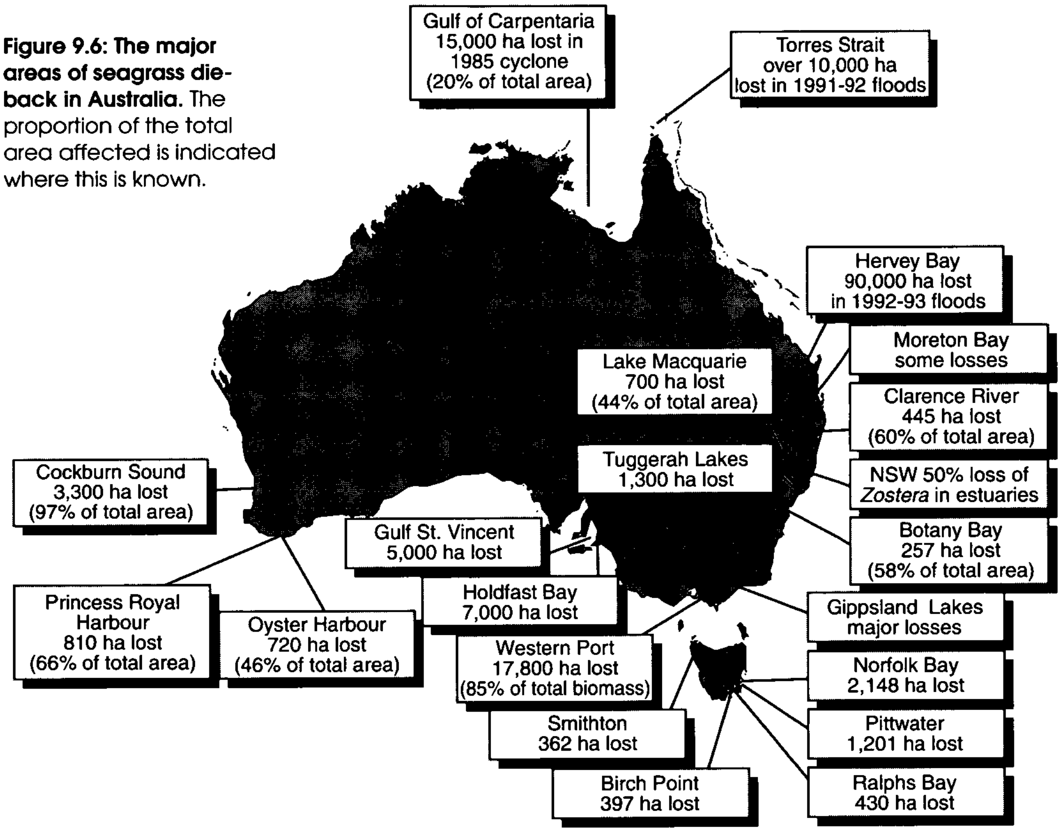
Issues in the management of seagrasses

Extent of declines in seagrass cover

Seagrass, one of the most important parts of Australia's coastal ecosystem, is being destroyed at an alarming rate. At least 450 square kilometres has been lost because of human-induced environmental

(Source: BRS, CSIRO)

Figure 9.6: The major areas of seagrass die-back in Australia. The proportion of the total area affected is indicated where this is known.



changes, and over 1,000 square kilometres through floods and cyclones. Though the latter are natural events, it is possible that in some cases the magnitude of the flooding and extent of the sedimentation have been exacerbated by poor land use practices.

Causes of declines

Most losses of seagrasses, whether natural or human-induced, are attributed to reduced light intensity due to either sedimentation or increased growth of attached algae resulting from nutrient enrichment, or both. In some cases other factors such as sediment instability, dredging and poor catchment management interact to make the process more complex.

Conservation of seagrasses

Conservation and management requires information on seagrass distribution, responses to human-induced changes in the environment, natural seasonal fluctuations, and on techniques for replanting.

Restoration of seagrasses

Recovery and recolonisation after losses are rare for temperate species, and long-term (>10 years) for tropical species. Attempts to replant seagrasses have been unsuccessful as the plants require special conditions in the substrate and these are not present on disturbed sandy areas.

(Source: A. Dalgetty, SARDI)

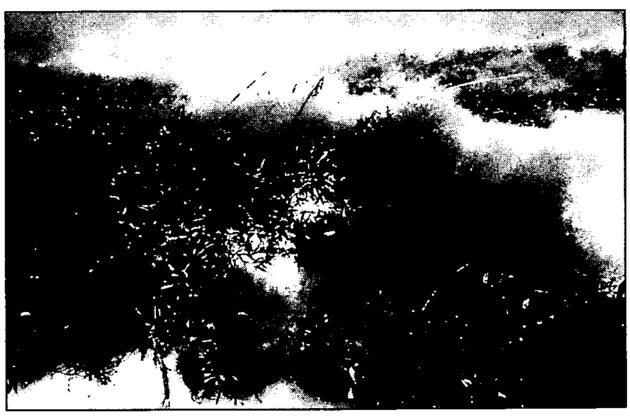


Figure 9.7: Die-back of seagrass beds is one of the most serious issues affecting Australia's marine environment. Blooms of epiphytic algae, thought to be caused by elevated nutrients from sewage and stormwater discharges, are smothering blades of this *Posidonia* seagrass off metropolitan Adelaide.

Marine protected areas

Because of their importance in coastal ecology, fisheries and as habitats for endangered species such as turtles and dugongs, seagrass beds have been given special protection in some areas of Australia.

Seagrass beds are recognised as 'critical habitat' in the Great Barrier Reef Marine Park and major beds are protected as General Use 'B' Zones where no trawling is allowed. In Queensland State waters, major beds are protected as fisheries reserves. The unique seagrass beds of Shark Bay are also protected under World Heritage listing.

While marine protected area status affords protection from destructive uses, it offers no protection from the real threats to seagrasses, namely, increased siltation and elevated nutrients from terrestrial sources. The management of coastal seagrasses would be best effected through the management of catchments and water quality.

Status of knowledge and monitoring

Major information gaps exist on seagrasses in Australia. Many regions are unmapped, and because a number of different methodologies have been used, it is often impossible to compare and repeat many studies. The development and standardisation of cost-effective and statistically robust methods for mapping and monitoring of seagrass is a priority.

Insufficient is known of the following:

- distribution of seagrasses (much of Australia's coastline has not been systematically mapped);
- temporal information (particularly fluctuations of seagrass beds);
- population biology of seagrasses (information on growth, reproduction and dispersal is necessary for predictive studies of the effects of environmental impacts, and on the effectiveness of management strategies);
- physiology and biochemistry (particularly responses to reduced light conditions, which are necessary for managers to set appropriate water quality criteria); and
- restoration techniques (specialised conditions are required; no attempts have been successful).

Summary and conclusions

1. Seagrass communities are critical for the long-term sustainability of Australia's marine environment.

2. Australia has some of the largest and most diverse seagrass beds in the world, and the greatest species diversity.

3. Serious declines have occurred in the area of seagrass in recent decades, particularly in south-eastern and southern Australia. This has occurred through both natural and human-induced factors reducing light intensity.

4. Once lost, seagrass systems do not readily recover. Temperate beds may never recover while tropical beds may take decades.

5. There are serious gaps in knowledge on the distribution, long-term fluctuations, population dynamics, physiology and biochemistry of seagrasses.

6. Conservation of seagrasses is best be achieved through management of catchments and water quality.

7. The decline of temperate and subtropical seagrasses is probably one of the most serious issues in Australia's marine environment.

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Acknowledgments:
The technical paper by Dr I. Poiner and C. Peterken was internally reviewed in CSIRO.

Chapter 10. Hard and soft shores[1]

Our island continent is ringed by hard and soft shores which form the interface between the land and sea. Rocky headlands and cliffs, and sandy beaches are features of the open coast, while mud and sandy tidal flats, often merging with seagrasses, mangroves and saltmarshes, are found in more sheltered areas. Bathed by sea and enriched by land, a great diversity of organisms live between the tide marks.

(Source: L. Zann, GBRMPA)

Figure 10.1: Intertidal rocky shores are dominated by sessile organisms such as barnacles and oysters (right), and mobile organisms such as crabs and snails (left).

Shores are also the most popular areas for recreation in Australia: for sunbathing, surfing, diving, boating, collecting bait and fishing. As a result, the shores are particularly subject to physical disturbances and loss of habitat, overharvesting and pollution.

Shores are often the most obviously degraded parts of Australia's marine environment. In most industrial, urban and resort areas, particularly in the more populous south, the soft shores in estuaries and inlets have been extensively reclaimed for seawalls and building sites, or excavated for ports and marinas. Those near industrial areas and ports are often visibly contaminated with industrial discharges and oil. On the open coast, rocky shores are intensively combed for bait and food. Even the remote beaches are strewn with plastics and other buoyant litter. As coastal strip development spreads along much of south-eastern Australia, management of the coastline is a major environmental issue (RAC 1993).

In this chapter the general ecology, characteristics, importance, status and management of rocky (hard) and sandy and muddy (soft) shores are discussed. Shores dominated by saltmarshes and mangroves have been specifically discussed in previous chapters, while issues affecting shores are discussed throughout this report.

Characteristics of hard and soft shores

Shore types

A great variety of shores are found around Australia because of the diverse geomorphological nature of the coastline, including the nature of the substratum (parent rock type or sediments), and the force of the waves and currents, and of the winds that sculpt them (Chapters 1 and 40).

High wave energy shores lose sediments as they are eroded and washed away, and wear down to the parent rock. More protected shores are characterised by smaller particle sizes, from sands to fine muds. Sand deposited on windward beaches may be blown inland to form dunes, while sand and mud in calm tidal embayments and estuaries settle into gently sloping flats. In estuaries much of this is consolidated by mangroves and saltmarshes.

Australia's southern and northern coasts are dominated by low-energy, small-wave regimes, while the west and east are mainly dominated by swell waves. Rocky coasts are more common in the south, (e.g. the Great Australian Bight), and much of Tasmania. Muddy sediments dominate the north, either under extensive mangroves, or as wide flat shores in areas subject to great tidal ranges, (e.g. around Broome in Western Australia and Mackay in

[1]The scientific description is based on a paper by Dr P.G. Fairweather, Graduate School of the Environment, Macquarie University, New South Wales; and Dr G.P. Quinn, Dept. of Ecology and Evolutionary Biology, Monash University, Victoria; and other sources. The management section was written by Dr L. Zann, SOMER Coordinator, from various sources in SOMER.

Table 10.1: Proportions (%) of shore types around Australia

	rock	sand	mud	mud/ mangrove	total*
Qld	4	36	1	19	59
NSW	33	65	1	2	100
Vic	26	64	7	9	99
Tas	29	68	2	2	99
SA	33	59	1	8	100
WA	19	49	2	19	87
NT	9	40	6	48	97

*The remainder of the totals includes coral reef and estuary mouths. Mud and mangroves are combined as many wetlands are fringed by mud.

Queensland). Sandy beaches are common in all States, but are longest, up to 150 kilometres, along the east and west which are swept by the prevailing East Australian and Leeuwin Currents, respectively.

Ecology of rocky shores

Rocky shores are amongst the most widely studied areas in the sea. Easily accessible, they show a fascinating transition between marine and terrestrial environments, as well as illustrating many fundamental ecological principles and processes. The distributions of the intertidal organisms are affected by differences in their physiological tolerances to the alternating inundation by salt water and exposure to air, their ability to withstand wave action and spray, and to biological factors such as competition and predation. As a result, there is a strong vertical zonation of intertidal species, which, despite gross differences in climate, is apparently similar worldwide.

Table 10.2: Characteristics of rock, sand and mud shore substrata and organisms

Characteristics	Shore type *rock*	*sand*	*mud*
substratum:			
sediment size	hard, continuous, pebbles to boulders	coarse grain size	fine grain size
mobility	immobile, but erodable	reworked by waves, abrasive	reworked by currents (infrequent)
burrowed?	rarely bored, bio-eroded by grazers	mainly interstitial meiofauna, some large burrowers	many burrowers, range of sizes
primary production, energy sources	micro- & macroalgae, plankton	nutrient-poor, no rooted plants, wrack, plankton, some surface diatoms	much organic matter, productive surface microalgae, plankton, seagrass, macroalgae
anaerobic?	no	rarely	yes, shallow depths
organisms:			
size range	small to large	mainly small	small to medium
appearance	epifaunal, from obvious to cryptic	infaunal	mainly infaunal
dominant/common taxa	gastropods, mussels, oysters, barnacles, echinoderms, cnidarians, flatworms, annelid tubeworms, sponges, ascidians, bryozoans, isopods, amphipods, sipunculans, >5 divisions of algae	crustaceans, annelids, molluscs, nematodes	various worms, clams, crabs, amphipods, gastropods, wading birds, fish, others
rare taxa		colonial animals, rooted plants, echinoderms	colonial animals, angiosperms

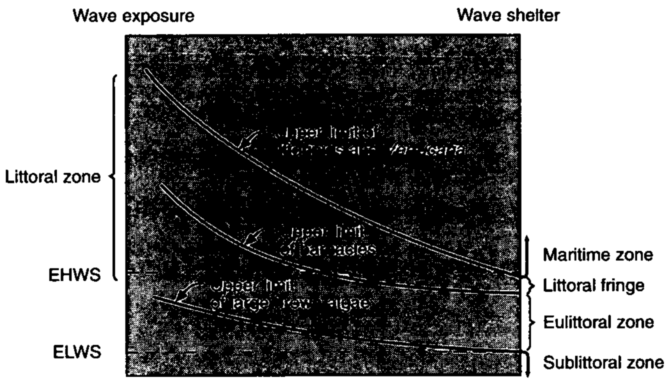


Figure 10.2: Relationship between intertidal zones, tidal levels and degree of water movement. (EHWS: extreme high water spring; ELWS: extreme low water spring). (After Womersley 1990)

Rocky shores provide an essentially two-dimensional benthic structure. They provide a substratum for a rich algal flora, which is eaten by a variety of mobile herbivorous snails, urchins and other animals. Rocky shores are also a substratum for attached plankton feeders such as barnacles, mussels and oysters, tube worms and other animals. The common animals usually have a hard outer shell which helps resist predators and drying out at low tide, and are either sessile or slow moving, usually with a planktonic larval dispersal stage.

The biota of Australia's rocky shores and their patterns of zonation have been described in a classic series of studies in the 1940s and 1950s by Professor W.J. Dakin and his assistants Isobel Bennett and Elizabeth Pope from Sydney University. Since the 1970s rocky shores have been the focus for ecological experimentation by Professor A.J. Underwood and colleagues at Sydney University as shore biota are very amenable to field manipulation, and have relatively short life cycles.

Although the ecology and population dynamics of the common rocky shore gastropods and barnacles are now relatively well-known, knowledge of populations and assemblages of algae, fish and shorebirds is generally lacking.

Ecology of soft shores

Soft shores are characterised by

- a three-dimensional structure, i.e. including depth; the prevailing effects of grain size, depth, chemistry (especially oxidation state) and sediment mobility (from waves, currents and bioturbation);
- the large range of organisms that feed on and under the surface;
- the lack of attached plants, especially in exposed locations; and
- their contiguity with seagrass, mangrove, saltmarsh and open-sea communities.

While the biota of soft bottoms have a high diversity and are good indicators of environmental health, tidal flats are the least-studied benthic habitats in Australia. Understanding of trophic interactions on sandy beaches and of the flows of energy is particularly limited.

Linkages amongst habitats

The exchange of water and biota are common between onshore and offshore areas, along coasts washed by the same sea, and across a variety of habitats. From overseas studies it is known that larvae of many species may be transported large distances, and that inputs from the terrestrial environment via run-off can provide nutrients, energy and matter for coastal habitats. These linkages have important implications for the management of our shores.

Status of shores and major environmental threats

Shores are the focus of many, often environmentally destructive and incompatible human activities, including urban, industrial and port developments; mining and waste disposal; transport, defence, fisheries and aquaculture; and recreation, research, education and conservation.

While there is some knowledge of the extent of physical disturbance to Australia's shores (Chapter 40) there has been no systematic attempt to assess the ecological status of shore communities, or to identify sensitive areas. However it can be assumed that the health of shores is, in part, inversely proportional to the local human population density, particularly in semi-enclosed waters where natural flushing is restricted. Shores in urban and industrial areas are disturbed to various extents, those in rural areas are generally little affected, and those of the uninhabited coastline remain more healthy.

Effects of toxicants

Intertidal shores are particularly vulnerable to pollution from floating contaminants such as oil, and chemicals and micro-organisms which are concentrated in the surface microlayer. They are often physically close to point-source discharges, and may be contaminated by tidal action and onshore winds.

Filter-feeding intertidal bivalves are well known bioaccumulators of pathogens and heavy metals, potentially affecting the health of the organism, and that of its predators, including humans (Chapter 47). The antifoulant tributyl tin (TBT) also bioaccumulates in intertidal molluscs, causing shell deformation in oysters and sex changes, known as 'imposex', in gastropods (Chapter 44). Shellfish have been contaminated by heavy metals and pathogens around sewage and industrial outfalls near Sydney, Melbourne and Perth and the Derwent Estuary in Tasmania (Chapters 52-56). Harvesting and mariculture have been prohibited in some areas.

Intertidal shores are particularly vulnerable to oil pollution as buoyant slicks are blown ashore. Effects have been very well documented around the world and include physical smothering, damage to respiratory membranes, and poisoning (Chapters 36 and 43).

Nutrients

Nutrients from sewage and agricultural fertilisers are problems on shores around sewage outfalls, and in estuaries and lagoons in urban and rural areas in all southern States (Chapter 40). Growth of certain algae is stimulated, smothering seagrasses where they are present. Effects of sewage discharge on rocky shores near Melbourne and Sydney include a reduction in large brown algae such as kelps and an increase of filamentous red and green algae such as *Ulva*.

Fishing and harvesting

The shore is a focus for recreational fishing and harvesting for bait, food and curios (Chapter 34). Around urban areas, rocky shore invertebrates such as bivalves, gastropods, octopuses, crustaceans, sea urchins and sea squirts, have been locally depleted for bait and food. Some mud flats have been disturbed by bait collectors pumping for ghost shrimps and digging for bloodworms. Shell collectors may also damage rocky shores by turning over rocks, and depleting uncommon species.

Introduced species

Species accidentally or intentionally introduced have become dominant on some shores (Chapter 48). For example, in Victoria the rice grass *Spartina townsendii*, introduced to stabilise eroded banks, now dominates some inlets and estuaries; the crab *Carcinus maenas* dominates shores in Victoria; and the green alga *Cladophora rugulosa* is the dominant intertidal alga on many rocky reefs.

Habitat modification and loss

Shores around urban areas have been extensively modified through port construction, seawalls, and the extension of airport runways. In rural areas some shores have been modified through the construction of fishing ports and flood mitigation schemes, and many estuarine shores have been extensively altered by sedimentation resulting from catchment erosion. In some cases engineering works have greatly altered the sediment composition, water quality and tidal exchange, and the shore communities. The opening of the Gippsland Lakes in Victoria for example, caused increased salinity which killed shore plants and enhanced blooms of the noxious alga *Nodularia*.

Sea level change

Shore communities would be directly affected by any greenhouse effect rise in sea levels. Changes would include upward shifts in vertical zonation and the 'drowning' of some low shores (Chapter 41).

Conservation and management

Shores have a very high conservation value. Intertidal communities are highly diverse, and are uniquely specialised to an alternating life in air and sea. Many species have relatively limited distributions and, particularly in temperate areas of Australia, there is a high proportion of endemic species. Intertidal habitats may occupy a very narrow band or fringe. On some vertical rock faces, some zones may be only tens of centimetres in width. Some shore types may also be locally restricted in extent and number.

Shores are vital feeding grounds for migratory shorebirds. Upper shores are roosting areas, and nesting sites for seabirds, and endangered species such as turtles, and seals and sea lions. As shores are the most accessible part of the marine environment to humans, they have a particular value for marine education and research.

Management

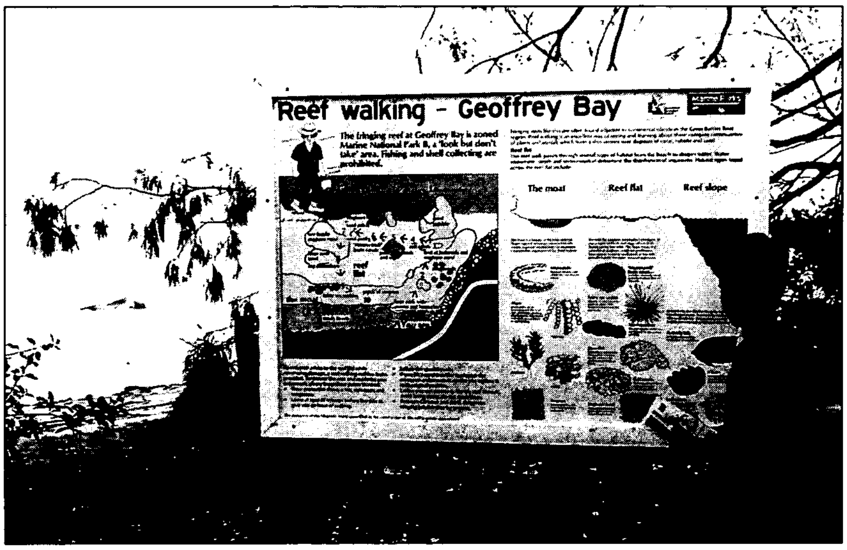
Many bodies are responsible for management of the shores in Australia. Recent government inquiries on the management of the coast (e.g. HORSCERA 1991, RAC 1993) have emphasised the large number of State/Northern Territory and Commonwealth departments and agencies involved in coastal management, and its resultant overlapping and fragmented nature. For example, water discharge controls are typically undertaken by State/Northern Territory environmental protection agencies; oil pollution prevention and clean up by Commonwealth, State/Northern Territory and local maritime authorities; building regulations by local councils and State/Northern Territory planning authorities; fishing by fisheries departments; endangered species by national parks departments; and marine protected areas variously by fisheries, conservation, or national parks agencies.

Although a small number of hard and soft shores around Australia have been specially designated as marine protected areas, shores are generally not adequately protected. Significant areas of shores are protected in Queensland within the Great Barrier Reef World Heritage Area, and in Western Australian marine parks. Smaller areas are protected in other States, e.g. in Victoria, Harold Holt Marine Reserve protects a shorebird habitat, and Bunurong Marine Park protects a rock platform. In an effort to reduce harvesting of shore species, some States have also established bag and size limits for shore invertebrates. A recent initiative by New South Wales to prohibit destructive techniques, tighten bag limits and protect large intertidal areas is an important new initiative.

Jurisdictional difficulties

Between land and sea, intertidal shores invariably presents jurisdictional difficulties. Coastal terrestrial national parks often only extend to the high-water mark, and marine parks and fisheries reserves often extend to the low-water mark. Complementary management arrangements are needed in areas where shores are under different jurisdictions than adjacent submerged areas. For example, in the Great Barrier Reef Marine Park intertidal areas of shores are under Queensland jurisdiction but are included in the Marine Park under complementary management arrangements.

Figure 10.3: Intertidal areas are generally not well protected around Australia. A marine national park self-guided walk, Magnetic Island (Qld).



(Source: L. Zann, GBRMPA)

Status of knowledge and monitoring programs

The ecology of rocky shores is relatively better studied, particularly in New South Wales, than that of the soft shores. Of 729 scientific publications on Australian benthos in the 1980s, 24% focused on rocky shores, 9% on sandy shores and 6% on muddy shores (Fairweather 1988). Most studies of rocky shores were quantitative in nature, while those on soft shores were descriptive. With the possible exception of localised effects of recreational fishing and collecting on rocky shores (Chapter 34), experimental studies on human impacts are generally lacking.

In recent years quantitative studies and experimental research on rocky shores have greatly advanced the experimental design of monitoring programs, and more recently, environmental impact studies. However there are no detailed inventories of

Protecting New South Wales' shores: recent initiatives

(Source: NSW Fisheries)

Intertidal invertebrates near major population centres in New South Wales have been under increased harvesting pressure for food and bait. Some populations have been greatly reduced and some species have become locally extinct. Foraging for intertidal seafood tends to be more prevalent amongst certain recently arrived ethnic groups that traditionally had strong cultural ties to coastal foraging.

In 1988 NSW Fisheries introduced bag limits on several species but these did little to solve the problem (e.g. Underwood 1993). A particular problem was destruction of habitat through the use of crow-bar and picks for breaking rocks, and shovels for digging in sediments.

The Committee for Intertidal Invertebrate Harvesting convened by NSW Fisheries has developed a management plan which included the prohibition of the use of destructive implements, reduced bag limits, and the establishment of Intertidal Protected Areas (IPA) which would act as breeding reservoirs for invertebrates. IPAs would prohibit collection of invertebrates from the high tide mark to 10 metres seaward of the low tide mark, but allow line fishing.

The IPAs were identified by priority (the Sydney Harbour and metropolitan areas were of the highest priority), and by public nomination and review. The first 15 rocky shore IPAs were declared in the Sydney region in July 1993. Other shore types and other areas are now under consideration. A significant publication program involves signage, brochures covering 16 languages, and education programs targeted at different ethnic groups.

New bag limits in New South Wales are: 10 abalone; 20 beach worms; 20 cunjevoi; 50 total pipis, cockles and mussels; 10 sea urchins; 10 crabs.

Sydney IPAs:
Barrenjoey; Newport Reef; Mona Vale Headland; Turimetta Head; Harbour Head; Fairy Bower and Shelly Beach; all of Sydney Harbour intertidal zone (except Manly Cove); Mackenzies Point, Bondi; Shark Point, Clovelly; Long Bay; Cap Banks; Sutherland Point; Boast Harbour; Cabbage Tree Point, Bundeena; Little Garie.

Australia's shores which might be used as bases for management, or long-term monitoring data to assess environmental health or the effectiveness of management.

Shore biota are widely used as bioindicators of pollutants. The International 'Mussel Watch' program, coordinated by the United Nations Environment Program, uses mussels and oysters as bioindicators. In New South Wales oysters are used as indicators in the monitoring of ocean sewer outfalls off Sydney and in the coastal lakes. In Victoria mussels are used to monitor toxicants in Port Phillip Bay. The incidence of 'imposex' in whelks is commonly used as an indicator of tributyl tin levels from antifouling paints.

Summary and conclusions

1. Shore biota are highly specialised for intertidal life, may be limited in distribution and have a high conservation value.

2. Shores are the most accessible, and most heavily used parts of the marine environment.

3. Along developed coastlines shore biota are vulnerable to disturbances, overharvesting, pollution and loss of habitat because of their limited intertidal distribution, and proximity to human disturbances.

4. Management of shores is constrained by jurisdictional problems, and a lack of coordination amongst the many agencies responsible for aspects of management.

5. Shores are generally not adequately represented in marine protected areas.

6. Australia's rocky shores are relatively well studied while soft shores are poorly known. The effects of human activities on either are not well understood.

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Chapter 11. Temperate reefs[1]

Australia's temperate reefs have an extraordinarily high species diversity and a very high proportion of endemic species. Red and brown algae, ascidians, bryozoans and crustaceans have a much higher species richness than in equivalent temperate habitats elsewhere in the world, and the reefs are possibly distinctive in their ecological processes. The temperate reefs are important for commercial and recreational fisheries and for recreational diving, and they are potential sources of natural products for the pharmaceutical industry. However, despite their great importance they are not well known scientifically, and are not well protected.

Subtidal hard substrata such as rocky outcrops and other hard surfaces provide attachment space for a wide diversity of sessile organisms beneath the sea. In temperate Australia the 'key' species in the shallower areas (<20 metre depths) are the large brown algae which provide food and a complex physical structure for fish and many other animals on these reefs. In deeper (>20 metre depths) or well shaded areas most of the algae are replaced by attached invertebrates, particularly sponges, bryozoans, corals and ascidians. This chapter describes mainly the shallower reef communities, and their status where this is known.

Dominant assemblages of temperate reefs

Algal assemblages

The algal assemblages vary with the degree of wave exposure, light and sedimentation. In exposed areas the kelps, canopy-forming large brown algae (*Ecklonia, Macrocystis* and *Durvillea)*, are commonly dominant from the shallow intertidal waters to around 15 metre depths, depending on the clarity of the water. Beneath their canopies are an assemblage of smaller red and brown algae, and a range of animals. In deeper and more turbid waters the kelps give way to smaller, tufting, primarily red

(Source: SARDI)

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(Source: N. Holmes)

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(Source: N. Holmes)

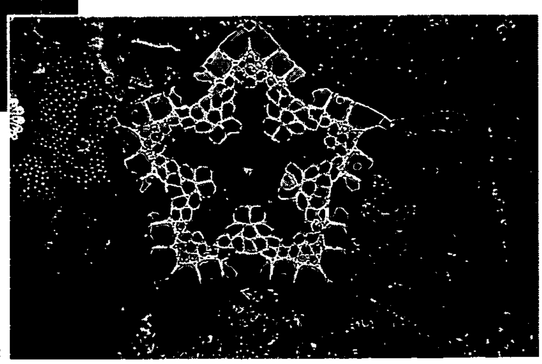

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Figure 11.1: Australia's temperate reefs have a very high species diversity of algae and invertebrates, with a very high proportion of endemic species. (a) Australian fur seals on reef, Sir Joseph Banks Group (SA). (b) The kelps are common canopy plants and important primary producers on temperate reefs. (c) Temperate reefs have a very high diversity of ascidians and other invertebrates.

[1]The scientific description is based on a paper by Dr M.J. Keough, University of Melbourne, Victoria; and Dr A.J. Butler, University of Adelaide, South Australia. The management section was compiled by Dr L. Zann, SOMER Coordinator, from various sources in SOMER.

algae. Encrusting coralline algae dominate a shallow water habitat known as 'barrens', in some cases caused by cropping by the common eastern Australian urchin *Centrostephanus rodgersii.*

The communities vary geographically. On the temperate east coast of Australia the dominant canopy formers are *Ecklonia* and *Phyllospora*. The former are common in Port Phillip Bay and Western Port in Victoria, South Australia and south-west Western Australia. In cooler Victorian, South Australian and Tasmanian waters, the kelps *Macrocystis* and *Durvillea* dominate. The barrens habitat is rare in the south, possibly because of the absence of the urchin *Centrostephanus*.

Table 11.1: Biogeography of Australia's macroalgae

Southern Australia is the outstanding region of the world for richness of benthic algae (Womersley 1990). The 5,500 km coastline from the south-west part of Western Australia to the NSW/Victorian border has around 427 genera and 1,155 species of benthic macroalgae. It is rich in Phaeophyta, but is particularly rich in Rhodophyta.

	total genera	no. and % endemic	total species	no. and % endemic
Chlorophyta (green algae)	39	2 (5%)	124	43 (30%)
Phaeophyta (brown algae)	104	20 (19%)	231	131 (57%)
Rhodophyta (red algae)	284	72 (30%)	800?	538 (75%)
Total	427	94(22%)	1,155	712 (62%)

(from Womersley 1990)

Fauna

Many of the animal groups have not been described by specialists in the same detail as the algae, so it is difficult to know the number of species and genera, or their degree of endemicity. We do know that southern Australia has very many species and relatively high diversity of some groups, such as bryozoans and ascidians.

Urchins are important algal grazers in temperate reefs. Dominant genera in open coast reef environments range from *Centrostephanus* and *Heliocidaris* in New South Wales, to *Heliocidaris* alone in South Australia, to a mixture of *Heliocidaris, Tripneustes* and *Echinometra* in south-western Western Australia.

In open-coast environments, sessile animals are most abundant in well-shaded rock faces, overhangs and caves, and undersides of boulders. The dominant animals are colonial or modular, such as sponges, ascidians, soft corals and hydroids, and bryozoans. In low-energy environments, the sessile animals are commonly dominated by solitary or unitary forms such as barnacles, sea squirts, bivalve molluscs and polychaetes. A large number of species of mobile animals such as small polychaetes, crustaceans and opisthobranch molluscs, and larger urchins, abalone, lobsters and reef-associated fish, are present in the communities.

Variability in temperate assemblages

Temperate reef assemblages are often highly variable in space and time. Biological and ecological processes affecting their species composition include:

- modularity of growth form (solitary or colonial);
- dispersal and recruitment processes (some dispersal stages are capable of travelling great distances across oceans, others only short distances);
- genetic structure (allowing adaptation to local conditions);
- competition (for space by sessile species);
- predation (grazers and predators may reduce canopy-forming species);
- wave action (waves may remove canopy-forming algae);
- turbidity (reduced light favours shade-tolerant plants, sediments clog suspension-feeding mechanisms);
- light (depth, turbidity and shade reduce light and algal dominance);
- oceanographic features (upwellings and fronts increase nutrients);
- linkages (mobile species may move into adjacent habitats or to other reefs); and
- substratum characteristics (rock type and shape).

Status of temperate reefs and potential environmental threats

Generally little is documented of the effects of human activities on temperate reefs. The most serious potential effects are probably those on the habitat-forming species, particularly the large algae.

Point-source and non point-source discharges

Sewage outfalls, thermal effluents, and chemical effluents may influence subtidal reefs, though their effects will vary with local hydrodynamics which will affect dispersal and dilution of toxicants. Sewage outfalls have been claimed to reduce canopy-forming brown algae in Victoria and overseas. Thermal effluent has reduced kelps in California.

Effects of diffuse discharges are less clear. Tributyl tin antifoulant is known to seriously affect mollusc populations, but effects on other groups are not known.

Fishing and collection

Commercial and recreational fishing by line, trap, spear and hand collecting may affect abundances of target species, and trawl nets may remove sessile species (Chapter 32).

In many areas stocks of spiny lobsters and abalone, and reef-associated fish such as snappers have been severely depleted. For example, in Victoria the greenlip abalone, at the edge of its geographic distribution, has been reduced to remnant stocks, and catches of the southern rock lobster have declined steadily since 1981. Catch per unit effort has declined six fold since 1950, despite major advances in technology.

While the direct effects of fishing on temperate reefs are little known, we are particularly ignorant of any indirect effects.

Introduced species

Species of barnacles, ascidians, bryozoans and polychaetes introduced via ships' fouling and ballast waters are a major part of many assemblages on subtidal hard substrata, particularly on artificial surfaces in harbours. As reef communities in harbours are disturbed by human activities, it is not possible to isolate any effect of introduced species *per se*. Harbour-fouling species have not been reported as a major component of the biota of exposed coasts.

Conservation, status and management

Conservation value

Australia's temperate reefs have a great conservation value because of their uniquely high species diversity and high degree of endemism. They also have great economic value as they support some of Australia's most valuable commercial fisheries, such as abalone and crayfish, and are important sites for recreational fishing and diving. They are also important areas for scientific research.

Status

The status of the vast majority of temperate reefs is not known. Apart from reductions in the populations of the fished species (and possible flow-on effects on their prey and other organisms), it is assumed that Australia's temperate reefs are relatively unaffected by human activities.

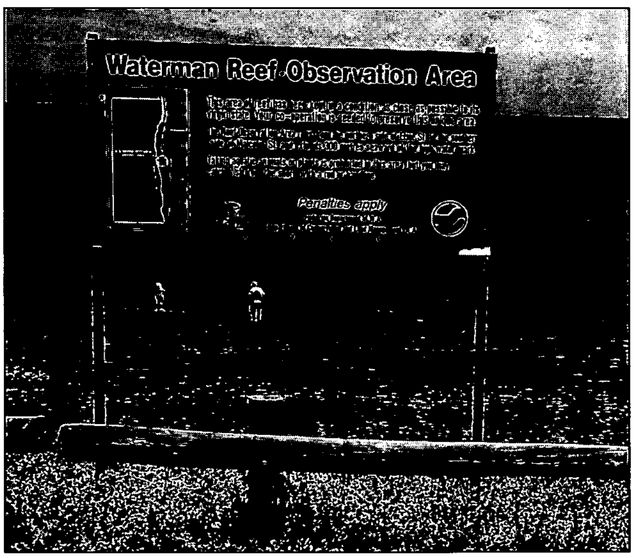
While the effects of fishing and pollution are little known, it might be assumed that reefs at greatest risk are those closest to metropolitan and industrial areas, or off river mouths subject to sedimentation. Embayments at risk may include those with limited ocean exchange and high catchment use and human populations, for example, Port Stephens, Sydney Harbour and Botany Bay in New South Wales; Western Port and Port Phillip Bay in Victoria; and the Gulf St Vincent and Spencer Gulf in South Australia.

Management

Relatively few temperate reefs are protected. Controls on point-source discharges into the sea have been established in most States and appear to have been successful in reducing levels of heavy metals and organochlorines in the water column and in surface sediments in at least some sites (Chapters 44 and 45). Controls of diffuse or non point-source discharges are generally lacking (Chapter 42).

Marine protected areas

Of Australia's marine protected areas (MPAs), only 7% (by area) lie outside the tropics, and much of these protect subtropical coral reefs. The total area of marine protected areas (both hard and soft bottoms) in New South Wales, Victoria, Tasmania and South Australia is only about 0.3% of Australia's total area of MPAs. Even considering the smaller lengths of the coastlines of the southern States, they have a disproportionately smaller area of MPAs (Chapter 67).



(Source: I. Dutton)

Figure 11.2: Few temperate reefs are protected. Waterman Reef near Perth (WA).

Status of knowledge and monitoring

As emphasised above, Australia's temperate reefs are not well known. While various sites have been described qualitatively, no systematic maps showing the extent and nature of reefs have been produced. Very few quantitative descriptions of the flora and fauna have been made, and these few studies are confined to only a few geographical areas. Such descriptions are hindered by poor systematic knowledge of many taxa and difficulties in field identification.

Table 11.2: Australia's temperate habitats underprotected

Only a small proportion of the marine environment of temperate Australia is protected. These estimates of areas of MPAs include temperate reefs and other habitats. (Western Australia is excluded as separate data on its southern coastline is not available, but like other southern States, relatively little of its temperate reefs are protected.)

State	no. MPAs	area (sq km)	area/coast (sq km/km)
NSW	23	922	0.3
Victoria	29	518	0.02
Tasmania	26	610	0.14
South Australia	56	363	0.08

While this dearth of information is partly due to the high cost and difficulties of underwater research (particularly in waters beyond scuba working depths), it is also due to a lack of recognition by natural resource managers of the great conservation and economic value of temperate reefs. Unlike the more celebrated coral reefs, the value of temperate reefs is not so well appreciated.

Survey techniques

Appropriate underwater survey techniques for monitoring have been developed. Because of great variability among sites and over time it has been found that considerable replication of survey sites is necessary.

A knowledge of the variation that occurs is the essential background against which we can measure changes caused by humans. Simple inventories are not useful in distinguishing between natural and human-induced environmental changes. To take the next step and actively manage natural habitats, it is important to understand the environmental processes that are responsible for the patterns that are observed. Knowledge of these processes allows predictions to be made about the impact of various human activities, and allows management to respond to protect the relevant habitats. There are at present very few appropriate studies of ecological processes, and they are concentrated in a few places.

The only attempt to design a comprehensive marine environmental monitoring program, 'Indicators for Victoria's Marine and Coastal Environments' (Coleman et al. 1991), includes monitoring of intertidal animal populations, monitoring of human activities such as dredging, shipping, fishing and monitoring of water quality including nutrient content, organic carbon and heavy metals. Subtidal monitoring is even more difficult than intertidal sampling and it will be difficult to design suitable indicators. The high cost of subtidal monitoring is currently outside the budgets of most State marine environmental management agencies.

There are no formal databases of temperate reefs although individual researchers maintain their own records in various forms. State and Commonwealth fisheries agencies maintain databases of commercial landings of various temperate reef species, but not generally by locality.

Summary and conclusions

1. Australia's temperate reef communities have a very high biodiversity. Red and brown algae, ascidians, bryozoans and crustaceans have a higher species diversity than in temperate areas elsewhere in the world.

2. The ecological characteristics and extent of Australia's temperate reefs are not well known. There are few quantitative descriptions of the flora and fauna, and these few studies are confined to only a few geographical areas. These descriptions are hindered by poor systematic knowledge of many taxa and difficulties in field identification. Further, the results of descriptive studies suggest that broad habitat classifications are not especially useful, because they obscure considerable smaller-scale variation.

3. Little is known of the effects of human activities on temperate reefs but it is assumed that they are in a relatively unaffected state, except possibly near metropolitan and industrial areas. While some predictions can be made about the effects of various human activities on subtidal reef assemblages, the predictions should be viewed with extreme caution, given the limited basis for their construction.

4. Australia's temperate reefs have a very high conservation value because of their high diversity and endemism, and their importance for fisheries, recreational diving and scientific research.

5. A relatively small number of temperate reefs have been declared as marine protected areas. Management includes size and bag limits on some species in some areas.

6. Considering their great conservation and economic value, Australia's temperate reefs are not adequately studied or managed. No systematic mapping has ever been undertaken and only a few sites have been monitored. The prediction of change, and identification of appropriate management activities, requires much more detailed biological information than is currently available. The identification of the processes that most influence the structure of assemblages is a priority.

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Chapter 12. Coral reefs[1]

Coral reefs are wondrous, living geological structures. They are one of the most productive, diverse and complex ecosystems in the biosphere, yet they grow best in nutrient-poor waters. Coral reefs have reached the pinnacle of their development off the northern coasts of Australia. Coral reefs are also fragile ecosystems. It is feared that perhaps the majority of the world's reefs have been affected by human influences, and grave fears are held for the survival of some of the major reef complexes in the next century.

Coral reefs are geological structures made by a symbiotic partnership between plant and animal. The practically unlimited resources of sunlight and inorganic carbon are utilised, through photosynthesis, to produce organic carbon and limestone structures so large as to create and control their own macro-environment, and support a great diversity of other species.

Geomorphology and ecology of coral reefs

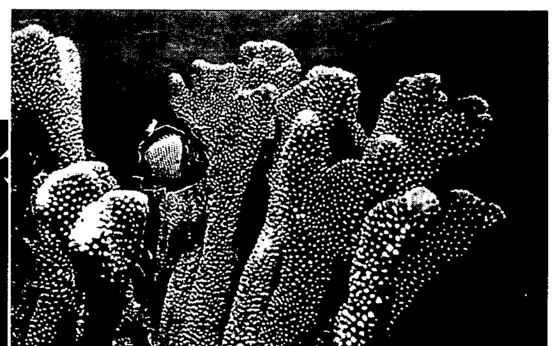
Unlike temperate rocky reefs, coral reefs are dynamic structures, constantly growing and eroding. Because they are confined to shallows, they are profoundly influenced by global climate changes, and sea level changes have repeatedly emerged and submerged reefs throughout geological history. Only 20,000 years ago when the sea level decreased to minus 120 metres, all of today's reefs were completely exposed and the world's reef development was limited.

The development of coral reefs depends primarily on depth (<100 metres depths) and temperature (>18°C), and secondarily on Cenozoic history, surface circulation patterns which transport larvae, oceanic salinity, substrate type (hard bottoms), and low nutrient levels.

A coral reef is a mosaic of different communities, each separate, but linked to the next by a complex web of ecological interactions. These communities are distinctive because, on a single reef, they form a series of narrow bands or zones, each having a particular place in an array of rapidly changing environmental gradients.

High species diversity

Coral reefs are remarkable for their high species diversity. On the Great Barrier Reef there are at least 400 species of hard corals, 1,500 species of fish, some 4,000 species of molluscs, and many thousands of other organisms. A number of endangered species such as turtles and giant clams are found on coral reefs.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(Source: all GBRMPA)

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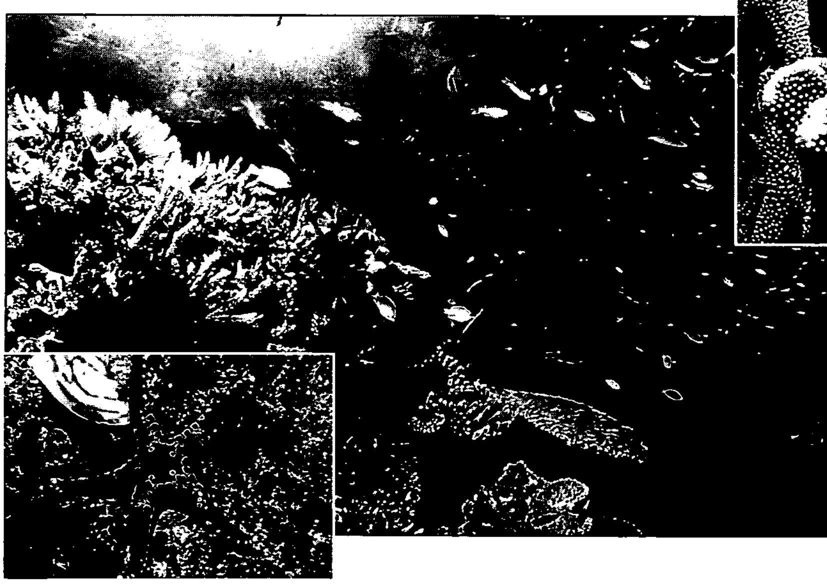
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Figure 12.1: Coral reefs are one of the most diverse and productive ecosystems on earth. (a) Coral reef, Great Barrier Reef. (b) Corals are the main canopy-formers and primary producers (through their symbiotic algae, the zooxanthellae) on coral reefs. (c) Coral reefs support many thousands of other species.

[1]Based on a paper by Dr J.E.N. Veron, Australian Institute of Marine Science, Townsville, Queensland with additions on management by Dr L. Zann, SOMER Coordinator.

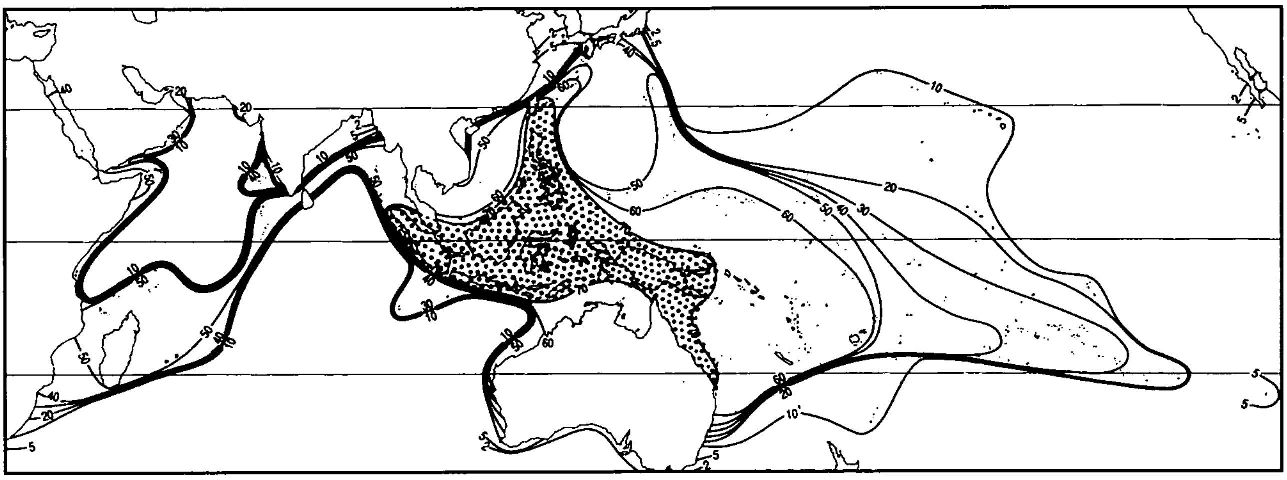

Figure 12.2: The Central Indo-Pacific is the centre of world coral species diversity. Contours show the number of genera of corals, with the centre (including northern Australia) highlighted. (after Veron 1992)

Corals and zooxanthellae: a remarkable symbiosis

Millions of hectares of coral dominate a large part of the world's tropical coastline. These massive structures result from the accumulation of skeletons of innumerable corals over thousands of years. Yet, as imposing as they are, the existence of modern coral reefs is the result of a most intricate and subtle relationships between the coral polyp and the single-celled algae which live symbiotically within the cells of the polyp.

These algae, which are commonly called zooxanthellae, belong to a group of unicellular brown plants known as dinoflagellates. Zooxanthellae take up much of the polyps' waste products such as nitrates and phosphates which they use as nutrients. The minute cells supply much of the polyps' carbohydrate requirements, up to 98% in some species, and assist in the deposition of the coral skeleton.

Australia's coral reefs: description, status and threats

Australia has the largest area of coral reefs in the world. The Great Barrier Reef off the north-east is the largest complex of reefs, and the Ningaloo Reef off the north-west is one of the largest fringing reefs. Most types of shelf-edge reefs are represented: fringing, platform, barrier and atolls. While coral reefs are best developed on Australia's tropical north-eastern and north-western coasts and shelves, a number of reefs are present in higher latitudes because of the southern flow of the warm East Australian and Leeuwin Currents.

High latitude reefs

The Solitary Islands off the northern New South Wales coastline, although not true coral reefs, contain a unique combination of reefal and non-reefal biota including 53 species of coral, and 280 species of fish (80% of which are tropical). These have recently gained protection in the Solitary Islands Marine Reserve (Chapter 71).

Lord Howe Island, lying on the Lord Howe Rise in the Tasman Sea, has a 6 kilometre-long reef along the western coast which is the world's southernmost coral reef. Dominated by tropical algae, it contains 65 species of coral, and 427 species of fish, primarily with tropical affinities. The reef was slightly to moderately affected by crown-of-thorns starfish in the late 1980s. Lord Howe is a national park and is entered on the World Heritage List (Chapter 77).

Elizabeth and Middleton reefs on the Lord Howe Rise, about 100 kilometres north of the island, are large platform reefs closely resembling those on the Great Barrier Reef, although they lie in very marginal conditions for reef formation. Although not well studied, they have great scientific interest because of their environment and isolation. Some 122 species of coral have been recorded. Both were extensively damaged by crown-of-thorns starfish in the early to mid-1980s, with the result that abundant coral is now largely confined to the lagoon. Both reefs are protected as Marine National Nature Reserves administered by the Australian Nature Conservation Agency (Chapter 73).

Other significant areas of coral include that at the Julian Rocks off Byron Bay (protected as a New South Wales fisheries reserve) and Flinders Reef off Brisbane, a coral-capped sandstone shoal. Neither has been adequately described.

(Source: Veron)

(Source: CALM)

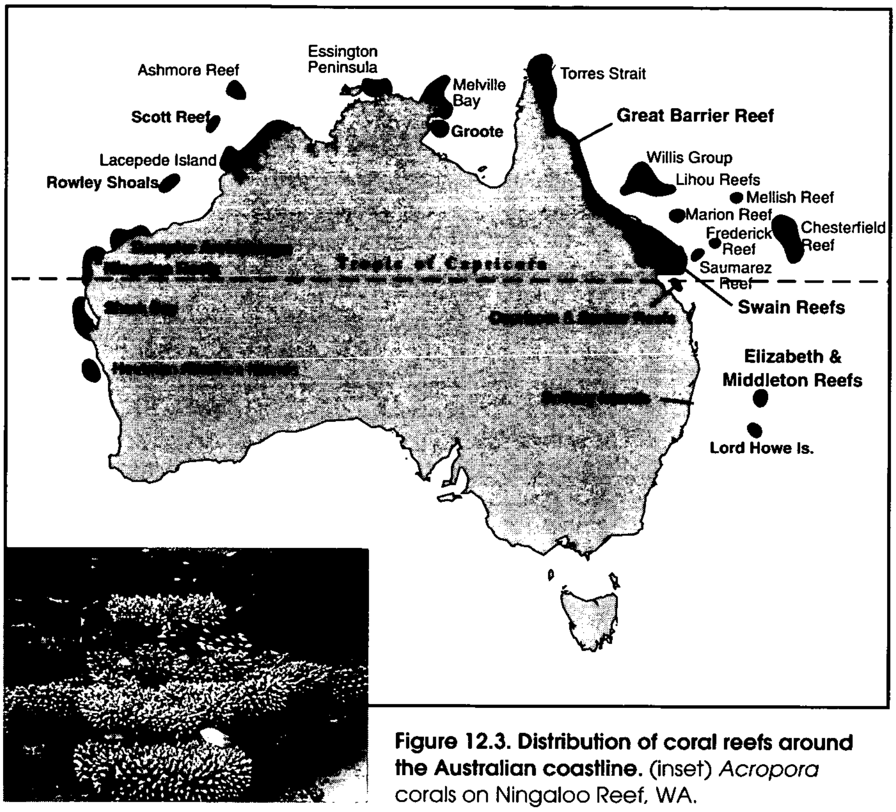

Figure 12.3. Distribution of coral reefs around the Australian coastline. (inset) *Acropora* corals on Ningaloo Reef, WA.

The Great Barrier Reef

The Great Barrier Reef is the largest single reef system in the world. Extending from the low latitude tropics to temperate zones, it is also the most diverse in reef types, habitats and environmental regimes. The Great Barrier Reef faunas have some regional differentiation along the length, while the cross-shelf variation is more marked. The western (inshore) edge is characterised by shallow waters with terrigenous sediments, exposed to periodic river run-off and consequently low salinity and high turbidity. The high (continental) islands in inshore areas provide much of the Reef's habitat diversity. The Great Barrier Reef is a Marine Park, the largest marine protected area in the world (Chapter 69).

The major regions of the Great Barrier Reef

Ecologically, the Great Barrier Reef can be divided into four main sectors, although these do not exactly coincide with the four Marine Park Sections.

Capricorn and Bunker Reefs

These groups are the southernmost and best known reefs of the Great Barrier Reef. They are characterised by well-defined platform reefs with entire, steeply sloping sides, and relatively deep inter-reefal waters. Many have vegetated sand cays which are frequently visited. The reefs are very uniform in zonation and fauna, and have the lowest coral diversity on the Great Barrier Reef. They were not affected in the crown-of-thorns starfish outbreaks but are subject to some pressures from tourism, reef fishing and prawn trawling.

Swain and Pompey complexes

These groups are the furthest offshore of the Great Barrier Reef. The Pompey complex is a spectacular array of interlocking deltaic reefs, meandering channels, sand bars and lagoons, well defined outer barrier reefs, and strong tidal currents generated by the highest tidal range on the Great Barrier Reef. The detached Swains complex of small platform reefs and shoals have exposed outer faces and protected inner margins, and some of the eastern reefs have developed coral cays. A higher number of coral species is a result of this high habitat diversity. Parts of the Swains were affected by crown-of-thorns starfish in the mid-1970s and mid- to late 1980s. These reefs are very remote, and are subject to minimal human pressures.

Central Great Barrier Reef

This is a vast area of reef characterised by the virtual absence of coral cays and well-defined outer barrier reefs. The cross-shelf zonation is well documented. Inshore waters are relatively shallow, turbid and sheltered, with a strong terrigenous influence because of seasonal river flooding. The complex of high islands of the Whitsunday and Lindeman Groups have a very high diversity of benthic fauna, perhaps the highest on the Great Barrier Reef. Some reefs were severely affected by crown-of-thorns starfish outbreaks around 1968-77, and 1982-90. Pressures include reef fisheries and prawn trawling, tourism in the Whitsundays, and possibly eutrophication and sedimentation of some inner shelf reefs.

Northern Great Barrier Reef

This area is characterised by a narrow continental shelf with well-developed inner-shelf reefs, fringing the mainland in places; a diverse range of high islands, cays and mangrove islands; large expanses of *Halimeda*, a coralline alga, in deep inter-reefal areas; extensive areas of mid-shelf reefs; and well defined, exposed outer barrier or 'ribbon' reefs which follow the edge of the continental shelf to Torres Strait. Lying off the main Great Barrier Reef, Raine Island has the largest nesting populations of green turtles in the world and is one of Australia's most significant seabird rookeries.

These reefs are considered the richest and most pristine in the Great Barrier Reef. Crown-of-thorns damage has been minor and human influences are limited as the reefs are remote from populated areas.

Torres Strait

Subject to strong tidal currents, the outer barrier reefs of Torres Strait are broken into a series of deltaic formations which range into an almost impenetrable line of 'dissected' reefs. Deep water and the freshwater influence of Papua's Fly River have prevented northern growth of the Great Barrier Reef. Inside the barrier line lies an aggregation of reef complexes, high islands and cays of great variety. The sea is shallow and turbid westward across the Strait. The vast Warrior Reefs are essentially vast mud flats fringed by coral in the east.

Commercial and subsistence fisheries are the main pressures on the Strait's marine environment but concerns are held regarding heavy metals from Papua New Guinea mines and on the possibility of oil spills from shipping using the Strait. While the fisheries are managed under a complex border arrangement with Papua New Guinea, reefs are not protected. A management plan is currently being developed for Torres Strait under the Ocean Rescue 2000 program (Chapter 74).

Coral Sea reefs

Australia's isolated, scattered Coral Sea reefs are not well described. Atoll-like Ashmore, Portlock and Eastern Fields Reefs lie in the north Coral Sea. In the centre, on the Coral Sea Plateau, lie Willis, Holmes, Flinders, Lihou and the Coringa-Herald complex. In the south lie the more isolated Marion, Kenn, Frederick, Cato and Wreck Reefs. Lihou and Coringa Herald are National Nature Reserves under the management of the Australian Nature Conservation Agency (Chapter 73).

Northern Territory

The shallow, turbid waters of the Arafura Sea are not conducive to reef growth. A scattering of little-known fringing reefs lie along the complex coastline of the Northern Territory and offshore islands. Reef development increases in the west, and reaches a modest coverage and diversity in the vicinity of the strongly tidal Essington Peninsula. Marine parks are planned in the Wessel Islands and Beagle Gulf (Chapter 82).

North West Shelf reefs

Ashmore reef, situated 350 kilometres off the Western Australian Kimberley coast on the outer edge of the Sahul Shelf, is a large sedimentary accumulation of reef patches. It has the highest diversity of corals and probably other reef taxa in the west. Scott and Seringapatam Reefs and Rowley Shoals are 'shelf-

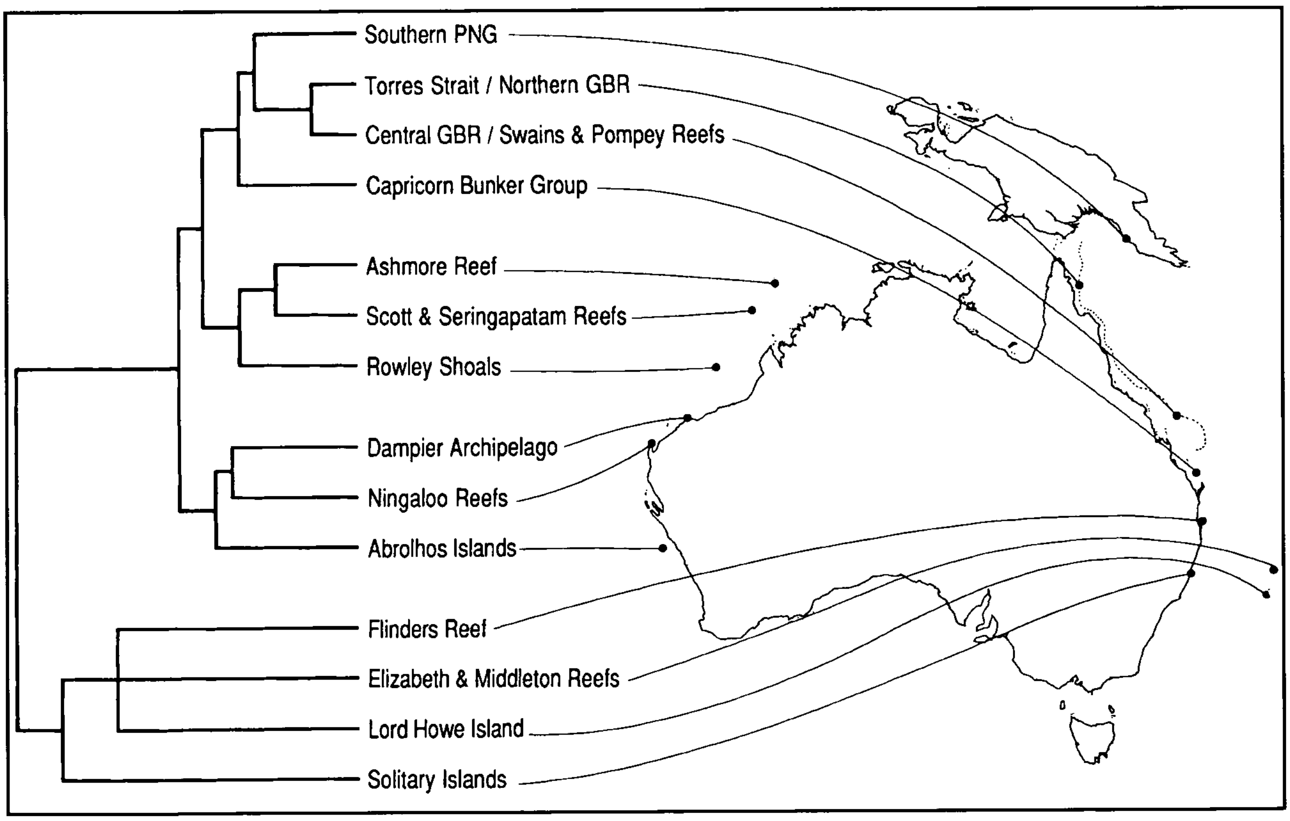

Figure 12.4: The relationship between the coral faunas of Australia based on presence/absence data. Links (nodes) in the dendogram are measures of dissimilarity. The diagram shows that there is a high degree of uniformity in the tropics and that tropical species become reduced in numbers towards higher latitudes. This broad pattern is repeated by reef species of most major groups. However, unlike corals, most major groups show replacement of tropical species by temperate ones, rather than in reduction in number of species.

edge atolls', a reef type not represented elsewhere in Australia. These are visually spectacular due to clear oceanic water and a high tidal range. Apart from a few faunistic studies, they are not well-described. Ashmore Reef is a National Nature Reserve administered by the Australian Nature Conservation Agency. Situated only 120 kilometres from Indonesia, the Reserve is closed to fishing and collecting under a Memorandum of Understanding between the Australian and Indonesian Governments. Poaching of turtles and seabirds and their eggs occurs from time-to-time (Chapter 73).

Reefs of coastal Western Australia

Compared with those on Australia's east coast, the western reefs have been much neglected scientifically. They are of interest as they are distributed down the coast in a series of stepping stones, connected by the southward flowing Leeuwin Current. This has resulted in a chain of geographically and environmentally discrete settings for long-distance dispersal of reefal fauna from Indonesia.

Kimberley and Dampier reefs

The reefs off Kimberley are only superficially known as the sea is very turbid and currents strong. Those of Dampier off the Pilbara coast are better described. With an environment ranging from muddy inshore waters to clear offshore waters and strong tidal currents, their diversity of habitats is unmatched in Australia.

Ningaloo reefs

The 230-kilometre-long Ningaloo Reefs are by far Australia's longest fringing reefs. They have around 300 species of coral, nearly 500 species of fish and over 600 species of mollusc. Lying along the mainland and readily accessible to Perth, until recently they were heavily fished. They were seriously damaged by an outbreak of coral-eating *Drupella* snails in the 1980s (Chapters 50 and 70). Ningaloo was declared a Marine Park in August 1987, under the Western Australian Department of Conservation and Land Management, in collaboration with the Australian Nature Conservation Agency.

Houtman Abrolhos reefs

Situated 400 kilometres north of Perth, these reefs are the most southerly reefs in the Indian Ocean and comprise the south limit of distribution of most Western Australia coral species. However, they show few signs of environmental stress and are amongst the most luxuriant in the country.

Cocos (Keeling) atoll and Christmas Island

Cocos (Keeling) in the eastern Indian Ocean is Australia's only true atoll, and of interest faunistically because of its isolation. It has significant populations of seabirds and its marine ecology is relatively well known. Christmas Island to the east is a high mountainous island with a plunging shoreline, and a similar reefal fauna.

General status of coral reefs and major threats

As most of the world's coral reefs lie around developing, overpopulated tropical countries, many have been seriously degraded in recent decades. It is considered that as much as 70% of all central Indo-Pacific coral reefs have been degraded to some extent.

Major impacts on coral reefs in the region include:

- overfishing, which has effectively removed the top of the food pyramid of most South East Asian and Japanese reefs, and many Pacific coral reefs;
- eutrophication and sedimentation from agricultural run-off, coastal zone development, urban outfalls;

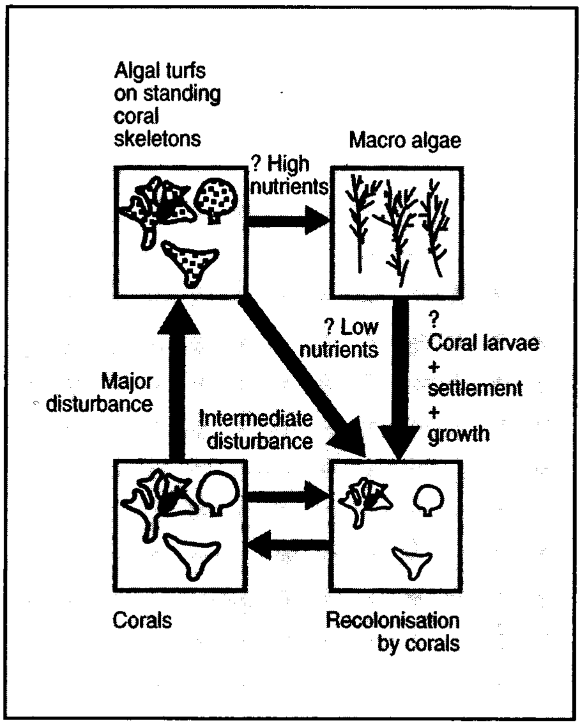

Figure 12.5: Postulated effects of episodic and chronic disturbance on the benthic community of a coral reef. Boxes indicate stages the community passes through when subject to disturbance and /or stress. Arrows indicate that reversion of disturbed areas to coral dominance does not necessarily take place. Question marks indicate location-specific factors influencing community trajectory (after Done, in press).

- predation by outbreaks of crown-of-thorns starfish and *Drupella* snails; and
- direct damage through food gathering, mining, port works, seawalls and other developments.

Of particular concern are the synergistic effects of sublethal chronic impacts, and the capacity of chronically affected reefs to recover from acute impacts such as crown-of-thorns starfish or cyclones.

Conservation and management

Conservation value

Australia's geographic position within the world's centre of coral reef diversity is critical to coral reef conservation because only a few countries in the region have a low population pressure and/or the capacity to regulate human impacts.

The Great Barrier Reef is one of the most valued parts of Australia's inheritance and a unique part of the World Heritage. Australia's coral reefs are currently only at the dawn of international tourism. The Great Barrier Reef, as no other reef region, offers true wilderness areas of vast proportions. While some other places in the Indo-Pacific have well-developed reef tourist industries, the pressures on many of these areas are great and the uses may not be sustained. Australia's reefs will be of unique tourist value in the twenty-first century.

As well as their ecological and tourist value, Australia's coral reefs have also great value for fisheries and scientific research, including biomedical research on natural products of pharmaceutical potential.

Management

Most areas of coral reefs in Australia are under some form of management. The degrees of protection range from preservation zones (no entry) in the Great Barrier Reef Marine Park, to marine parks (no extractive use), to general use areas under fisheries management plans. However, as reefs are remote, distances are vast, and resources are limited, in most cases the level of day-to-day management is not adequate.

Status of knowledge and monitoring programs

Status of knowledge

Australia's coral reefs have been relatively well studied over the past 20 years, although major ecological and geographic gaps do exist. The very extensive north-western Australian reefs, and those off the Northern Territory are not well-known. Australia has become a world leader in coral reef studies through the research programs undertaken at the Australian Institute of Marine Science and James Cook University, and at the research stations on Heron, One Tree, Orpheus and Lizard Islands. Significant advances have been made in the understanding of coral reef structure, functions and dynamics. Australia has also achieved world prominence in coral reef management through the establishment of the Great Barrier Reef Marine Park.

Monitoring programs

The Great Barrier Reef Marine Park Authority has a comprehensive monitoring program at fixed sites along the Great Barrier Reef to assess ecological health. It also monitors developments such as pontoons, tourist resort discharges and dredged sites to assess their impacts. Much of this information lies on computer databases. Other reefs around Australia are not systematically monitored.

Figure 12.6: Coral reefs have a great ecological, scientific and tourism value. The Great Barrier Reef is one of the most valued parts of Australia's natural heritage. Hook and Hardy Reefs off the Whitsunday Group.

(Source: GBRMPA)

Summary and conclusions

1. Australia has the largest area of coral reefs in the world. The Great Barrier Reef and Western Australian reefs are well developed and diverse.

2. Coral reefs are threatened in many parts of the world. Around 70% of reefs in the central Indo-Pacific are disturbed to some extent. Australia's reefs are generally minimally disturbed, and many remain pristine.

3. Representative areas are protected in all Australia's reef systems but outside the Great Barrier Reef Marine Park, management is limited.

4. Major environmental threats and potential threats include sedimentation and elevated nutrients; overfishing of reef fish; predation by crown-of-thorns starfish (Great Barrier Reef Marine Park and Tasman reefs) and *Drupella* snails (WA); effects of tourism in localised areas.

5. A systematic monitoring program exists only in the Great Barrier Reef Marine Park. The Great Barrier Reef is relatively well-studied (but it is a vast area and problems exist in translating scientific knowledge into management). Other reefs (particularly in Western Australia) are poorly-known.

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Acknowledgments:
The technical paper by Dr J.E.N. Veron was internally reviewed within the Australian Institute of Marine Science,

Chapter 13. Deep water communities[1]

The greater part of the marine environment off continental Australia lies in the deeper waters off the coast. The continental shelf, half of which is less than 50 metres in depth, is 2.5 million square kilometres in area. The continental slope, which starts at depths of 150-200 metres and drops into the abyssal plain at about 4,000 metres, is a further 1.5 million square kilometres in area. Very little is known of the deeper water communities around Australia and although they are remote and inaccessible, significant areas are subject to trawling and other fishing.

Characteristics of the continental shelf

The continental shelf is a continuous feature around Australia ranging in width from 15 kilometres off the south-east coasts, to 400 kilometres in the Timor Sea (Chapter 3). The type of communities present on the shelf and slope depends on the type of sediments, terrestrial inputs, and depth. The south-eastern to south-western shelves are covered with coarse calcareous and mainly relict sands, the remains of bryozoans, molluscs and foraminiferans, and terrestrial input is minimal.

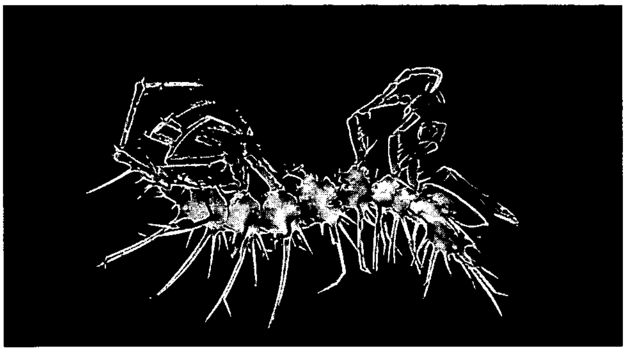
The eastern shelf off New South Wales comprises relict, sandy sediments which are terrigenous in origin closer to the coast, and calcareous below 60 metres depths. Terrigenous muds dominate the inner shelf sediments of the Great Barrier Reef, and carbonates dominate the mid and outer shelf. The sediments of the Gulf of Carpentaria are very fine and are rich in faunal remains. Those of the Arafura Sea and most of the west coast are mostly coarse and calcareous. There is very little terrigenous sediment.

The Australian shelf environment is peculiar, especially in the south, in the dominance of coarse particles and virtual absence of terrestrial material. The coarse materials create the complex microhabitats which contribute to high macrofaunal densities and species diversities.

Biological communities

The physical environment of the shelf is almost entirely soft sediment and is inhabited by infauna (burrowing into the top few centimetres), epifauna (attached to or walking on the sea floor), and demersal species (swimming over the bottom). Offshore reefs are a very small and little known part of this environment (Chapter 11).

Scientific knowledge of Australia's shelf and slope communities is very patchy. The water is generally too deep for scuba diving, necessitating time-consuming and expensive shipboard sampling using dredges, grabs and recently, underwater video. Much of the coast is remote and the large climatic range makes generalisations difficult. Only three areas around Australia have been studied in some detail. These are discussed below. Surprisingly, very little is known of the shelf communities off Sydney and most other State capitals.



(Source: M. Marmach)

Figure 13.1: Isopod crustaean (genus *Antarcturus*) from 800 metre depth off New South Wales. Isopods are one of the most diverse groups in deep water.

The Great Barrier Reef shelf and slope

Studies by the James Cook University on the Great Barrier Reef shelf found a diverse epifauna (for example, 103 species of echinoderms and 196 species of molluscs) separated into an inshore community on muddy sediments, and an offshore community on deeper calcareous sediments. Rubble was important for attachment for solitary and colonial species, forming multispecies isolates. Feeding strategies included filter-feeding, browsing, carnivory and deposit feeding, and varied patchily across the shelf. The deeper slope communities have been only recently investigated by the Australian Institute of Marine Science.

Bass Strait and South-East Australian slope

Studies by the Museum of Victoria found an exceptionally diverse fauna on the Bass Strait shelf. In only 1.2 square metres of sea floor there were 353 invertebrate species, half of which were crustaceans

[1]Based on a paper by Dr G.C.B. Poore, Museum of Victoria, Melbourne, Victoria.

and the rest polychaetes and molluscs. Ten square metres of sea floor contained over 750 different species.

A rich fauna was also found on the slope between 200 and 3,000 metres. Many undescribed aplacophoran molluscs, a relict group of Tethyan origin, were present. Three species pairs, each with related species on the shelf and deeper slope, were found, indicating local speciation and a slope origin for some species. Isopod crustaceans comprised 359 species, of which only 10% were known to science. More than 90 species of ostracods were found, most new to science.

North West Shelf

A multidisciplinary study by CSIRO found the epibenthos was composed of sponges, gorgonians, soft corals and sea-pens, scattered over rippled bare sand. Some 308 species of demersal crustaceans were found, including crabs, penaeid prawns and carid shrimps, and distributions were correlated with depth. The infauna was dominated by polychaetes of extremely high species diversity.

Status of deep water communities, and major threats

Little is known of human impacts on Australia's shelf communities. In fishing grounds, otter trawls may remove bottom species and modify the bottom habitat. The discarded 'trash' or by-catch may alter food chains by providing more food for carnivores, scavengers and decomposers (Chapter 32). Localised damage may occur around ports and industrial areas from dumping of dredge spoil and industrial wastes at sea (Chapter 36) and by discharged muds and effluents around offshore oil platforms (Chapter 37).

Populations of some shelf and slope fish have been greatly reduced by overfishing (Chapter 30). These include school and gummy sharks (Bass Strait, depths to 200 metres); grenadier (New South Wales to South Australia, depths 200-700 metres); and orange roughy (New South Wales to Western Australia, depths 700-1,400 metres). While stocks have been significantly reduced, no species' survival is threatened. The effects of the removal of these high level predators on the ecology of the sea floor are unknown.

Conservation and management

Because it is out of sight and scientifically unknown, most of Australia's shelf and slope sea floor is not actively managed. Trawling is prohibited on some areas of shelf, for example, in areas of the Great Barrier Reef Marine Park and in the Protected Zone of Torres Strait. Sea dumping of wastes is regulated under MARPOL (Chapter 36).

Status of knowledge and monitoring

Vast areas of Australia's shelf and all except two tiny areas of slope have never been visited by biologists. Only three quantitative studies have ever been undertaken. Specimens from these have been curated and taxonomic studies are underway, but little has been published in the scientific literature.

Summary and conclusions

1. Little is known of the biology of Australia's continental shelf and slope. The three quantitative studies conducted indicate a high species diversity.

2. Despite the importance of prawn and fish trawling on Australia's continental shelf, the effects on benthic communities are virtually unknown.

3. Management is limited. Trawling is prohibited in shelf waters only in a relatively small area of the continental shelf. Sea dumping is controlled under MARPOL.

4. Further taxonomic and ecological research is necessary on Australia's continental shelf and slopes.

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Chapter 14. Phytoplankton: the pastures of the sea[1]

The minute algae that make up the floating pastures of the seas are the food base that supports, either directly or indirectly, the entire production of the open sea. There are growing concerns that the deteriorating environment of most major rivers and estuaries near Australia's large coastal cities is affecting phytoplankton and food chains. Red tides and blooms of toxic marine algae are increasing because of increasing nutrients from catchments, in the same manner as the toxic algal blooms which are devastating Australia's inland waterways.

Like land plants, phytoplankton require carbon dioxide, water, sunlight and nutrients for growth and photosynthesis. For their nutritional requirements (nitrates, phosphates, silicates) phytoplankton are strongly dependent upon upwellings. While Australian waters have no major upwelling systems comparable to those off Peru, California or north-west Africa, enrichments of a lesser kind do occur regularly and provide the nutrients for rich diatom blooms which support Australia's most productive fisheries grounds (Chapter 2).

Anthropogenic nutrient discharges via domestic and industrial wastes can also increase the algal biomass of coastal waters but, more seriously, this has the potential to dramatically alter the original phytoplankton species composition with far-reaching implications for the structure of entire marine food chains.

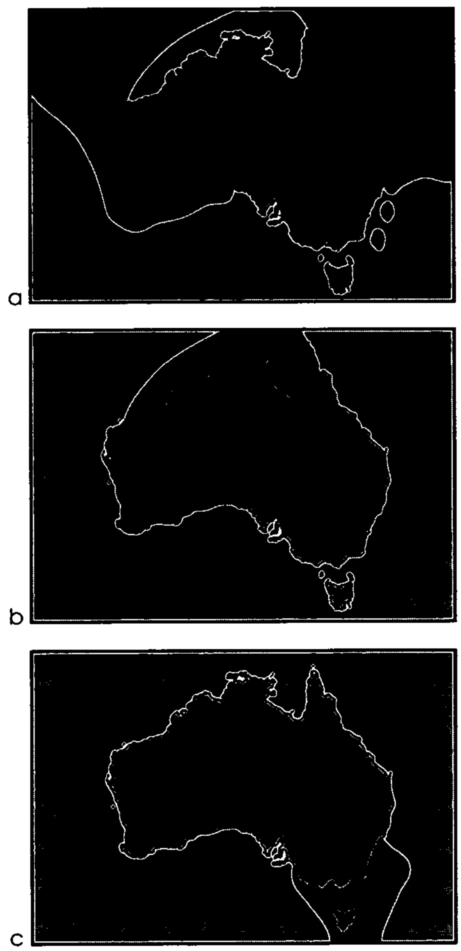


Figure 14.1: The distribution of three distinct marine phytoplankton assemblages in Australian waters: (a) tropical oceanic species; (b) tropical neritic species; and (c) temperate neritic species (after Jeffrey and Hallegraeff 1990). These assemblages support different marine food chains and are likely to have different sensitivities towards nutrient and pollutant stress.

Characteristics

Biodiversity

Australia's marine phytoplankton comprises representatives of 13 algal classes, including the well-known diatoms (5,000 species), dinoflagellates (2,000 species), golden-brown flagellates and green flagellates (several hundreds of species). The phytoplankton flora of the Australian region has strong similarities with the warm and cold water phytoplankton floras of the northern hemisphere. There is virtually no endemism.

Ecology

There are three distinct phytoplankton assemblages in Australia's marine environment: a temperate neritic community in coastal waters of New South Wales, Victoria and Tasmania; a tropical neritic community confined to the Gulf of Carpentaria and North West Shelf; and a tropical oceanic community in the offshore waters of the Coral Sea and Indian Ocean (Figure 14.1). Depth distribution of phytoplankton is limited by the extent to which photosynthetically available sunlight can penetrate, which ranges from several metres in turbid estuaries, to 200 metres in the clearest oceanic conditions.

[1]Based on a paper by Dr G.M. Hallegraeff, Department of Plant Science, University of Tasmania, Hobart, Tasmania.

Phytoplankton community status and major environmental issues

There is a growing concern about the environmental quality of most major rivers, estuaries and coastal waters near Australia's large population centres, where discharges of industrial, domestic and agricultural wastes are raising the nutrient levels in the water.

Phytoplankton blooms

Phytoplankton species that always have been present in low concentrations respond to this nutrient increase by growing to bloom proportions (millions of cells per litre), and generate anoxic conditions resulting in indiscriminate kills of both fish and invertebrates, especially in sheltered bays.

The dinoflagellate *Scrippsiella trochoidea* has caused red-brown seawater discolourations and fish kills, for example, in West Lakes (SA) and the Hawkesbury River (NSW), and has also been implicated in causing fish kills in Sydney Harbour as early as 1890. Other estuaries with annually recurrent algal bloom problems are the Port River (SA), Huon and Derwent Rivers (Tas), the Peel-Harvey estuary and Cockburn Sound (WA), and Port Phillip Bay (Vic). As in many other parts of the world in the past two decades there has been an apparent increase in the frequency, intensity and geographic distribution of such harmful algal blooms in the Australian region.

Cultural eutrophication

Overseas experience from areas such as Hong Kong Harbour, the Seto Inland Sea in Japan and North European coastal waters indicates that 'cultural eutrophication' from domestic, industrial and agricultural wastes can stimulate harmful algal blooms (Chapter 42).

The nutrient composition of treated waste water is different to that of the waters in which it is being discharged, and indiscriminate reductions in nutrient discharges are therefore not addressing the problem of changing nutrient ratios of coastal waters. Such altered nutrient ratios may favour blooms of nuisance flagellate species which replace the normal spring and autumn blooms of 'wholesome' siliceous diatoms. Changed patterns of land use can also cause shifts in phytoplankton species composition by increasing the concentrations of humic substances in land run-off. The only long-term phytoplankton or nutrient data available for any Australian waters are for the CSIRO hydrological stations at Maria Island (Tas), Rottnest Island (WA) and Port Hacking (NSW).

Cyanobacterial blooms

The filamentous cyanobacterium *Trichodesmium erythraeum* is the most common 'red tide' organism in tropical Australian coastal and oceanic waters. This produces seasonal (February-April) blooms in the Java, Banda, Arafura and Coral Seas, and from there the East Australian Current and Leeuwin Current transport the algal masses (covering up to 40,000 square kilometres) as far south as Sydney and Perth. The alga is a nuisance to swimmers on Australian beaches and has significant impacts on recreation. It is capable of fixing atmospheric nitrogen, which allows the alga to thrive under nutrient-impoverished oceanic conditions, but it is possible that coastal nutrients (especially phosphates) can stimulate or prolong the blooms once they are washed inshore.

Toxic blooms of the cyanobacterium *Nodularia spumigena* are increasing in frequency and distribution in the Gippsland Lakes system (Vic), the Peel-Harvey, Cockburn Sound and Vasse-Wonnerup estuaries (WA), and the Darling and Murray Rivers (SA). They appear to be related to phosphorus from agricultural fertilisers and sewage being washed into the river systems. They produce the peptide hepatotoxin, nodularin, which has killed domestic and wild animals that drink from the shores of eutrophic ponds, lakes and reservoirs.

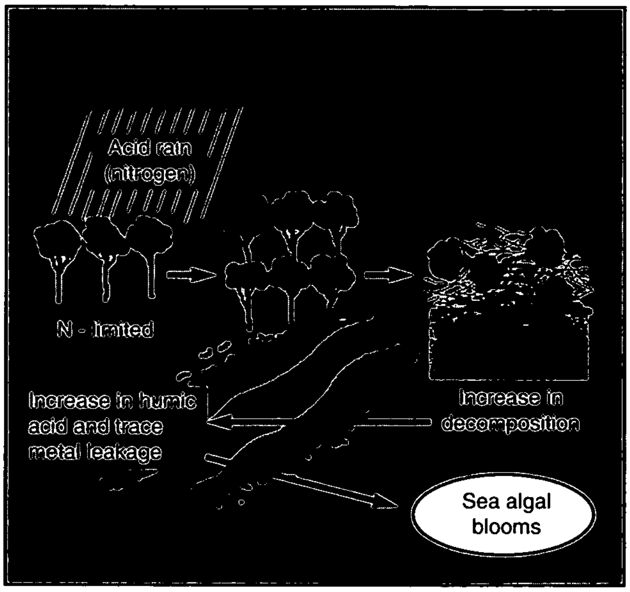
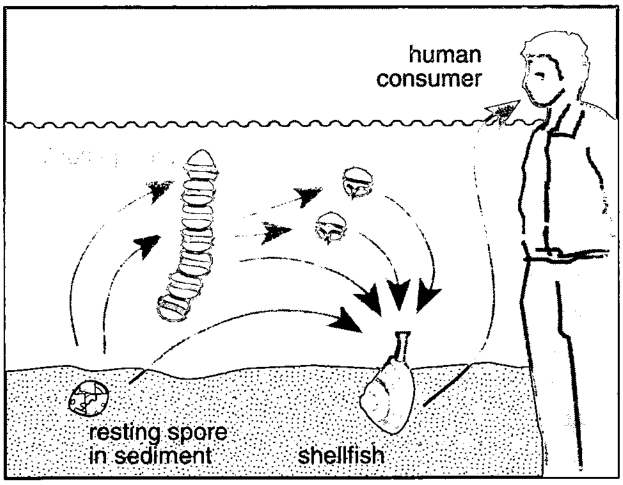


Figure 14.2: Changed patterns of land use can affect phytoplankton communities. For example, deforestation can increase the concentration of humic substances and trace metals in land run-off. This can cause shifts in phytoplankton species' composition.

Toxic marine algae

Algal blooms may contaminate shellfish with neurotoxins or damage the sensitive gill tissues of finfish, especially when held in intensive cage culture systems. Until the late 1980s, the phenomenon of paralytic shellfish poisoning (PSP) was unknown from the Australian region. Blooms of the dinoflagellate *Gymnodinium catenatum* in 1986, 1987, 1991 and 1993 caused the temporary closure of up to 48 Tasmanian shellfish farms for periods of up to 6 months. This species may have been introduced and cyst stages of this species have been detected in ships' ballast water entering Australian ports from Japan and Korea (Chapter 48).



(Source: G. Hallegraeff)

Figure 14.3: Blooms of introduced toxic dinoflagellates, microscopic single-celled algae, may contaminate shellfish and poison seafood consumers.

Red tides of the toxic dinoflagellate *Alexandrium minutum* were first recognised in the Port River area near metropolitan Adelaide in October 1986. This species now produces annually recurrent red water blooms (up to 108 cells per litre) in the period September to November, making wild mussels from the Port River highly toxic. This could also be an introduced species as genetic studies using ribosomal DNA sequencing have confirmed a close affinity between Australian and Spanish isolates of this species. The toxic dinoflagellate *Alexandrium catenella* was first recognised in 1986 in Port Phillip Bay where it has caused significant toxicity in wild mussels. It is also known from Sydney coastal waters.

Once an area has been infested with cyst-producing toxic dinoflagellates, there is little possibility of eradicating the problem. The only solution is an avoidance strategy of regularly monitoring shellfish products for toxins and, if necessary, imposing temporary closures of aquafarms. Every attempt should be made not to spread the problem, for example, by resuspending cysts by dredging operations or by relaying shellfish stocks to noninfected areas.

Effects on phytoplankton of chemical pollutants

Chemical pollutants, including both organic and inorganic compounds, can cause selective inhibition of phytoplankton species, with wide ranging effects at higher trophic levels. Chlorinated organics, including DDT, dieldrin, chlordane, PCBs and chlorophenols, are of particular concern because they readily absorb to particulates and sediments, are resistant to degradation and have the potential to bioaccumulate. PCB levels (1-10 micrograms per litre) have been reported in Port Phillip Bay and Botany Bay, and may depress the growth of sensitive diatoms.

Pesticides in agricultural land run-off may inhibit zooplankton grazing, thereby stimulating algal blooms. Discharges from chlorine-bleaching pulp and paper mills, including chlorate, chlorophenols, resin acids and chlorinated lignin derivatives may also affect phytoplankton. Some of the chlorophenolic compounds, such as the more substituted chlorocatechols, are toxic to freshwater algae and marine diatoms. Petroleum hydrocarbon contamination (1-23 micrograms per litre) has also been documented in Australian waters, for example in Port Phillip Bay. While occasional oil spills may lead to acute toxic effects and plankton mortality, chronic effects are less likely to occur because of degradation and removal processes.

Heavy metals (zinc, copper, lead, mercury, cadmium, nickel, chromium, silver, arsenic and selenium) from metal smelting, mining and other industrial processes may affect phytoplankton around Cockburn Sound and Albany Harbour (WA); Spencer Gulf (SA); Corio Bay (Vic); the Derwent estuary, Macquarie Harbour and the north coast of Tasmania; Port Kembla, Newcastle, Sydney Harbour, Botany Bay, Lake Macquarie and Lake Illawarra (NSW); and Townsville Harbour (Qld).

Maximum concentrations of cadmium (2 micrograms per litre), lead (10 micrograms per litre) and zinc (142 micrograms per litre) have been reported in the Derwent River. Mercury concentrations up to one microgram per litre have been found in Victorian coastal waters, although it is the physico-chemical form of the metal and not just its total concentration which determines its bioavailability and toxicity to phytoplankton. Metal speciation is influenced by temperature, pH, salinity, nutrients, and the presence of other metals and organic chelators such as humic and fulvic acids. Low concentrations of metals can stimulate, but higher concentrations inhibit, algal growth.

(Source: F. Kristo)

Figure 14.4: Phytoplankton (coccolithophorid) bloom, Jervis Bay, January 1993.

In general, the dinoflagellates, diatoms and cyanobacteria are the most sensitive to heavy metals, whereas the green flagellates are the most resistant. The sensitivity of different phytoplankton species varies by orders of magnitude, and the major impact of heavy metal stress therefore would be a shift in species composition.

Possible effects of global climate change

Global climate change and El Niño phenomena have the potential to modify existing current regimes in the Australian region and thereby alter natural nutrient-enrichment patterns. Ozone depletion has the potential to alter the species composition and depth distribution of phytoplankton organisms sensitive to ultraviolet radiation. The most serious consequences would be for the structure of marine food chains.

Conservation and management

Nutrient loading criteria are needed for all Australian coastal waters if these waters are to be managed in a sustainable manner, and if conflict situations arising from new developments are to be solved on a sound scientific basis.

Agencies responsible for management decisions on pollutant loadings of rivers and coastal waters, including decisions on agricultural and forestry practises in catchment areas, should be aware that one probable outcome of increased nutrient loading will be an increase in harmful algal blooms.

Guidelines have been developed for the discharge of ships' ballast waters in the open sea to avoid further introductions of harmful exotic phytoplankton into sensitive coastal waters (Chapter 48).

Summary and conclusions

1. Adequate phytoplankton baseline studies are lacking for many parts of the Australian coastline. Long-term nutrient and species data are virtually absent, making it extremely difficult to recognise the introduction of immigrant species or to provide early warning of cultural eutrophication.

2. Experience in Europe, North America and Japan has demonstrated that domestic and industrial nutrient discharges to inland and coastal waterways have the potential to increase phytoplankton biomass levels as well as dramatically altering phytoplankton species composition.

3. Most rivers, estuaries and coastal waters near Australia's large population centres show signs of cultural eutrophication, e.g. Port Phillip Bay and Gippsland Lakes (Vic); Derwent and Huon River (Tas); Port River and West Lakes (SA); Peel-Harvey estuary and Cockburn Sound (WA); and the Hawkesbury River and Tuggerah Lakes (NSW).

4. The management of nutrient discharges to inland and coastal waterways is necessary to arrest the increasing impact of harmful algal blooms.

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Chapter 15. Issues in the conservation of rare, threatened and endemic marine species[1]

While there has been great concern regarding the loss of biodiversity around the world, this has largely focused on terrestrial species, and a few marine species such as the whales. Recognition of the general threats to marine biodiversity is relatively recent. The world wide decline in coral reefs, changes to temperate kelp bed communities, declines in seagrass beds, and loss of saltmarsh and mangroves are now viewed with growing alarm.

Although there are several examples of marine birds and mammals that have become extinct (such as the great auk and Stellar's sea cow), or endangered (such as the blue, fin, humpback, sei and southern right whales), little is known of the status of the vast majority of marine fish and invertebrates. Only one extinction of a marine invertebrate has been reported: the limpet *Lottia alveus* from eelgrass beds off eastern North America. The extent of the problem of marine extinctions is not known. Nor is it known whether the current approaches to species conservation will be appropriate for marine organisms.

In Australia public concern and research on endangered species has centred on the unique terrestrial mammals and birds, of which around 18 have become extinct over the past century, and 120 are thought to be threatened. While there have been no known marine extinctions, concerns have been expressed on the growing number of overfished and overharvested species.

This chapter examines the concepts of rare and threatened species and the peculiarities of marine species. It focuses on the key issues of the extent of species endangerment and extinction in the marine environment; the extent to which the basic concepts of conservation biology developed for terrestrial organisms can be applied to marine species, particularly those with dispersive larval phases; and the characteristics of species most likely to become threatened. It concludes with a discussion of appropriate conservation strategies for potentially threatened marine species.

Rare and threatened species: a marine perspective

What is the difference between rare and threatened species?

It is initially important to draw the distinction between rare and threatened species. The majority of marine organisms are, for whatever reason, naturally rare in that they have low local abundances. However, many also have wide geographic distributions and overall numbers of individuals in the species may be high. For example, of the 1,500 or so fish species on the Great Barrier Reef, most have a broad Indo-Pacific distribution and many would be considered rare on the basis of average density. Naturally rare species may be more vulnerable to extinction than abundant ones, particularly if they have narrow geographic ranges or are highly specialised, but rare species are not necessarily threatened.

(Source: G. Bull, GBRMPA)

Figure 15.1: Many species of coral reef fish are rare but have wide distributions. Long-nose butterflyfish, *Forceptiger longirostris.*

Endangered or threatened species are defined as those in which their survival is unlikely if the causal factor(s) for their declines continue operating. Species at risk are not necessarily rare.

The International Union for the Conservation of Nature (IUCN) has attempted to account for the variability in status by establishing a range of

[1]Based on a paper by Dr G.P. Jones and Dr U.L. Kaly, Department of Marine Biology, James Cook University, Townsville, Queensland.

categories: 'Extinct'; 'Endangered'; 'Vulnerable'; 'Rare'; and 'Indeterminate'. However, these are highly subjective and there are no standards which can be applied across taxa or habitats.

Difficulties in determining the status of marine species

Marine populations have characteristics which make the detection of depletions difficult.

Fluctuations in recruitment and breeding population size can obscure long-term trends. An imminent population crash may not be detected, such as in the case of the collapse of the Peruvian anchovy fishery.

Patchy distributions can make reliable estimates of density or population size difficult to obtain, even for very common species. Often only quantum changes in numbers can be detected.

Adequate methodologies for detecting and determining the trends in abundances of rare species are generally lacking.

Why are there fewer threatened species in the sea?

While there are many clear examples of endangered species on land, there are few in the sea. They either may not exist, or we may not have detected them. While it is likely that the impacts of humans have not been as devastating on the sea as on land, the life history and population characteristics of the majority of marine organisms make them less prone to global extinction.

Most marine invertebrates and bony fish have a dispersal stage and wide geographic distributions. Isolated sub-populations of adults are linked by larval dispersal which can replenish areas where local extinction occurs. Survival of larvae in the plankton may also be largely independent of a falling stock size or processes affecting adult populations.

Effects of local and ecological extinctions

Although global extinction in marine species is uncommon, local extinctions may have a major impact on the structure of marine communities and the functioning of marine ecosystems. For example, where the Californian sea otter has become locally extinct, benthic communities are dominated by sea urchins and the kelp becomes overgrazed. Similar effects may follow an 'ecological extinction' when a species is reduced to such low abundances that it no longer plays its original ecological role. For example, in North America overfishing of lobsters, once important predators in kelp forests, has led to community changes. On the Great Barrier Reef it is suggested that overcollecting of triton shells and overfishing of fish predators of the crown-of-thorns starfish has led to outbreaks.

In the marine environment the local or 'ecological' extinction of species playing 'keystone' ecological roles is of far more concern than the unlikely global extinction of the vast number of essentially 'redundant' species.

Threatened marine species in Australia

A recent review of endangered Australian species (Kennedy 1990) lists only five fish (Chapter 16). A listing by Fry and Robinson (1986) described 230 species of molluscs (including 44 tropical cowries, 23 cone shells and 6 tritons) as potentially vulnerable and requiring monitoring to determine their status. Only the Queensland cowry, *Cypraea queenslandica*, was considered endangered (Chapter 16).

So far there has not been a systematic approach to the conservation of marine species in Australia, although various species have been specifically protected (Chapter 60). For example, the giant clams (family Tridacnidae) which have been harvested to local extinction in over part of their ranges, and large cods (potato cod, *Epinephelus tukula*; estuary groper, *E. tauvina*; and giant groper *Promicrops lanceolatus*) which have been locally depleted, are protected on the Great Barrier Reef (Chapter 16).

(Source: L. Zann, GBRMPA)

Figure 15.2 The giant triton *(Charonia tritonis)*, a predator of crown-of-thorns starfish, is a naturally rare species. It has been suggested that overcollecting may lead to outbreaks of the starfish.

Application of terrestrial species management strategies to marine environments

It is evident that much of the current theory developed in terrestrial conservation biology cannot be uncritically applied to marine species and habitats.

Minimum viable population size

The minimum viable effective population size for terrestrial animals is usually based on the '50-500 rule'. This states that an 'effective population' size (Ne) of greater than 50 is necessary to avoid inbreeding problems, and that an Ne of greater than 500 is necessary to avoid loss of genetic variation to genetic drift. Inbreeding and loss of genetic variation can rapidly lead to extinction in 'closed' populations.

An Ne of 500 may equate with an 'actual population' (N) of up to 2,500, depending on the number of mature, actively breeding individuals present. While the '50-500 rule' is not universally accepted for terrestrial species, genetic factors do not apply to the small 'open' populations of marine organisms. This is because marine populations are characterised by high levels of gene flow among subpopulations.

Threatened species categories

The estimates of minimum viable populations are used as criteria for threatened species categories:

- Critical: Ne fewer than 50 individuals (N fewer than 250)
- Endangered: Ne between 50 and 500 individuals (N fewer than 2,500)
- Vulnerable: Ne between 500 and 2,000 (N fewer than 10,000)

Marine mammals appear to be arbitrarily classified as endangered when numbers are reduced to four digit estimates but no marine invertebrate or fish is known to be within these ranges. It is doubtful if precise estimates could be collected for any marine species, except perhaps for endemic species with very restricted geographic ranges. Simple thresholds in population size are unlikely to be applicable to the majority of marine species because of their extremely high juvenile mortality, fluctuating recruitment, and a poor relationship between recruitment and adult numbers.

Population Viability Analysis and habitat fragmentation

Population Viability Analysis is a more general approach using models to assess the extinction pressures on a small population, for example demographic variation, chance environmental factors, population structure and increasing fragmentation. While the approach is considered promising, there are few models which can be realistically applied to marine species' open populations. In addition, no realistic estimates of numbers of subpopulations, the trends in the subpopulations, the level of larval and adult exchange, and interconnectivities of subpopulations are available for marine species.

Reserve design and shape

Community and ecosystem responses to habitat fragmentation have led to considerations of the appropriate size and configuration of reserves. Terrestrial reserves are treated as 'islands' and island biogeography theory is applied to maximise colonisation and minimise extinction. This has culminated in the 'SLOSS' debate (single large, or several small reserves).

However, studies on coral reef fish indicate that rates of colonisation and extinction appear to be largely independent of variation in the number of resident species, patch size and shape because of the unpredictable nature of larval supply and adult mortality. The use of 'corridors' in terrestrial reserves to connect habitat fragments and reserves is not applicable in the sea.

Characteristics of potentially threatened marine species

At this early stage of marine conservation, any attempt to grade species according to the degree of threat is likely to prove futile. An alternative, although still subjective approach, is to recognise the characteristics of species that are at least 'potentially threatened' by extinction, and develop management strategies as a precautionary measure.

It must be stressed that species having these characteristics are not necessarily endangered. Some marine species exhibit combinations of these characteristics, increasing the risk. However, for the majority of marine species there is not sufficient information on distribution, recruitment and population variability, susceptibility to stress, degree of exploitation and other characteristics to assess their vulnerability.

(Source: GBRMPA)

Figure 15.3: Giant clams have become locally extinct in many parts of Asia and the Pacific because of overcollecting.

Potentially vulnerable marine species

Species with restricted geographic ranges
Examples of Australian endemics with narrow ranges include the starfish *Marginaster littoralis* which has a known range of one hectare in Derwent Estuary; the triplefin blenny (*Forsterygion gymnotum*) which is confined to Derwent Estuary; the skate *Raja cf. nasuta* which is confined to Bathurst Harbour Estuary; and four coral species which are confined to the Abrolhos Islands. Such species may suffer global extinction from relatively small-scale impacts.

Species with unusually restricted breeding sites
Many highly mobile marine species converge on specific breeding grounds, representing only a small part of their geographic range, e.g. southern blue-fin tuna. Here they are potentially vulnerable to overfishing or environmental disturbances.

Species that are very large, long-lived and/or of low fecundity
Typically, these species are also naturally rare and aggregated, slow to mature and have consistently low recruitment. These characteristics make them prone to overexploitation and slow to recover. Australian examples include giant clams, black cod, and great white sharks. Large, live-bearing fish such as sharks and rays, and most marine reptiles and mammals are particularly susceptible to overexploitation.

Species subject to large-scale mass mortality
A number of marine species exhibit catastrophic declines in abundances over a short period. Examples include mass mortalities of sea urchins in the Caribbean, seagrasses die-back, and mass mortality of marine mammals due to parasites, toxins and strandings.

Species subject to prolonged recruitment failure
While most marine species exhibit variable recruitment and 'year-class phenomena', this occurs over extended periods in species such as the potato cod.

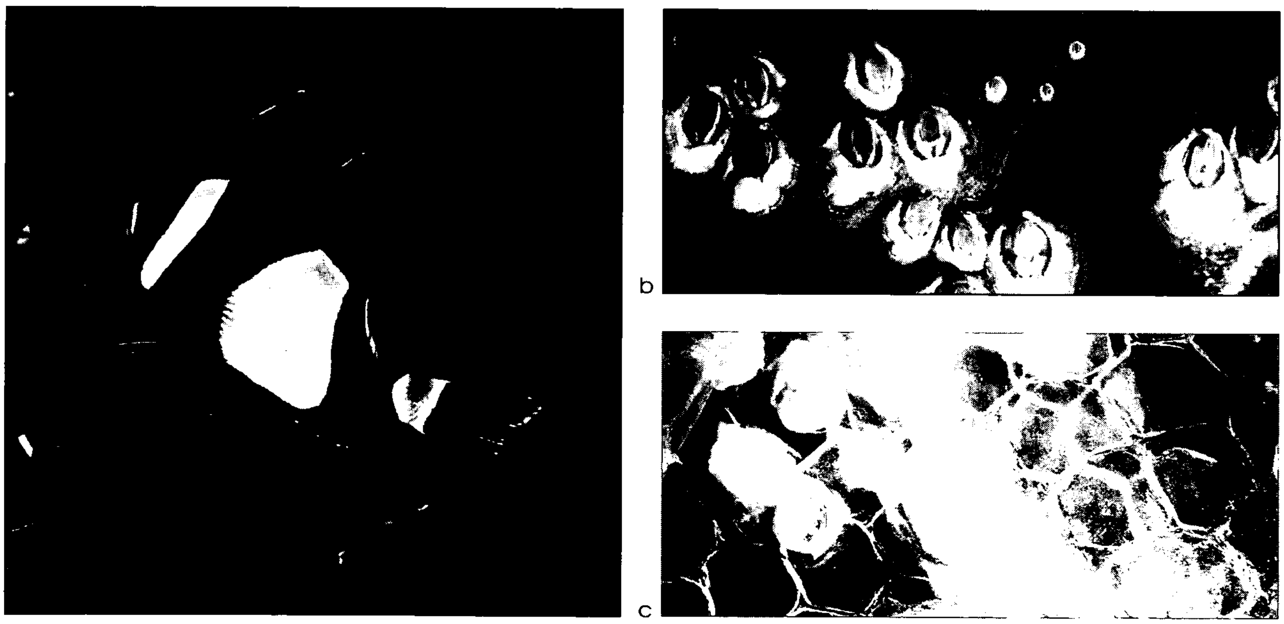
Species highly susceptible to environmental stresses
These may be the first to become extinct locally, and may be the first to succumb to global threats such as ocean warming. They may be used as 'early warning' indicators of changes.

Species that are extreme habitat specialists
These include symbiotic species associated with a single species of host, for example anemone fish and turtle barnacles.

Obligate supratidal, intertidal, estuarine and coastal embayment species
The potentially limited habitats and their susceptibility to human disturbances makes these vulnerable.

Species subject to excessive exploitation
A growing number of marine reptiles and mammals (Chapter 18), fish (Chapter 16) and invertebrates in Australia have been overexploited.

(Sources: all L. Zann)



a b c

Figure 15.4: Species with highly specialised habitats may be vulnerable. (a) Anemone fish, symbionts of giant sea anemones, may be overcollected for the aquarium trade. (*Amphiprion latezonatus*, Solitary Is, NSW). (b and c) Certain epizotic barnacles have very specialised habitats: *Platylepas hexastylos* (b) is found only on dugongs and turtles; *P. ophiophilus* (c) is found only on sea snakes.

(Source: L. Zann)

Figure 15.5: Species with restricted geographic ranges are potentially vulnerable. The young of the gastropod snails of the Family Volutidae hatch directly from eggs and most species have narrow distributions. Top: *Cymbiolacca cracenta* (Cairns area); middle: *C. pulchra* (Heron Island left, and deepwater, Rockhampton variety right); bottom: *C. complexa* (deepwater, southern Queensland).

Conservation strategies for rare, threatened and endemic marine species

One of the oldest debates in ecology, whether research effort should favour the species by species approach, or focus on communities and ecosystems, is being revisited by marine conservation biologists and managers. While the debate was never resolved, a diversity of approaches will maximise the chances of protecting species within the ecosystem in the long-term. The very large number of marine species (many of which are undescribed), our inability to recognise the endangered among them, and the potentially high level of ecological redundancy favours the ecosystem perspective. The need to maintain water quality also favours a large scale or systems approach.

Species of special conservation status

Five types of species deserving special conservation status have been identified (Noss 1990). These are:

- ecological indicators (species which may provide an early warning of detrimental impacts on the community);
- keystone species (pivotal species upon which the diversity of a large component of the community depends);
- umbrella species (species with large area requirements, which given sufficient protected habitat area, will bring many other species under protection);
- flagship species (popular species that serve as rallying points for major conservation initiatives); and
- vulnerable species (those which are actually prone to extinction).

Vulnerable species are the most difficult to identify in marine ecosystems, while the flagship species are most identifiable.

Networks of marine protected areas

The most effective way of ensuring some degree of protection of widely distributed, but rare marine organisms is the establishment of a network of marine reserves encompassing a proportion of all marine habitats and biographical regions. Marine reserves have been shown to have considerable beneficial effects on excessively exploited species and can shift communities back toward a 'more natural' community structure. Their effectiveness as a management tool for rare or endangered species has yet to be evaluated, and they may not be effective for highly mobile species. A system of species-oriented approaches is also likely to be necessary.

As a precautionary measure, marine protected areas should also be selected to contain populations or breeding areas of 'potentially vulnerable' species. This species include endemic species with small geographic ranges, and localised breeding sites; and long-lived, large species which aggregate.

Rare habitats which support endemic species are a high priority for protection. For example, Shark Bay (WA) contains the famous stromatolytes at Hamlin Pool, the extensive Wooramel seagrass beds, and the habitats of several rare and threatened species such as dugongs which all require protection.

Other conservation tools

Other means of preserving threatened species include regulation of collecting or fishing of them; imposition of quotas and size bans on them; preservation of their habitats; enhancement of their natural populations through artificial breeding programs; and pollution controls to protect water quality.

The transfer of remaining individuals to 'island refuges' free from predators and exotic competitors, a last resort for endangered terrestrial species, may not be effective for marine species with dispersive larvae. Where the probability of extinction has been increased through loss of habitat, restoration ecology may be necessary.

Summary and conclusions

1. It is difficult to apply the endangered species concept to marine animals other than mammals and some reptiles. Management strategies for conserving terrestrial species are generally not appropriate for the marine environment.

2. Many marine species are relatively rare but are not necessarily endangered.

3. While species extinctions are infrequent in the marine environment, local and ecological extinctions of keystone species are more common, and have a major impact on marine habitats and ecosystems.

4. Many marine species are undescribed. Most are little known. An enormous taxonomic and monitoring effort would be required to establish the full complement of species and their status.

5. Given this lack of knowledge, precautionary population management strategies in the marine environment include protected areas for endemic species with small geographic ranges or restricted breeding sites; protection of long-lived, large and wide-ranging species; and population enhancement for excessively exploited species.

6. Networks of marine protected areas are an important' catch all' strategy for protecting the majority of species of unknown status and importance.

7. Information on ecologically important species, their interactions, methods for detecting and monitoring ecologically important species, and a greater knowledge of population structure and larval dispersal will be essential for more targeted management strategies.

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Chapter 16: The status of marine invertebrates and fish[1]

Australia has a very high diversity of marine invertebrates and fish. Northern Australia lies towards the centre of species richness in the Indo-Pacific, and southern Australia has a very high proportion of endemic species, some of which are 'living fossils'. As discussed in the previous chapter, marine invertebrate and fish conservation is a relatively new area, and the status of very few of these species and mechanisms for their conservation remain little known.

Although no Australian invertebrate or fish species is known to have become extinct in recent times, a number of species are considered to be threatened because of their specialist habitats, restricted distributions, and low reproductive rates. Several Australian freshwater fish species have been listed by the International Union for the Conservation of Nature and Natural Resources (IUCN) as 'Endangered' or 'Vulnerable', and a number of marine invertebrate groups found in Australia are listed in the Convention on International Trade in Endangered Species of Wildlife Flora and Fauna (CITES) Appendices (Chapter 60).

This chapter briefly examines the diversity of Australian marine invertebrates and fish, and discusses threatened species, and threatening processes. The following chapters assess the status of seabirds, marine reptiles and mammals, but no attempt is made to assess the status of marine plants and micro-organisms because of lack of information.

Status of marine invertebrates

Species diversity

A very large number - probably well in excess of 100,000 - species of marine invertebrates are found in Australian waters. Even an approximation is impossible as most groups, particularly the micro-organisms, the nematodes and other worms, and the small crustaceans and molluscs, are very incompletely described. Our knowledge of species in different habitats is also extremely patchy. The deep water benthic fauna, in particular, is huge and almost completely unknown (Chapter 13).

Species diversity is exceptionally high in the better studied groups. Australia lies towards the centre of the most diverse marine province on earth, the tropical Indo-Pacific region. For example, there are around 350 described species of reef-forming corals and over 4,000 species of larger molluscs in northern Australia.

Australia has two major faunal regions, the tropical north and the temperate south, and a large but uncertain number of bioregions or provinces. The fauna of the north is typically Indo-Pacific in origin, with a relatively low number of endemic species, around 5-10% in most groups. The fauna of the temperate south, long isolated geologically and climatically, is Tethyan and Palaeoaustral in origin, with a large number of endemic species (80-90%) in most groups (Chapter 5).

Because of the very incomplete taxonomy of marine invertebrates, the absence of accurate distributional and abundance data on any species, and the conundrum posed by the high frequency of 'rarity' in marine species and the survey problems inherent in this (Chapter 15), the conservation status of very few invertebrate species is adequately known. In most cases these are the better-known specimen sea shells, but these are probably indicatory of the wider situation.

Value of invertebrates

Around 60 species of crustaceans and 30 species of molluscs are commercially fished and aquacultured in Australia. The most valuable are rock lobsters ($330m per year), prawns ($130m per year), pearl oysters and pearls ($130m per year) and abalone ($90m per year).

Marine invertebrates are important in the diets of coastal Aboriginal and Torres Strait Islander peoples. Species such as oysters and mussels have long been harvested by non-indigenous Australians, and octopus, sea urchins and other invertebrates are increasingly collected by Australians of Mediterranean, Pacific and Asian origin. A large range of species are also collected for bait. Some mollusc shells are collected for semi-precious jewellery, handicrafts, curios and specimens.

Threatened invertebrate species

Fry and Robinson (1986) listed over 230 molluscs (including 44 tropical Cypraeidae and 23 Conidae, and representatives from numerous other tropical families) that are potentially vulnerable and need monitoring to

[1]Based on papers by Dr F. Michaelis, Department of the Environment, Sports and Territories, Canberra, Australian Capital Territory; and Dr L. Zann, SOMER Coordinator.

determine their status. Little is known of the status of these and other marine invertebrates, or of threatening processes. Much of the following information is from an unpublished report by Edgar et al. (1991).

Vulnerable endemic species

Endemic species with direct developing stages (i.e. which do not produce planktonic larvae) and with restricted, vulnerable inshore distributions are at most risk (Chapter 15). For example, the type locality of the endemic Western Australian cowry *Cypraea (Zoila) friendii* which lives in seagrass communities is Cockburn Sound (WA). Because the heavily industrialised Sound has suffered a large-scale die-back of seagrass (Chapters 9 and 56), the type population now appears to be almost extinct.

Serious concerns also exist about the virtual disappearance of local populations of the *Zoila* species in South Australia and Western Australia. Popular with shell collectors and very valuable, these species have restricted distributions and are easy to locate by scuba divers. Populations will be slow to recover (if at all), and because they are polytypic, the extinction of local populations may result in the loss of a distinctive local genetic variant.

The members of the gastropod family Volutidae, which is largely endemic to Australia, also have restricted distributions. For example, in Queensland, the Heron Island volute *Cymbiolacca pulchra woolacottae* (a distinctive shallow water form of the more widely distributed species: see Figure 15.5) is restricted to that island and nearby reefs in the Capricorn/Bunker Group. Populations have been declining for many years because of intensive shell collecting, and local genetic variants may be extinct on some islands. Fears were held in the late 1980s that sedimentation following dredging of a boat channel at Heron Island may have caused the extinction of the local population. However, surveys indicated that it was still present, but in small numbers.

Australian marine invertebrates listed on Appendix II of CITES and on Schedule 2 of the *Wildlife Protection (Regulation of Exports and Imports) Act* 1982

Coenothecalia ('blue' hard corals)
Tubiporidae (organ pipe corals)
Antipatharia (black corals)
Scleractinia (hard corals)
Milleporidae (hard corals)
Stylasteridae (hard corals)
Tridacnidae (giant clams)

In Tasmania the seastar *Marginaster littoralis*, a direct-developing intertidal species, is particularly vulnerable as it is restricted to an area of less than one hectare adjacent to Hobart's oil terminal in the Derwent estuary. This species has not been found during recent surveys and is possibly now extinct (Materi 1994). Other direct-developing seastars such as the Tasmanian *Patiriella vivipara* and the South Australian *P. parvivipara* are also vulnerable because of their restricted intertidal habitats and possible competition from an introduced New Zealand *Patiriella* species.

Vulnerable Indo-Pacific species

A number of marine invertebrate species found in Australia are endangered in other parts of their range (e.g. giant clams, family Tridacnidae), or have been subject to uncontrolled international trade (e.g. corals) and have been listed in CITES (Chapter 60).

Local depletions

Intensive shell collecting has resulted in declines of certain intertidal species in popular shelling localities such as Dingo Beach (central Queensland), Long Reef (Sydney), Woodman Point (Perth) and North West Cape (WA).

Loss of habitat

Loss of habitat is probably an even more serious problem than overcollecting. Concerns exist on estuarine and coastal lake species in southern Australia, because of the widespread degradation of their habitats (Chapter 6).

Protective legislation

Edible and bait invertebrate species are subject to bag limits in some States. In the Great Barrier Reef Marine Park collection of corals is prohibited and commercial collection is limited by permits. Recreational shell collection is permitted in general use areas but is subject to bag limits.

Commercially fished invertebrates are covered by the Commonwealth *Wildlife Protection (Regulation of Exports and Imports)* Act 1982, and in the *Great Barrier Reef Marine Park Act* 1975 as these are subject to management plans.

No invertebrates (terrestrial, freshwater or marine) are yet included on the Commonwealth *Endangered Species Protection Act* 1992. A similar Act, the United States *Endangered Species Act* 1973, has begun to include invertebrates and it is likely this will occur in Australia in the future.

As emphasised in the previous chapter, habitat protection through marine protected areas, and maintenance of water quality, are the most effective management mechanisms.

Status of marine fish

Species diversity
Australia has one of the largest fish faunas of any nation. Of the world's 22,000 known species, around 4,000 species, belonging to 303 different families, have been recorded in Australia. As taxonomic knowledge increases, this number is expected to rise to 4,000 to 4,500 species. Around 25% of these, mainly from the south, are endemic.

Value of fish
Around 200 species of 'finned fish' are taken in commercial and recreational fisheries in Australia. The total commercial production is over 100,000 tonnes per year, and the recreational catch is thought to be around 50,000 tonnes per year (Chapter 30 and 33).

The non-consumptive values of marine fish are not known. Australia's aquarium fish industry was estimated to be worth around $80 million per year, of which the marine component is a minor part. The annual value of the Cairns marine aquarium fish industry is estimated to be worth around $1 million per year.

Threatened fish species
The IUCN Red List of 'Threatened' animals contains ten species of marine and freshwater fish species found in Australia. Of these, seven species (all freshwater) were considered 'Endangered' or 'Vulnerable'. The whale shark was considered to be of 'Indeterminate status', and the great white shark and basking shark were considered 'Insufficiently known'.

A review of Australian endangered species by Kennedy (1991) listed five species of marine fish: the great white shark, the grey nurse shark, Herbst's shark, the southern bluefin tuna and the black cod.

The 1992 meeting of the Australian Society for Fish Biology listed the grey nurse shark as 'Threatened'. The 1993 meeting listed the whale shark as of 'Indeterminate Status', and considered that insufficient information was known of the great white and basking sharks. The status of Herbst's shark, the black cod and southern bluefin tuna were considered, but they were not been given any national listing. The 1994 meeting listed one species of handfish *(Brachionichthys hirsutus)* as 'Endangered', two species of handfish as 'Vulnerable', and four species of sawfish as 'Uncertain' (below). *B. hirsutus* is the first marine fish to be listed nationally as 'Endangered'.

No marine fish are currently listed on the schedules to the Commonwealth *Endangered Species Protection Act* or the *Wildlife Protection (Regulation of Imports and Exports) Act.* Consideration is being given to listing species of sygnathiids (sea horses, pipefish and sea dragons) under the latter Act to control the exports of these fishes for the Asian medicine trade, and the aquarium trade.

'Commercially Threatened' species
The IUCN category of 'Commercially Threatened' species applies to those whose populations are threatened as a sustainable commercial resource, or will become so unless their exploitation is regulated. It has only been used for species that have been overfished in several parts of their ranges.

Sharks and rays
Many elasmobranchs (sharks, rays and other cartilaginous fishes) are vulnerable to overfishing because of their low fecundity, and their migratory and aggregative behaviour. They are also subject to loss of habitat, particularly in nursery areas. Because of worldwide concerns on their status, an IUCN Species Survival Commission Elasmobranch Specialist Committee has been established.

In Australia, sharks have been the target of commercial fisheries, and populations of school and gummy sharks have been depleted in the south. Populations of grey nurse sharks have been depleted in the south-east by spearfishing. Sharks are also taken as by-catch of other fisheries, and are caught in the shark nets which protect bathing beaches.

Although incidents of shark attacks are occasional (and are far exceeded by deaths from water related activities such as fishing and drowning), there has been a long-term campaign of shark netting off Australian surfing beaches. By-catch of marine wildlife such as turtles, dugongs, whales and dolphins in these nets is of concern (Chapter 18). Catches of sharks have been steadily declining in many areas, indicating both the effectiveness of the technique, and declines in shark populations. The status of threatened shark species is discussed in the next section.

Southern bluefin tuna
There has been continuing concern on the state of southern bluefin tuna stocks in southern Australia because of overfishing (Chapter 30). While stocks are not considered endangered in the biological sense, the Australian Society for Fish Biology is keeping a watching brief on the issue. The 1992 Convention on International Trade in Species of Wild Fauna and Flora (CITES) considered a proposal by Sweden to have the western and eastern Atlantic populations of northern bluefin tuna placed on CITES Appendices I and II respectively. While the proposal was later withdrawn, this would have automatically listed the southern bluefin tuna under 'look-alike' provisions.

Whitebait
The Derwent whitebait *Lovettia sealii* (Family Aplochitonidae), a small migratory species, is a commercially threatened species in Tasmania. After

peaking in the late 1940s, catches suffered a massive decline leading to the closure of the fishery in 1974. It has slowly recovered, and a limited recreational season has been allowed since 1990 in a few rivers.

Antarctic finfish

Australia is a member of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) which covers the area south of the Antarctic convergence. Various antarctic fish species have been severely depleted. For example, the stocks of *Notothenia rossii* in the South Georgia area are now estimated to be less than 1% of their original size.

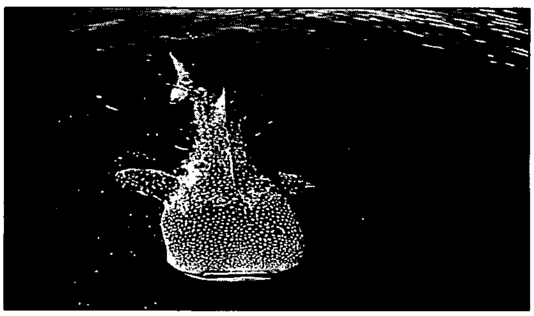
Status of threatened species

Grey nurse sharks

Populations of the grey nurse shark (*Carcharias taurus*) in south-eastern Australia have been seriously depleted by recreational spearfishing. The grey nurse shark and Herbst's shark *(Odontaspis ferox)* are now protected under the regulations of the New South Wales *Fisheries Management Act* 1994.

Whale shark

The whale shark (*Rhincodon typus)* is a rare, cosmopolitan species found generally between 30°N and 35°S. As there were only 320 scientific recorded sightings prior to the mid-1980s, there was considerable interest in the discovery of a local migratory population of around 200 sharks off Ningaloo Reef in Western Australia. Of these, 60 have been tagged to date but it is too early to establish population trends. The range and migratory patterns of the population are not known, and their conservation status when not resident in Australian waters can only be surmised.



(Source: GBRMPA)

Figure 16.1: Whale shark.

Sawfishes

Five species of these large rays (related to sharks) are found in tropical Australia's marine, estuarine and freshwater habitats. The four marine species, *Pristis clavata, P. ziisron, P. pectinata* and *Anoxypristis cuspidata,* are listed by the Australian Society for Fish Biology as 'Uncertain Status'. Further research and surveys are required to evaluate the level of threat, particularly to *P. clavata* and *A. cuspidata.*

These species will be proposed to CITES for listing by the IUCN Elasmobranch Specialist Group to regulate the 'saw' trade, and will be considered by the CITES Conference of Parties in 1996.

Leafy seadragon

The leafy seadragon (*Pycodurus eques)* (family Syngnathidae) is endemic to Australia's southern waters. Concerns have been expressed that numbers are decreasing. Possible causes are trawling, destruction of habitat, and collection for aquaria and use in traditional Asian medicines. This species was protected in South Australia in 1982, and in Western Australia in 1991. The related weedy seadragon or common seadragon (*Phyllopteryx taeniolatus)* is protected in New South Wales and Tasmania.

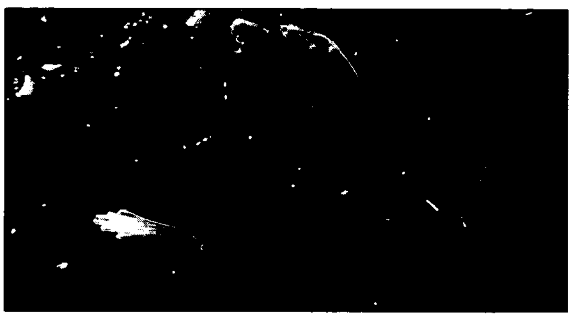
(Source: SARDI)

Figure 16.2: Leafy seadragon.

Handfish

The anglerfish family Brachionichthyidae, known as handfish, is endemic to south-eastern Australia. At least seven species are found in Tasmania. The family is unusual in lacking a pelagic larval stage, and consequently, have extremely localised distributions. *Brachionichthys hirsutus* is restricted to shallow, soft sediment habitats within a small area of south-eastern Tasmania. It was considered abundant until around ten years ago, but has now virtually disappeared, possibly because of overcollection for the aquarium trade. Fears are held that handfish eggs may be vulnerable to predation by the introduced seastar, *Asterias amurensis,* in Tasmania.

B. hirsutus is now listed by the Australian Fish Society as 'Endangered'; a new species known as Ziebell's



(Source: J. Bryan)

Figure 16.3: Handfish.

handfish and another new species found at Waterfall Bay are listed as 'Vulnerable'; *Sympterichthys politus* is listed as 'Indeterminate'.

Black cod

The black cod, *Epinephelus daemelii* (family Serranidae) occurs from Bass Strait to southern Queensland, and eastwards to Lord Howe and Norfolk Islands. It is an inshore reef species, which has made it vulnerable to recreational fishing and habitat disturbances. It is protected in New South Wales, and in the Commonwealth Marine Nature Reserves of Elizabeth and Middleton Reefs in the Tasman Sea. To protect this species on the latter reefs, all dropline and bottom fishing is prohibited within two kilometres of the reef edges.

Other species

A number of States have protected other fish species. For example, New South Wales also protects the Ballina angelfish *(Chaetodontoplus ballinae)*; the eastern blue devilfish or Bleekers devilfish *(Paraplesiops bleekeri)*; the elegant wrasse *(Anampses elegans)*; the estuary rock cod *(Epinephelus coioides)*; and the giant Queensland groper *(Epinephelus lanceolatus)*.

Threats to marine invertebrates and fish

Marine pollution and habitat loss

The most serious threats to inshore invertebrates and fish are declining water quality and loss of habitat. Elevated nutrients and sediments pose a large-scale problem in estuaries, embayments and coastal lakes by directly smothering benthic species, by promoting algal growth and eutrophication, killing seagrass beds and changing habitats (Chapters 9 and 42).

The problem is most severe in the most populated and developed south-east and south-west, where the proportion of vulnerable endemic species is highest. Intertidal species with restricted distributions and direct development are at greatest risk.

Species exploitation

Marine invertebrate and fish species are unlikely to become extinct through commercial exploitation for several reasons. Capture techniques in wild fisheries are not efficient enough to take all individuals in an invertebrate or fish population. Economic factors also prevent total depletions of fished populations as fisheries become unprofitable long before they are biologically threatened. Australian fisheries management agencies also intervene to control fishing effort on overexploited stocks. Semi-commercial collecting for specimen shells may be more threatening as values increase with rarity, and specific localities and species or subspecies may be overcollected.

Other potentially threatening processes include netting and trawling which take large numbers of non-target species or by-catch, and which alter bottom habitats (Chapter 32).

Introduced species and diseases

Introduced species may reduce populations of native species by eating them, by competing for space and food resources, and by producing biotoxins (Chapter 48).

The European shore crab *Carcinus maenas* which has been introduced into southern Australia and the United States has reduced mussel populations in the latter by predation. The introduced Pacific oyster *Crassostrea gigas* has become feral in south-eastern Australia, and out-competes native oysters for space. The northern Pacific seastar *(Asterias amurensis)* is a voracious predator of bivalves and heart urchins on soft sediments in south-eastern Tasmania. The Japanese kelp *Undaria pinnatifida* has formed monospecific beds off eastern Tasmania, excluding native species. The fanworm *Sabella spallanzanii*, probably introduced from Europe, also forms dense beds in parts of Victoria and south-western Australia.

Long-term climate change

Ocean warming could extend the range of tropical species to more southern latitudes, and contract the range of temperate species. Cool-temperate southern Tasmanian inshore species may be most affected as there is no suitable habitat further south. A gradual warming of sea water by about 1.5°C off eastern Tasmania since the 1960s (Harris et al. 1987) is believed to have caused the loss of most giant kelp *(Macrocystis pyrifera)* beds in this country.

Lack of knowledge

Lack of taxonomic information on most marine invertebrate groups, and many fish (e.g. the gobies, family Gobiidae), is a basic impediment to marine species management. Distribution and abundance information is also lacking for even the best described groups.

There is also a lack of knowledge on marine community structure and diversity, habitat needs and interactions among marine organisms, and mechanisms for invertebrate and fish conservation. Baseline data on marine communities and populations against which changes can be assessed, and of the effects of human disturbances is seriously lacking.

Summary and conclusions

1. Northern Australia has a very high species diversity of invertebrates and fish. Southern Australia has a particularly high proportion of endemic species.

2. The status of very few invertebrate species, and only a small proportion of fish (mainly commercial species) is known.

3. Endemic species with low fecundity and direct development, and restricted distributions and aggregative behaviour are under greatest threat. These include some molluscs (e.g. certain cowries, cones and volutes) and some seastars and fishes (e.g. certain sharks, seadragons, and handfish).

4. The most serious threats to inshore invertebrates and fish are declining water quality and loss of habitat. Elevated nutrients and sediments pose a large-scale problem in estuaries, embayments and coastal lakes.

5. Other potentially significant threats include the catch of non-target species (the by-catch problem) and the threat posed by introduced species.

6. Conservation of marine invertebrates and fish is a relatively new field worldwide, and in Australia.

7. Several marine fish species found in Australia are listed, or may be candidates for conservation listings at the international level (through IUCN), at the National level, and at the State/Territory level. Review of inconsistencies among these levels is required.

8. Because of insufficient knowledge on the status of invertebrate and fish species, they are probably best conserved by habitat protection.

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Chapter 17. The status of Australia's seabirds[1]

The seabird fauna of Australia and its external territories comprises 110 species, representing 12 families. Of these, 76 (69%) breed here, and the remainder are regular or occasional visitors. Some 14 species or subspecies of our seabirds are considered threatened, largely because of the restricted number and vulnerability of their colonies. Problems include illegal poaching of adults, chicks and eggs; mortality from bushfires, fishing nets and longlines, and feral animals; and disturbances to nesting colonies by visitors and by low-flying aircraft.

Seabird breeding colonies were a valuable and predictable food source for coastal Aborigines and for Torres Strait Islanders, and later for European mariners, explorers and entrepreneurs. Until recently, seabirds were extensively used for crayfish bait in southern Australia. They are still a significant food in some indigenous communities.

In this chapter, estimates of the number of breeding pairs have been compiled from published and unpublished data for over 300 Australian islands and several coastal sites. The status of seabirds around the Australian mainland and adjacent islands, and on the oceanic islands and external territories in Indian Ocean, Tasman Sea and Subantarctic and Antarctic Territories are described separately as the avifauna, and the threats, are distinct in each area.

Description and status of seabirds around Australia

The seabird fauna around the Australian continent is made up of tropical, temperate and subantarctic elements, some species of which have a wider geographic distribution (Table 17.1).

Status

Population estimates for the Australian continent range from two pairs for the white-tailed tropic bird, to 16.8 million pairs for the short-tailed shearwater (Table 17.1). Four species are known from fewer than 100 breeding pairs. Of these, the white-fronted tern is a recent arrival, while the status of the minuscule colonies of white-tailed tropic birds, herald and black-winged petrels is unknown. Threatened species are discussed below.

Eleven species exceed 100,000 pairs. These are the little penguin, fairy prion, common diving petrel, three shearwaters, white-faced storm-petrel, silver gull and three terns. Of these, the short-tailed shearwater constitutes 74% of the total breeding seabirds, the wedge-tailed shearwater a further 7.7%, and the flesh-footed shearwater constitutes 6.2%.

Ecology

When trends in feeding habits (i.e. plankton, small or medium fish, cephalopods, scavengers) are compared, the plankton feeders have by far the highest biomass. Bass Strait has the highest biomass of planktivores: 13,690 tonnes of short-tailed shearwaters, or almost 67% of the total biomass of seabirds breeding in Australia. Adults of this species feed largely on the krill *Nyctiphanes australis*, probably in the productive waters off southern Tasmania, and breed in the less productive Bass Strait.

The highest concentrations of birds which feed on small fish, for example the flesh-footed shearwater, occur in the Houtman Abrolhos Islands (WA), one of the most important breeding locations in Australia. The southern Great Barrier Reef supports a large biomass of several tern species, and the northern Reef and Torres Strait supports terns and lesser frigatebirds. North Bountiful Island in the Gulf of Carpentaria supports the largest colony of crested terns in the world. In Bass Strait, little penguins comprise 98% of the birds feeding on small fish. There are a few concentrations of birds which feed on medium-sized fish, such as the masked and brown boobies. These occur mainly off north-western Australia, Torres Strait and the Wellesley Islands in the Gulf of Carpentaria.

Status of seabirds in oceanic islands and External Territories

Indian Ocean islands

The tropical seabirds of the external territories of Cocos (Keeling) and Christmas Islands (Table 17.2)

[1]Based on a paper by Dr G.J.B. Ross, Australian Nature Conservation Agency, Canberra, Australian Capital Territory; and others (see conclusion).

Table 17.1: Estimates of numbers of breeding pairs of Australian seabirds along the Australian coast and Coral Sea (lower and upper range of estimates given)

	lower	upper
Little penguin (C)	149,130	249,900
Shy albatross (C)	6,900	8,500
Great-winged petrel (C)	33,050	84,100
Herald petrel (T)	3	3
Black-winged petrel (T)	3	3
Gould's petrel (T)	250	500
Fairy prion	1,055,060	1,682,000
Wedge-tailed shearwater	(T) 1,301,150	1,344,400
Flesh-footed shearwater (C)	104,540	310,600
Sooty shearwater (C)	300	1,210
Short-tailed shearwater (C)	12,787,070	16,059,700
Little shearwater (C)	27,060	61,600
White-faced storm-petrel (C)	370,180	396,600
Common diving-petrel (C)	127,220	184,000
Australasian pelican (I)	1,030	1,680
Australasian gannet (C)	5,560	6,140
Masked booby (T)	3,750	4,270
Red-footed booby (T)	1,380	4,990
Brown booby (T)	59,940	73,900
Pied cormorant (T)	13,080	19,120
Little pied cormorant (I)	140	200
Black-faced cormorant (C)	7,740	8,110
Great frigatebird (T)	1,610	1,610
Lesser frigatebird (T)	18,680	19,430
Red-tailed tropic bird (T)	290	380
White-tailed tropic bird (T)	2	2
Silver gull (I)	133,890	163,620
Pacific gull (C)	1,900	1,950
Kelp gull (C)	315	315
Caspian tern (I)	1,160	1,410
Roseate tern (T)	7,220	13,370
White-fronted tern (C)	44	44
Black-naped tern	1,7100	2,080
Sooty tern (T)	328,760	383,750
Bridled tern (T)	20,040	57,870
Little tern (T)	560	570
Fairy tern (I)	2,420	2,990
Crested tern (I)	74,350	89,940
Lesser crested tern(T)	4,710	8,170
Common noddy (T)	174,480	214,130
Lesser noddy (T)	79,500	79,500
Black noddy (T)	119,340	130,840

(T) denotes tropical species
(C) denotes Southern Ocean species
(I) denotes those originating from tropical species

have been extensively influenced by humans. The main atoll of Cocos (Keeling) has lost most of its bird fauna from long-term human interference. Hunting of red-footed boobies, lesser and greater frigatebirds and other species is increasing in the more remote North Keeling Island. On Christmas Island clearing for mining has affected populations of the endemic Andrew's frigatebirds and the endangered Abbott's booby. Hunting has declined since the closure of the phosphate mines.

Tasman Sea islands

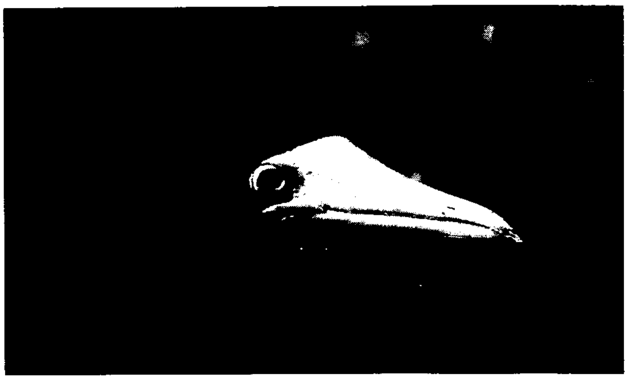
On more temperate Lord Howe Island, breeding populations of Kermadec petrels and white-bellied storm-petrels may have been eliminated by feral cats and black rat predation, though populations survive on adjacent islets. On Norfolk Island the providence petrel became locally extinct because vast numbers were killed for food in the 1790s. A few pairs were discovered breeding on nearby Phillip Island in 1985.

Cats and rats have also reduced Norfolk Island little shearwaters, white terns and red-tailed tropic birds. Clearing of trees has reduced nesting habitat of black noddies and white terns, but may have assisted ground-nesting masked boobies. Egg collection of sooty terns continues on a seasonal basis.

Subantarctic Islands and Antarctic Territories

The seabird fauna of Macquarie Island and Heard and McDonald Islands is subantarctic in nature (Table 17.3). On Macquarie, where a penguin-oil industry existed, populations of royal and probably king penguins have fully recovered. A decline in wandering albatrosses from 29 pairs in 1967, to seven in 1984 is attributed to incidental capture by longliners. Rabbits threaten burrowing species by inducing vegetation changes and maintaining cat and skua populations. Feral weka (an introduction from New Zealand, eradicated in the 1980s), cats and black rats prey on seabirds and were probably responsible for the extermination of grey petrels on the island. Pesticide and mercury levels in penguins, giant petrels and skuas estimated in 1978 ranged from 0.02 to 2.9 parts per million and 0.16 to 2.6 parts per million, respectively. No anthropogenic impacts have been identified at Heard or McDonald Islands.

The Australian Antarctic Territory (AAT) has major populations of antarctic birds (Table 17.3). One third of the total world populations of emperor and adélie penguins breed in the AAT. Most species have stable or increasing populations but those of the giant petrel have declined markedly. Threats are minimal. Levels of heavy metals and pesticides are very low.



(Source: L. Zann)

Figure 17.1: Brown booby, Cato Island, Coral Sea.

Human impacts and major threats

Past use of seabirds

The impact of traditional harvesting is unknown but there is some evidence that the more accessible colonies such as those in Western Australia may have been depleted. Torres Strait Islanders continue to harvest chicks and eggs of boobies on Bramble Cay and several smaller islands, and harvest a variety of species on Kusamet Island.

Seabirds were used until recently for crayfish bait in southern Australia. Little penguins were preferred, but black-faced cormorants, short-tailed shearwaters and Australasian gannets were widely taken. The effects were most evident in the decline of the Cat Island gannetry from 2,500 to 5,000 in 1908, to fewer than seven pairs in 1977. King and royal penguins were the target of an oil fishery in Macquarie Island: up to 150,000 were taken each year between 1890 and 1920.

Table 17.2: Estimated numbers of breeding pairs of seabirds on Australian tropical and sub-tropical oceanic islands of Cocos (Keeling) (a), Christmas (b), Lord Howe (c) and Norfolk (d)

	(a)	(b)	(c)	(d)
Providence petrel			27,000	
Kermadec petrel			few	
Black-winged petrel			100-1,000	50-100
Wedge-tailed shearwater	<100			100,000s
Flesh-footed shearwater			20,-40,000	
Little shearwater			4,000	100-1,000
White-bellied storm petrel			>1,000	
Australasian gannet				<5
Masked booby	75		300	300
Red-footed booby	22,800	12,050		
Brown booby	40	4,910		
Abbott's booby		3,000		
Great frigatebird	ca 200	3,250		
Lesser frigatebird	ca 200			
Andrew's frigatebird	1,280			
Red-tailed tropic bird	1	1,380	200	230-300
White-tailed tropic bird	40	6,000		
Sooty tern	40		50,000+	40,-70,000
Common noddy	4,800	5,390	1,000	100-1,000
Black noddy				1,000-10,000
Grey ternlet			<1,000	1000-10,000
White tern	abundant		<10	abundant

Present use of seabirds

Bass Strait Islanders, largely of Tasmanian Aboriginal descent, still harvest muttonbird (short-tailed shearwater) chicks from seven islands in the Strait under the management of the Tasmanian Government. The current take is around 400,000 per year, worth $330,000 per year to the harvesters, and retailing at $3.2 million. The impacts of illegal muttonbirding on Victorian and Tasmanian island populations are not known.

Seabird colonies are becoming the focus of ecotourism. The 'Penguin Parade' on Phillip Island (Vic) has been an attraction since 1928 and now draws around half a million visitors a year. Penguins are the feature of a new tourist venture in Jervis Bay and at Montague Island (NSW). Managed tours of seabird colonies are undertaken on Michaelmas Cay (Great Barrier Reef) and the Houtman Abrolhos Islands (WA).

Threats to seabirds

There are numerous human influences on Australian seabirds. Illegal poaching of adults, chicks and eggs; predation by feral animals; and mortality by fishing lines and nets are direct impacts. Disturbances by tourists, vehicles and aircraft are indirect impacts.

Of a sample of 215 nesting islands, 47% have been found to be subject to one or more direct human threats. Islands which are difficult to land on (30% of the total) are far less prone to such impacts. Bushfires seriously affected nesting populations on over 7% of the islands.

Feral animals are a serious problem. Cats and black rats are present on 4% of the islands. Cats, rats and guano mining together have killed an estimated several millions of seabirds on Rat Island in the Houtman Abrolhos (WA).

Table 17.3: Estimates of numbers of breeding pairs of seabirds on Macquarie Island (a), Heard and McDonald Islands (b), and the Australian Antarctic Territories (c)

Species	(a)	(b)	(c)
King penguin	218,000-250,000	5,700	
Emperor penguin			59,335
Gentoo penguin	5,000	16,574	
Adélie penguin			661,965
Rockhopper penguin	500,000	10,000	
Macaroni penguin		2,000,000	
Royal penguin	810,000-960,000		
Wandering albatross	7	(1)	
Black-browed albatross	70	680-790	
Grey-headed albatross	80-100		
Light-mantled sooty albatross	500-700	200-700	
Southern giant petrel	4,000	4,400-4,600	163
Northern giant petrel	1,000		
Southern fulmar			29,065
Antarctic petrel			164,521
Cape petrel		br	4,033
Snow petrel			8,599
White-headed petrel	7,850		
Blue petrel	500-600		
Antarctic prion	48,900	>10,000	2
Fairy prion	40		
Fulmar prion		>1,000	
Sooty shearwater	1,770		
Wilson's storm-petrel		br	41,624
S. Georgian diving petrel	10,000-20,000		
Common diving petrel	20	>1,000	
Macquarie Island shag	760		
Heard Island shag		89	
Subantarctic skua	br	550	>100
Antarctic skua			357
Kelp gull	br	50-100	
Antarctic tern	40	1,348	

br: breeding birds, numbers unknown
() breeding doubtful

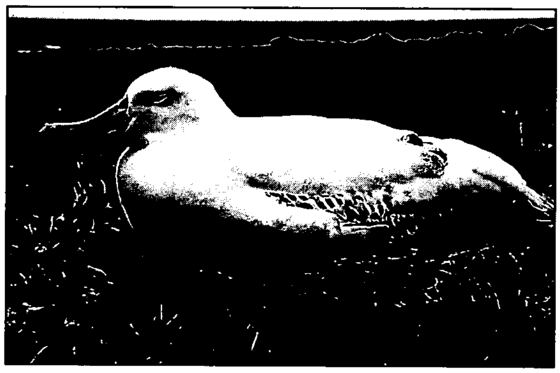
(Source: C. Speedie)

Figure 17.2: King penguins, Heard Island.

Foxes and dogs also kill many little penguins on Phillip Island (Vic).

Some populations are increasing because of greater availability of food. Discarded by-catch from trawlers has promoted pied and little pied cormorants and crested terns in Moreton Bay (Qld), and in various species in Torres Strait. Populations of the scavenging silver gull are increasing at an exponential rate of 10-13% per year in response to increased domestic garbage around the cities.

Fishing gear kills large numbers of some species of seabirds. The serious decline of albatrosses in the Southern Ocean is attributed to a mortality of some 44,000 birds annually on Japanese longlines. Oiling of feathers in oil spills and entanglement in and ingestion of plastic litter, are also problems, though data on mortalities are limited.



(Source: G. Robinson, Antarctic Division)

Figure 17.3: There has been a serious decline of wandering albatross because of fishing longlines.

Status of threatened species

Fourteen species or subspecies of seabirds in the region are considered threatened. The wandering albatross on Macquarie Island, Abbot's booby on Christmas Island, and the Australian subspecies of the little tern (*Sterna albifrons sinensis*) are classified as endangered under IUCN criteria. The tern has been reduced to less than 500 pairs as a result of disturbance by humans, dogs and off-road vehicles.

(Source : C.Totterdill, ANCA)

a

(Source: P. Goh)

b

Figure 17.4: The status of seabirds with only a small number of oceanic rookeries is of concern. (a) Christmas Island frigatebird and (b) Abbot's booby on Christmas Island are listed as endangered.

Vulnerable species include Lord Howe's Kermadec petrel and white-bellied storm-petrel, and Christmas Island's Christmas frigatebird. The last exists as a single colony which is susceptible to cyclones. At Macquarie Island the small populations of the grey-headed albatross, Macquarie Island shag, the New Zealand subspecies of the Antarctic tern and the fairy prion are at risk from predators and longliners. The Heard Island shag comprises fewer than 500 birds and is confined to one island. There are only around 150 pairs of a subspecies of Gould's petrel which breeds only on Cabbage Tree Island (NSW). Fewer than 100 pairs of a subspecies of the soft-plumaged petrel are thought to breed on Maatsuyker Island (Tas).

Conservation and management

Almost all seabird islands within three nautical miles of the coast are managed by the relevant State or Territory wildlife authority, many as declared nature or faunal reserves, or as part of larger national parks. A few coastal islands are under local council management. Seabirds on islands between three and 200 nautical miles from the coast and external territories (Cocos (Keeling) and Christmas Islands, Ashmore Reefs, Coral Sea Territory and Norfolk Island) are protected under National Parks and Wildlife Regulations administered by the Australian Nature Conservation Agency (ANCA). Those within the Great Barrier Reef are protected under the *Great Barrier Reef Marine Park Act* 1975 and Queensland legislation. Those on Lord Howe Island are protected under New South Wales' legislation. Macquarie Island is administered by Tasmania and Heard and McDonald Islands is administered by the Commonwealth Department of the Environment, Sport and Territories.

Treaties and obligations

The Japan-Australia Migratory Birds Agreement (1974) and the China-Australia Migratory Birds Agreement (1988) impose obligations on Australia to protect migrating species of shorebirds only. The South Pacific Regional Environment Programme (SPREP) and the Convention on the Conservation of Nature in the South Pacific (Apia Convention) promote conservation of seabirds with restricted distributions in the region. The Convention on International Trade in Endangered Species (CITES), to which Australia is a party, controls trade in seabirds and their products. Antarctic seabirds are protected under the *Antarctic Treaty (Environmental Protection) Act* 1980 *and the Antarctic Marine Living Resources Conservation Act* 1981.

Status of knowledge and monitoring

The basic information on species within the region ranges from inadequate to excellent. For example, the short-tailed shearwater has been monitored since 1947. However, for most species their activity at sea, diet, feeding areas and effects of fishing are poorly understood, and data on sizes of breeding populations are too imprecise in most cases to detect trends.

Seabirds as environmental indicators

Seabirds are suited as environmental indicators since most breed in observable colonies in fixed locations and in sufficient numbers to permit a variety of statistical analyses. Seabird populations and condition are also good indicators of changes in regional prey abundance, for example, during El Niño-Southern Oscillation periods. Their diets can be monitored through regurgitation or pellet analyses. Eggs are ideal for assessing bioaccumulation of persistent chlorinated hydrocarbons, and heavy metals can be measured in their tissues and feathers.

Databases on seabirds

Databases on seabird breeding populations are maintained by a number of Commonwealth, State and Territory agencies. Data on banded seabirds are maintained by the Bird and Bat Banding Unit of ANCA. The Antarctic Division holds census data for breeding seabirds in the Australian Antarctic

Territories, and for some 40,000 sightings of birds at sea between Tasmania and Antarctica. Because of the scattered nature of the databases, a national network of State and Territory databases, such as that operated by the Canadian Wildlife Service, is needed.

Summary and conclusions

1. The status of most species of seabirds breeding in the region appears to be satisfactory. In most instances, populations formerly exploited have recovered well.

2. However, 14 species and subspecies (13% of the total) have been identified as threatened. Eleven of these are on the oceanic islands, two are on coastal islands and one is on the mainland.

3. The oceanic island populations are generally susceptible to loss of species because of feral predators. Particular threats include longlining on Macquarie Island albatrosses; forest clearing on Christmas Island frigatebirds; and disturbances by humans and dogs of little tern colonies.

4. While populations on most continental islands are secure, disturbance by human visitors is an increasing problem. Management solutions are feasible.

5. Seabirds are well suited as environmental indicators of prey food availability and contaminants.

6. A large number of databases on seabird breeding exist. For more effective management, a coordinated national network of State and Territory databases is necessary.

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The technical paper by Dr G. Ross and co-authors was reviewed by Dr J. Warham, Department of Zoology, University of Canterbury, Christchurch, New Zealand.

Chapter 18. The status of marine reptiles and mammals[1]

Marine species of invertebrates and fish are generally safe from global extinction because of their abundant, widely dispersed planktonic larvae and wide distributions. Conversely, the relatively low birth rates, generally slow growth rates, air-breathing habits, and sometimes restricted habitats of marine reptiles and mammals, make them vulnerable to overexploitation or habitat loss.

There is considerable world concern regarding the status of many species of marine reptiles and mammals. The giant Steller's sea cow (*Hydrodamalis stelleri*) was exterminated by hunters not long after its discovery in the 18th century. Several of the great whales, including the largest animal which has ever existed, the blue whale (*Balaenoptera musculus*) were hunted to the brink of extinction during this century, and are currently listed as endangered. Of the seven species of sea turtles, five are listed as endangered and one as vulnerable to extinction. The maintenance of biodiversity of the higher marine vertebrates is a major challenge for future marine environmental management.

(Source: GBRMPA)

Figure 18.1: Around 60% of the world's sea snake species are found in Australia.

All major groups of marine reptiles and mammals are well represented in Australian waters. There are around 30 species of sea snakes, six species of sea turtles, one species of sirenia or sea cow, three species of fur seals and sea lions, and around 44 species of whales and dolphins. This chapter briefly describes the Australian marine reptiles and mammals, their conservation status, factors affecting their survival, and their management.

Sea snakes

Biology and ecology

The sea snakes (four families, 50+ species) are restricted to the Indo-Pacific, and concentrated in the warm Indo-Malaysian region (30+ species, 60% endemic) and northern Australia (30+ species, 50% endemic). The four functional groups of true sea snakes are Hydrophiids (40 species, 30 of which are in northern Australia); Aipysurids (7 species, all in northern Australia); *Pelamis platurus* (a pelagic species); and Laticaudids (4 species of kraits, none of which breeds in Australia).

The sea snakes are much smaller than other marine reptiles and mammals, and have shorter lifespans. The heaviest snake (*Astrotia stokesii*) weighs around two kilograms; the longest (*Hydrophis elegans*) is almost three metres. *Aipysurus laevis* reaches sexual maturity at three years, and may live to at least ten years. Laticaudids lay eggs on land, while the others bear live young at sea. Sea snakes have smaller clutches (an average of 2.6 for *A. laevis*) and larger offspring than equivalent-sized terrestrial snakes. The Hydrophiids live in inter-reefal waters, and the Aipysurids are reefal. The former may migrate some distances (possibly inshore in summer), while the latter have smaller home ranges (between 0.15-0.18 hectare for *A. laevis*). *Pelamis* are carried over wide distances by ocean currents.

Human impacts

Prawn trawling is the major impact on the inter-reef Hydrophiids in northern Australia. Between 10 and

[1] Based on a technical paper by Professor H. Marsh, Department of Tropical Environment Studies and Geography, James Cook University, Townsville, Queensland; Dr P.J. Corkeron, Department of Veterinary Anatomy, University of Sydney, Sydney, New South Wales; Dr C.J. Limpus, Queensland Department of Environment and Heritage, Brisbane, Queensland; Dr P.D. Shaughnessy, CSIRO Division of Wildlife and Ecology, Canberra, Australian Capital Territory; and T.M. Ward, Department of Tropical Environment Studies and Geography, James Cook University, Townsville, Queensland; and other sources.

42% of sea snakes taken in trawls die. Trawled snake skins have been sold over the past 20 years. In Queensland, three licences have been issued to take a total of 20,000 sea snakes of several species each year. Reefal habitats are generally well protected and there is little pressure on the Aipysurids.

Management

The Queensland Department of Primary Industries controls the annual State harvest by licence. The *Commonwealth Wildlife Protection (Regulations of Exports and Imports) Act* 1982 restricts the export of sea snake products. The conservation of Great Barrier Reef species is undertaken within the context of large-scale habitat management.

The development of national management plans for the commercial use of Australian Hydrophiids caught in prawn trawls is considered a high priority.

Sea turtles

Of the world's seven species of sea turtles, six occur in Australian waters: the leatherback turtle *(Dermochelys coriacea)*; loggerhead turtle *(Caretta caretta)*; green turtle *(Chelonia mydas)*; hawksbill turtle *(Eretmochelys imbricata)*; olive ridley turtle *(Lepidochelys olivacea)* and flatback turtle *(Natator depressus)*. The leatherback, loggerhead, green and hawksbill turtles have pantropical distributions; the olive ridley is widely distributed in the tropical and subtropical Indo-Pacific; and the flatback has a limited distribution and is effectively endemic to Australia.

Biology and ecology

Sea turtles are amongst the largest extant reptiles. Mature specimens range from 40 kilograms (olive ridley) to over 300 kilograms (leatherback). They are exceptionally long-lived, and are slow to reach sexual maturity. For example, female loggerheads take around 35 years to reach sexual maturity and then breed on around five occasions, at intervals of several years. They lay on land, between 50 and 130 eggs per clutch, and have several clutches in the breeding season. Sex is determined by incubation temperature. Hatchlings have a pelagic dispersal phase lasting several years, after which they recruit to shallow benthic feeding areas where they remain for life, except for intermittent breeding migrations. Leatherbacks remain pelagic. Diets vary with the species: green turtles eat algae and seagrasses; loggerheads molluscs and crabs; hawksbills sponges and algae; and leatherbacks eat jellyfish.

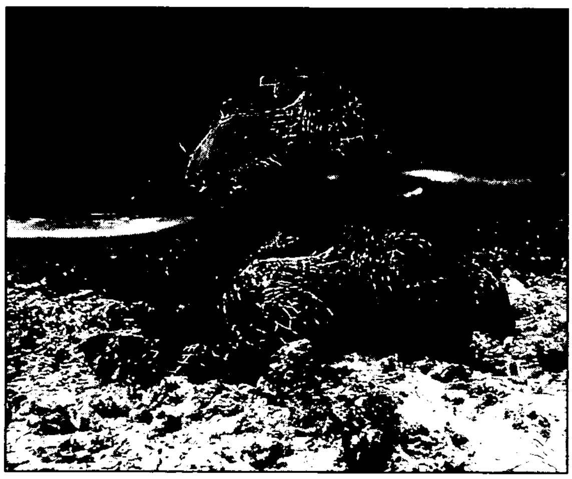
Breeding migrations typically cover distances of hundreds of kilometres. Sea turtles return to the same beaches where they were hatched. For 118 loggerhead and 273 green turtles tagged in Queensland rookeries, the distances between feeding and breeding areas ranged from eight kilometres (green) to over 2,600 kilometres (green and loggerhead). The range of Australia's breeding populations covers many territorial boundaries and creates international problems in management.

Human impacts

Sea turtles have long been important to coastal and island peoples in the tropics as a source of eggs and meat, shells and as clan totems. However, the development of large-scale commercial trade in 'tortoise shell' (from the hawksbill), meat, eggs, and leather has placed severe pressures on stocks. Females

Profile of a vulnerable species: life history parameters of the loggerhead turtle

Age at first breeding:	35 years
Egg production:	128 /clutch; 4 clutches/ breeding season; 4 years between breeding seasons
Reproductive life expectancy:	about 5 breeding seasons
Survivorship: eggs & hatchlings:	low and variable between rookeries, about 40% to open waters
pelagic phase:	not quantified
benthic feeding young:	high, >90%
adult:	high, >95%



(Source: GBRMPA)

Figure 18.2: Loggerhead turtles mating on the Great Barrier Reef.

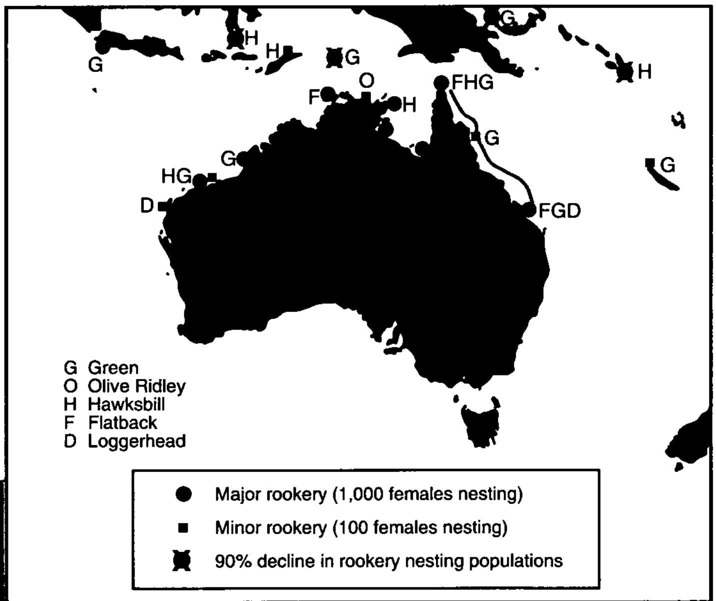


Figure 18.3: Known rookeries of sea turtle species in Australia and region. Note the number (X) which have suffered significant declines.

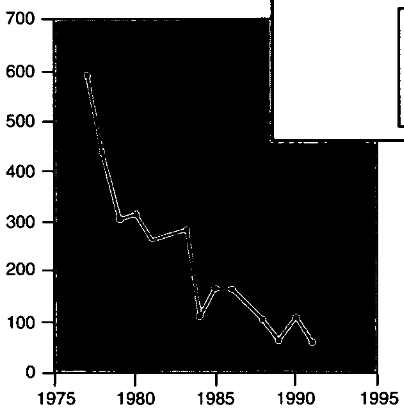


Figure 18.4: Nesting loggerhead turtles over two weeks at peak of season, Wreck Island (Great Barrier Reef), indicating decline in population.

are particularly vulnerable during nesting. In Australia turtles are an incidental catch in fishing nets and may be drowned. A study of prawn trawlers operating in the northern prawn fishery in 1988 found they took around 4,100 turtles, comprising flatback (43%), loggerhead (19%), olive ridley (15%) and green turtles (4%). Mortality was around 6%. Although the study concluded this was not of immediate concern, this has been challenged elsewhere. The catch and mortality in gillnets and shark set-nets have not been quantified. Other sources of mortality include predation on nests by feral animals, disturbances of rookeries by coastal developments, and collisions with speed boats.

Status, information requirements and databases

Despite their apparent abundances, declines in the populations of green, loggerhead, hawksbill and leatherback turtles are evident in Australia and Oceania, and regional populations of loggerhead and olive ridley turtles are threatened.

The populations of sea turtle breeding units comprise tens to hundreds of thousands of individuals. Olive ridleys form massive breeding aggregations of up to 150,000 turtles. An estimated 11,500 green turtles were recorded nesting on Raine Island off Queensland on a single night in 1984. Population models show that populations will not withstand significant increases in mortality above natural levels.

The most sensitive life history parameter is the survivorship of large pre-reproductive and adult females, the sex and size classes most targeted for food.

Problems in assessing the status of breeding units include the paucity of census data; difficulties of estimating abundances in feeding grounds and in fluctuating populations; the mixed stocks; the long age to maturity, long breeding life, and lack of knowledge of life history parameters; and the dispersed feeding and breeding behaviour and migration of members of a breeding unit.

Management

All turtles are protected in Australia, except for hunting by indigenous communities. All species of sea turtles are listed in CITES Appendices I and II. The leatherback, green, hawksbill and olive ridley are listed as endangered by IUCN, and the loggerhead is listed as vulnerable. The flatback is considered potentially vulnerable. Commonwealth Endangered Species Legislation lists all sea turtles except the flatback. The loggerhead is listed as endangered, the other species as vulnerable.

Management practices in neighbouring countries in which Australian breeding turtles range are more limited. Indonesia protects selected species (loggerhead, ridley and leatherback); Papua New Guinea has some protected areas and bans export; the Solomon Islands protect certain size classes; and Fiji has a closed season. As a shared international resource, sea turtles should be managed under international agreements. An agreement among the countries bordering the Arafura and Coral Seas (Australia, Indonesia, Papua New Guinea, Solomon Islands, Vanuatu and New Caledonia) is urgently required.

Sea cows (Sirenia)

Biology and ecology

The dugong *(Dugong dugon)*, a herbivorous marine mammal, is the only Sirenian to occur in Australia. Its range extends throughout the tropical and sub-tropical Indo-Western Pacific but has been reduced to relict populations separated by large areas in which it is extinct, or close to extinction. Australia has

(Source: Lochman Transparencies)

Figure 18.5: While dugongs have been depleted over much of their former range, Australia's populations appear secure.

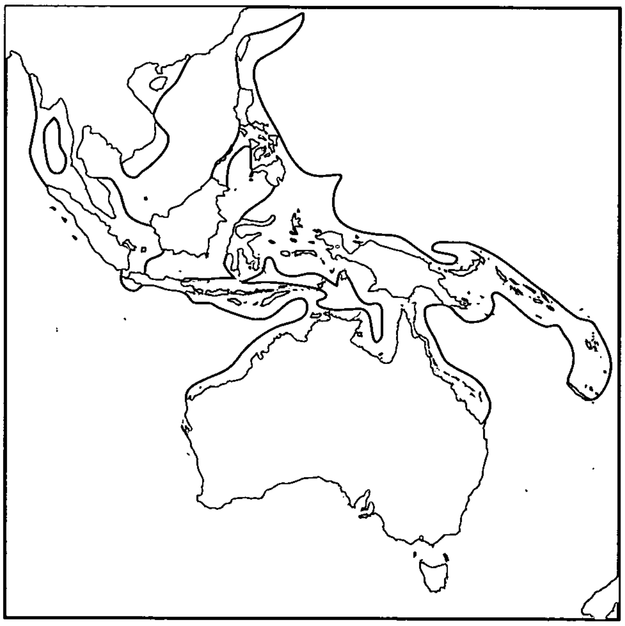


Figure 18.6: Distribution of dugongs in Australia and South-East Asia.

significant populations in northern waters, between Moreton Bay in the east and Shark Bay in the west and is the dugong's last stronghold.

Dugongs reach three metres in length and weigh up to 420 kilograms. They may live to 70 years or more, but females do not calve until at least their tenth year. They then calve every 3-5 years after a gestation period of around 13 months. Dugongs' staple diet is seagrass and they may move considerable distances between seagrass beds. Over a six week period, one marked with a transmitter moved between beds over 140 kilometres apart three times. Their capacity for relatively long-range movements creates international management problems in Torres Strait.

Human impacts

Humans have been hunting and netting dugongs for meat and oil for subsistence purposes for thousands of years. In more recent times the development of commercial fisheries and new technologies has severely reduced populations. A cottage industry for dugong oil existed in Moreton Bay from the 1850s to the 1930s. A commercial fishery developed in Torres Strait from Daru in Papua New Guinea between 1976 and 1983 but this declined because of overfishing.

In Australia, Torres Strait Islanders and some northern Aboriginal communities continue to hunt for dugongs. It is not known whether the Torres Strait catch, estimated to be around 1,000 in 1991, is sustainable. The eastern Cape York catch, estimated to be less than 100 per year is considered sustainable. An unknown number of dugongs are killed incidentally in commercial gillnets and shark nets set for bather protection. A total of 576 dugongs died in shark nets in Queensland between 1964 and 1988. Loss of habitat from coastal residential, industrial and tourist development, and natural causes, is a potential threat. After a cyclone and flood in 1992 destroyed around 1,000 square kilometres of seagrass in Hervey Bay (Qld), dugong numbers in the Bay declined from around 1,400 to less than 100 because of migration and starvation.

Status

Systematic aerial surveys indicate that dugongs are the most abundant marine mammal in inshore northern Australia, with an estimated population of over 80,000. Difficulties in estimating populations by air include water turbidity and observer bias. Because of the large statistical error associated with population estimates, trends are difficult to detect. Simulations suggest that a 5% annual decline in the 8,000 dugongs in the northern Great Barrier Reef would take at least 10 years to detect, by which time the population would have declined to around two thirds of its original size.

Management

The dugong is listed as vulnerable to extinction by the IUCN. Trade in dugong is regulated or banned (depending on the populations involved) by CITES. It is protected throughout Australia except for hunting by Aborigines and Torres Strait Islanders.

The management of dugongs in Torres Strait is an international problem as they are also hunted by Papua New Guineans. Dugong hunting is a nominated fishery under the Torres Strait Treaty for bilateral management (Chapters 22 and 74).

The Great Barrier Reef Marine Park Authority and other management agencies have funded extensive research by Professor Helene Marsh at James Cook University on dugong population dynamics, hunting, and management.

Seals and sea lions (Pinnipeds)

Biology and ecology

Three species of pinnipeds breed in Australian waters: Australian sea lion *(Neophoca cinerea)*; New Zealand fur seal *(Arctocephalus forsteri)* and Australian fur seal *(A. pusillus doriferus)*. The Australian sea lion is endemic; the New Zealand fur seal is common to Australia and New Zealand, and the Australian fur seal also breeds in South Africa. Five species of true seals and two other fur seals breed on antarctic pack ice and subantarctic islands, antarctic Islands and territories, but are omitted from this discussion.

(Source: J. Lochman, Lohman Transparencies)

Figure 18.7: Although once heavily hunted, Australia's seals appear to be recovering. The rare Australian sea lion in Western Australia.

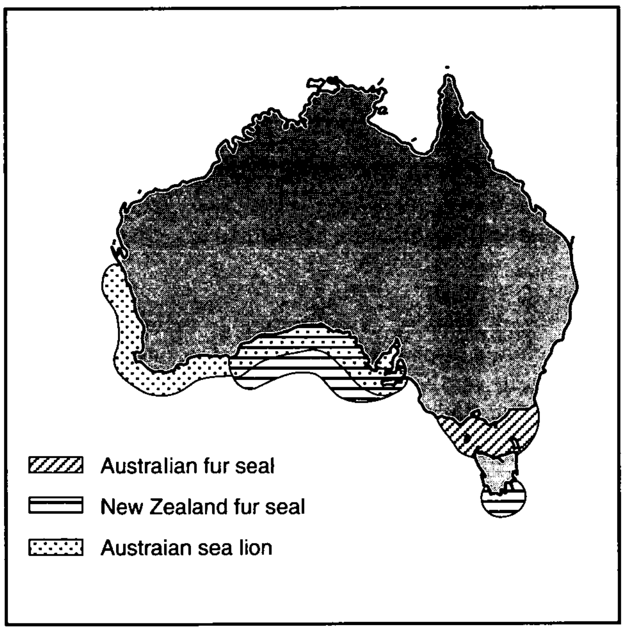


Figure 18.8: Distribution of fur seals and sea lions in Australia.

Australian sea lions may reach 400 kilograms, the Australian fur seal up to 360 kilograms, and the New Zealand fur seal 185 kilograms. All breed ashore, generally on remote islands, and feed at sea, mostly on fish and squid. Female fur seals reach sexual maturity at three to five years, and bear single pups each year. Australian sea lions have 18-month breeding cycles. Adult females suckle the young ashore for about 10 months but regularly feed at sea for several days at a time. The maximum rate of population increase recorded for the New Zealand fur seal is 15% per year. No species undertakes long migrations but the number ashore varies through the year.

Human impacts

Major impacts include fisheries, oil pollution, entanglements in human-made objects, and disturbances from tourism. Both species of fur seals have been shot at fish-farms in south-east Tasmania, but this should ease with the introduction of predator-proof fencing. In 1990 an oil spill from the *Sanko Harvest* in Western Australia affected New Zealand fur seal pups (Chapter 39). Oil pollution is likely to increase as a threat. The rate of entanglement in ocean litter such as plastic straps and net fragments is around 1.9% in Tasmanian waters, and is high by world standards (Chapter 46). Disturbances to breeding colonies are also increasing as people become more mobile and interested in wildlife.

Status

The Australian sea lion is considered by the South Australian and Western Australian governments as rare although this species has received no national conservation listing. A survey of over 200 islands in 1989-90 found 13 breeding colonies of fur seals in Western Australia (of which five were previously known), and four new locations in South Australia. It was concluded that the populations of New Zealand fur seals were increasing in the three locations previously recorded. Several new breeding colonies of sea lions were discovered, but it was not possible to assess whether numbers were decreasing or increasing.

Determining the distribution and abundance of pinnipeds is difficult because the proportion of the total population ashore or on the sea surface is not often known, and they usually occur in remote locations. Abundance estimates are generally based on pups as this is the only age-class recognisable and ashore together. Age population data to estimate overall abundances are generally not good.

Management

Pinnipeds within State waters are managed by a variety of State conservation and fisheries agencies. Outside the three-mile territorial limit they are managed by the Australian Nature Conservation Agency.

Whales and dolphins (Cetacea)

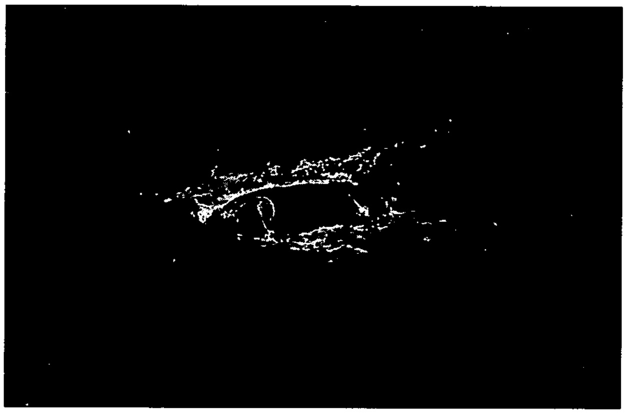
Biology and ecology

Around eight species of baleen whales (Mysticeti) and 35 species of toothed whales, porpoises and dolphins (Odontoceti) are found in Australian waters. The incomplete knowledge of cetacean taxonomy creates some uncertainty of the exact number. The patterns of distribution are: cosmopolitan species; temperate and polar species; species with a southern hemisphere, and generally circumpolar, distribution; and tropical and warm temperate species. There are no endemics in Australia.

Residents of inshore waters include the bottlenose dolphin *(Tursiops truncatus)*, the tropical Irrawaddy River dolphin *(Orcaella brevirostrus)* and Indo-Pacific humpback dolphin *(Sousa chinensis)*. Humpback whales *(Megaptera novaeangliae)* pass close to the eastern and western coasts on their annual breeding migration, and southern right whales *(Eubalaena australis)* breed in southern coastal waters.

Cetaceans occurring in Australian waters are all large, to extremely large mammals. Those in Australian waters range from two metres (spinner dolphin, *Stenella longirostris*) to thirty metres (blue whale, *Balaenoptera musculus*). Baleen whales are generally larger, but do include smaller species such as the ten-metre minke *(B. acutorostrata)* and seven-metre pygmy right whale *(Capera marginata)*. Toothed whales range from the giant sperm whale *(Physeter macrocephalus)* to the small dolphins.

Cetaceans typically bear one young at a time, at intervals of one to several years. Gestation ranges from 10 months in small dolphins, to 17 months in beaked whales. Calves may suckle for up to several years and take from two years (for small dolphins) to 20 years (in male sperm whales) to reach maturity. Cetacean populations therefore have slow rates of natural increase. Most baleen whales undertake extensive migrations for feeding and breeding, some over 40° of latitude, from Antarctica to the tropics. By contrast, the range of some inshore dolphins may be only tens of square kilometres.



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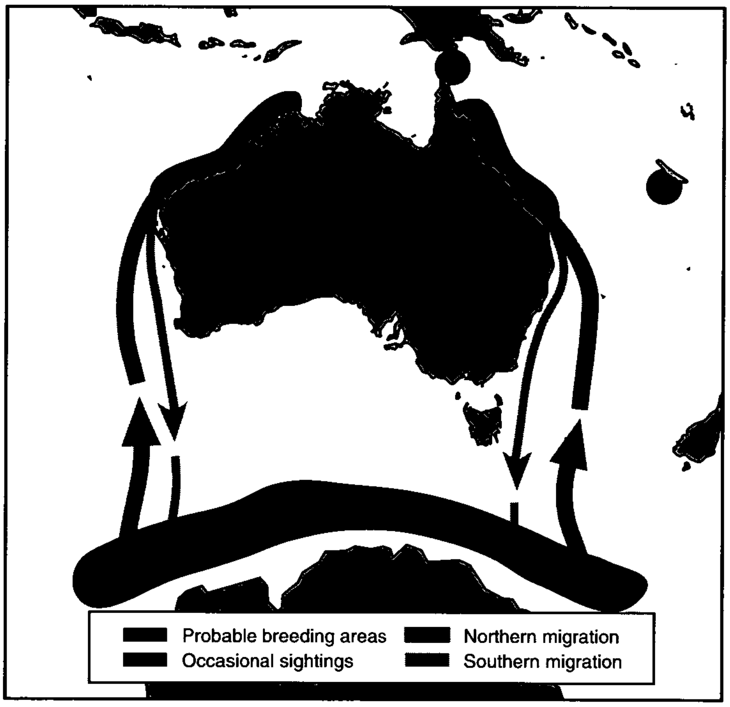


b

Figure 18.9 (a): Humpback whale and calf off Queensland. Depleted by whaling by 1963, populations are now steadily increasing. (b) Humpbacks migrate northwards in winter to breed and feed in Antarctic waters in summer.

Human impacts

Hunting

Until recently, the major impact on populations was hunting. The inshore-calving right whales were the first to be depleted in the northern hemisphere in the seventeenth century, and in Australia by 1845. Attention then shifted to the blue and sperm whales in the Southern Ocean. Catches escalated with the development of the explosive harpoon in 1864, of fast steam-powered chasers, and large factory ships around 1900. In 1930-31 (the first year of internationally kept records) there were 41 factory ships and 200 chasers operating, and the world catch was 38,000 whales. The antarctic industry increased after WWII with Norway, Russia and Japan dominating. As stocks of the blue whale collapsed, progressively smaller species were targeted: the fin, humpback, sei and minke.

Whaling for southern right whales was one of the first industries in Australia, and whale oil was Australia's main export until 1833. A station was established in the Derwent in 1806. Others were established

(Source: SARDI)

a

b

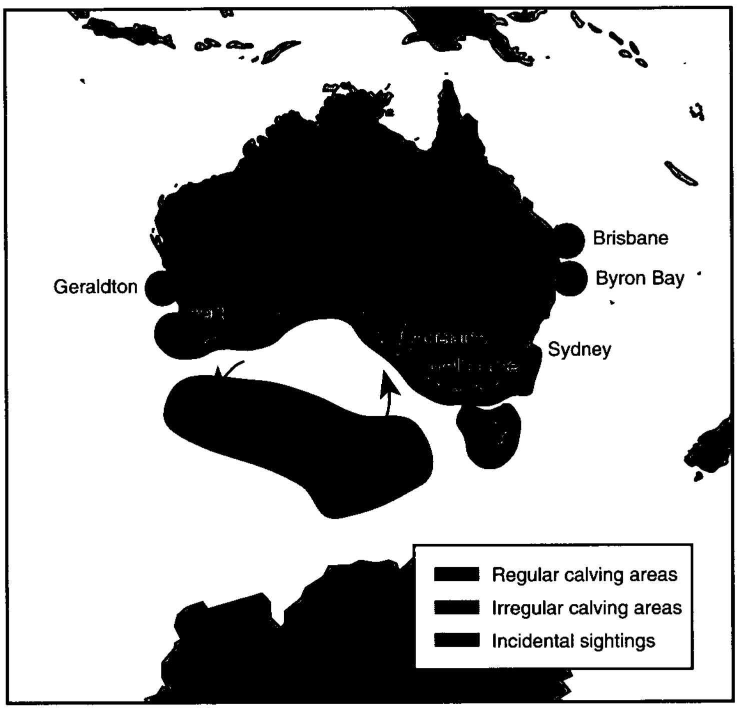


Figure 18.10 (a): Southern right whales and calf at the Head of the Bight (SA). Very seriously depleted by whaling by 1845, populations appear to be slowly recovering. (b) The southern right whale migrates northwards to southern Australia to breed.

elsewhere in Tasmania, and in Victoria, New South Wales, South Australia and Western Australia by 1830. However, populations of the southern right whale had been reduced by 75% by 1845 and bay whaling declined after the 1850s. Over 26,000 southern right whales were taken in Australia and New Zealand waters and only a few hundred now remain.

Shore-based humpback whaling commenced after World War II, with stations on Norfolk Island (off NSW), Tangalooma (Qld), Byron Bay (NSW), and Carnarvon, Point Coates and Albany (WA), but stocks could not withstand the intensive hunting, and humpback whaling ceased in 1963 in Australia. Sperm whaling continued at Albany until 1978.

Fishing by-catch

While dolphins have never been intensely hunted, it is estimated that over six million dolphins, mainly spotted dolphins and spinners, have been drowned in tuna purse seines and drift gillnets in the eastern Pacific over the past 30 years. Modifications in net designs have reduced this 'incidental' catch of dolphins. The dolphin catch from the United States of America eastern Pacific tuna fleet has declined from 133,171 in 1986, to 27,292 in 1991, and fewer than 20,000 in 1992. This is still considered unacceptably high, and the Commonwealth has expressed concerns to the nations involved. Between 1981 and 1985, the incidental catch by Taiwanese gillnets off northern Australia was around 14,000 dolphins. Gear restrictions then placed on the fleet rendered the fishery uneconomic in 1986, and the problem was removed from Australian waters.

Pollution

Pollution from organochlorides (particularly poly-chlorinated biphenyls or PCBs) is regarded as a significant threat to the world's cetaceans, and could even threaten them with extinction. Marine mammals are particularly sensitive to reproductive failure due to bioaccumulated PCBs. There are few data on PCBs in Australian cetaceans, but it has been suggested from levels in fish from Moreton Bay that local dolphins could be affected. A serious epidemic amongst whales and dolphins in the United States of America in 1987 was attributed to toxic red algae caused by fertilisers and sewage.

Other impacts on especially inshore species may include loss of habitat through coastal development; reduction in prey numbers because of fish habitat loss and overfishing (this is difficult to quantify); increasing motor boating and risks of collision (this is evident in injured strandings); entanglement in gillnets, protective shark nets and discarded fishing nets; ingestion of plastic bags (a killer whale found stranded in New South Wales starved to death because its stomach was full of plastic bags); and disturbance of migrating and breeding populations by boat traffic and by 'whale watching' tourists.

Status

The Commonwealth Endangered Species Legislation classifies blue, humpback and southern right whales as endangered. Longman's beaked whale is considered the least known whale in the world, and is recorded from only two specimens, one of which was found near Mackay (Qld). Most other species of cetaceans are classified by the IUCN as insufficiently known, reflecting the paucity of knowledge of the order generally.

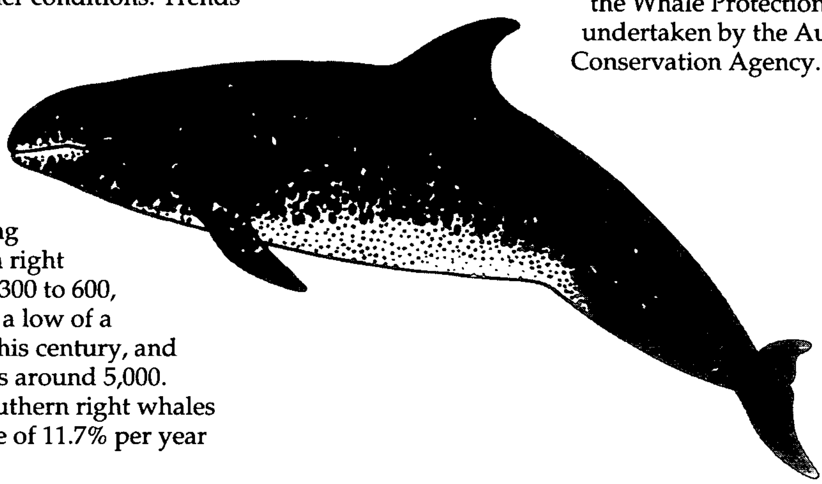
Whale watching in Australia - guidelines

Whales and dolphins are now major tourist attractions in some areas in Australia. Humpbacks migrate northwards from antarctic waters along the east and west coasts between May to August, and return from September to December. They may be seen from headlands at several locations on the east and west coasts. In Hervey Bay a major shipboard tourist industry has developed. Southern right whales come in to the southern coast to calve between May and November, and may be seen from headlands along the Otway coast of Victoria, e.g. Warrnambool, Port Fairy and Portland Bay, cliffs of the Great Australian Bight, Cape Leeuwin (WA) and Storm Bay (Tas).

Dolphins may be seen year round. The Monkey Mia (WA) dolphins which play around tourists in the shallows have become world famous, and a major tourist attraction. Guidelines have been established by the Australian Nature Conservation Agency for whale watching.

Commonwealth guidelines to avoid disturbance to whales include restrictions on:
- proximity of contact (minimum approach 100m for vessels, 300m for aircraft);
- contact with mothers with calves;
- pressure (maximum number of vessels per whale or school);
- vessel operation such as chasing whales, making loud noises, scattering schools, feeding and making wakes.

The determination of the status of cetacean populations is difficult because of their often vast oceanic distributions, difficulties and expense in carrying out systematic aerial or shipboard surveys, sightability, and weather conditions. Trends are also difficult to establish because of imprecise population estimates and the slow rates of increase.



The Australian breeding population of southern right whales is now around 300 to 600, having increased from a low of a hundred or so earlier this century, and the world population is around 5,000. Western Australian southern right whales have increased at a rate of 11.7% per year since 1977.

Two different estimates of humpbacks migrating along eastern Australia in 1987 were 790 (with an increase of 14.4% pa), and 1,107 (with an increase of 9.7% pa). It is estimated that the Western Australian population of humpbacks has increased at 8.8% pa since the cessation of whaling in 1963. Databases on whales are maintained by the Australian Nature Conservation Agency.

Management

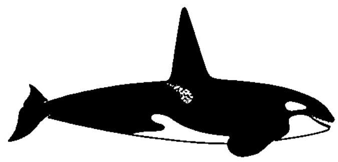
In 1946 the International Convention for the Regulation of Whaling established the International Whaling Commission (IWC) to conserve whale stocks while maintaining the industry. With the overexploitation of stocks and a change in world opinion on hunting, the IWC's focus shifted towards conservation, and it finally placed a moratorium on all commercial whaling from 1986. Some hunting of minke whales continues for 'scientific purposes' but this is strongly opposed by Australia. Management of stocks of small cetaceans is presently under consideration by the IWC.

Australia has been very active in whale management. It was an original signatory to the 1946 Convention and has attended all meetings of the IWC. With the Seychelles, it initiated the 1979 IWC declaration of the Indian Ocean whale sanctuary in 1979. It was at the forefront in the 1982 decision on the moratorium on commercial whaling, and the 1994 IWC decision for the Southern Whale Sanctuary.

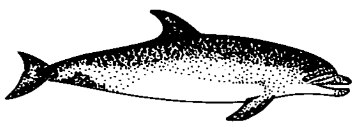
Australia passed the *Whale Protection Act* in 1980. This prohibits the killing, capturing, injuring, harassing, chasing and herding of whales, dolphins and porpoises in the Australian territorial waters. Cetaceans are protected under complementary State and Territory legislation within three nautical miles.

The maintenance of dolphins and whales in captivity has been tightly controlled after a Senate Select Committee investigation in 1983-85. Cetacean management and administration of the Whale Protection Act is undertaken by the Australian Nature Conservation Agency.

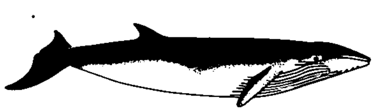
Cetacean species in waters of Australia, distributions and approximate status



Killer Whale



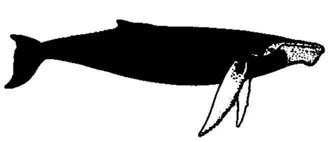
Bottlenose Dolphin



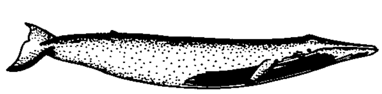
Minke Whale

Sperm Whale

Irrawaddy Dolphin



Humpback Whale



Blue Whale

The following lists cetacean species recorded from Australian waters. The abundances are poorly known and are approximate only.

Cosmopolitan:

Minke whale (*Balaenoptera acutorostrata*) (Common, increasing popn., but still hunted. Antarctic popn. ca 750,000)
Blue whale (*B. musculus*) (Previously heavily hunted: endangered. Antarctic popn. ca. 660)
Pygmy sperm whale (*Kogia breviceps*) (Abundance unknown)
Dwarf sperm whale (*K. simus*) (Abundance unknown)
Humpback whale (*Megaptera novaeangliae*) (Previously heavily hunted: endangered but recovering. (S. hemisphere popn. ca. 12,000)
Killer whale (*Orcinus orca*) (Common)
Sperm whale (*Physeter macrocephalus*) (Previously heavily hunted: secure)
Cuvier's beaked whale (*Ziphius cavirostris*) (Rarely seen)

Temperate and/or polar waters worldwide:

Sei whale (*Balaenoptera borealis*) (Previously extensively hunted: uncommon. S. hemisphere popn. ca 40,000)
Fin whale (*B. physalus*) (Previously extensively hunted but recovering. S. hemi. popn. ca. 24,000)
Long-finned pilot whale (*Globicephala melas*). (Little hunted. Numbers in S. hemi. unknown)
Hector's beaked whale (*Mesoplodon hectori*) (Rare or very rare)

Tropical and/or (warm) temperate waters worldwide (Higher latitude limits to ranges variable):

Bryde's whale (*Balaeoptera edeni*) ('Sizeable' world popn.)
Common dolphin (*Delphinus delphis*) (Common)
Pygmy killer whale (*Feresa attenuata*) (Moderately rare?)
Short-finned pilot whale (*Globicephala macrorhynchus*) (Moderately common)
Risso's dolphin (*Grampus griseus*) (Common)
Fraser's dolphin (*Lagenodelphis hosei*) (Probably relatively common)
Dense-beaked whale (*Mesoplodon densirostris*) (Little known)
True's beaked whale (*Mesoplodon mirus*) (Known from few specimens only)
Melon-headed whale (*Peponocephala electra*) (Little known, moderately rare?)
False-killer whale (*Pseudorca crassidens*) (Not very abundant)
Spotted dolphin (*Stenella attenuata*) (Common, main dolphin caught in purse seines outside Australian waters. Pacific popn. 2-4 million)
Striped dolphin (*S. coeruleoalba*) (Common, heavily fished in W. Pacific)
Spinner dolphin (*S. longirostris*) (Common, but a major by-catch of purse seines outside Australian waters)
Rough-toothed dolphin (*Steno bredanensis*) (Possibly moderately common)
Bottlenose dolphin (*Tursiops truncatus*) (Common, coastal but world population reduced by pollution, fisheries)

Southern hemisphere (Latitudinal limits to ranges variable)

Speckled porpoise (*Australophocoena diotropica*) (Rare?)
Arnoux's beaked whale (*Berardius arnuxii*) (Not common)
Pygmy right whale (*Caperea marginata*) (Little known)
Southern right whale (*Eubalaena australis australis*) (Previously heavily hunted, endangered, world pop. ca 5,000 but recovering.)
Southern bottlenose whale (*Hyperoodon planifrons*) (Little known)
Hourglass dolphin (*Lagenorhynchus cruciger*) (Possibly fairly common)
Dusky dolphin (*L. obscurus*) (Common, coastal)
Southern right whale dolphin (*Lissodelphis peronii*) (Fairly common)
Andrews' beaked whale (*Mesoplodon bowdoini*) (Little known)
Grey's beaked whale (*Mesoplodon grayi*) (Rare?)
Strap-toothed whale (*M. layardii*) (Relatively common?)
Shepherd's beaked whale (*Tasmacetus shepherdi*) (Little known)

Indo-Pacific

Ginkgo-toothed beaked whale (*Mesoplodon ginkgodens*) (Probably rare)
Longman's beaked whale (*M. pacificus*) (Little known. Probably rare)
Irrawaddy river dolphin (*Orcaella brevirostris*) (Probably fairly common, inshore, estuarine, riverine)
Indo-Pacific humpbacked dolphin (*Sousa chinensis*) (Fairly common)

(Source: Klinowska 1991)

Summary and conclusions

1. Sea turtles and marine mammals are particularly vulnerable to extinction compared with other marine species because of their relatively slow growth and low reproduction rates.

2. Australia's sea snakes are of world significance. Around 60% of the world's species occur in northern Australia, and a high proportion are endemics (50%). Prawn trawling appear to be the main threat. Sea snakes are protected and populations appear secure.

3. Australia's sea turtles are of world significance. Six of the seven species are found in Australian waters, and one (the flatback) is endemic. Rookeries are of regional significance. Although protected and secure within Australia's waters, populations are declining because of overharvesting in neighbouring countries. Regional management is a high priority.

4. Australia has the largest, and most secure populations of dugongs in the world (estimated at over 80,000). Populations elsewhere are considered severely depleted. Impacts in Australia include habitat loss, indigenous hunting and incidental catch in fishing nets. The relative importance of these impacts is unknown.

5. Southern Australia has significant populations of fur seals (two species) and sea lions (one species). Populations were once severely overexploited, but they are now fully protected. The fur seals are secure; the sea lion is rare.

6. Australia has significant populations of cetaceans. Around 43 species (approx 58% of world species) have been recorded from Australia. Hunting very severely depleted Australia's humpback and southern right whale populations, but populations are recovering. Antarctic whaling has endangered oceanic blue whales and severely depleted other baleen species. Major threats include pollution and fishing nets. Australia has been a world leader in cetacean conservation.

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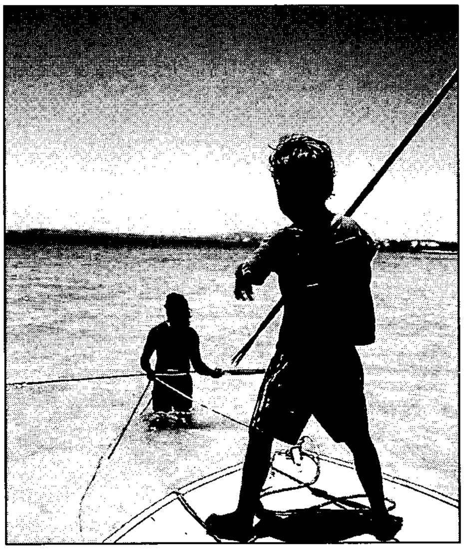
Part 3
The Human Environment

The Aboriginal peoples, the first Australians, have lived along the coast for around 60,000 years. This greatly pre-dates the formation of the present coastline, around 5,000-10,000 years ago. Many Aboriginal creation stories tell of rising seas and great floods. 'Sea country' was, and remains, a culturally and economically important part of the estates of the coastal clans. Torres Strait Islanders, more recent arrivals from the north, are a maritime people who rely on the sea for their sustenance.

The coast and sea are no less important culturally and socially for non-indigenous Australians. The first visitors came by sea, and the British settlements clung tenuously to the coast for many years. Despite the popular myth of 'the bush', the non-indigenous population has remained firmly coastal, and urban, for over two centuries. Today, Australia has a characteristic coastal and beach culture, and the 'beach', a national icon, is the focus of summertime activities.

Humans are an intrinsic part of the environment and the maintenance (or enhancement) of the human environment must be a major objective of environmental management. The human/environment relationship is an uneasy one in Western social and environmental sciences but the realities are, of course, that the natural environment is an essential part of our culture and being, and humans are an intrinsic part of the environment.

(Source: GBRMPA)

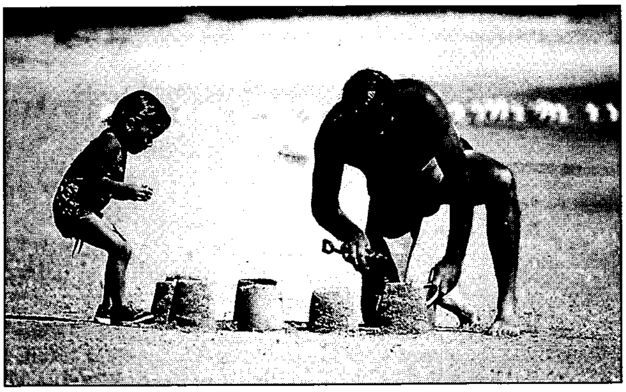


'Saltwater country' remains important in the culture and subsistence of coastal Aboriginal people.

While the economic uses of the sea and the biophysical aspects of the marine environment are described throughout this report, the social value is of particular importance and receives special description in this part.

Importance of marine environment for indigenous Australians

Chapters 19-22 describe the complex and little-documented social and cultural values of the marine environment to the indigenous peoples of Australia. The first chapter provides an archaeological background to Aboriginal use of the marine environment. Chapter 20 describes past and present importance of the marine environment to Aboriginal peoples around Australia, and examines in particular indigenous issues in the coastal zone, and implications of the historic 'Mabo decision'. Chapter 21, written by Aboriginal authors, provides a more detailed case history of indigenous issues in one area, northern New South Wales. The final chapter describes the maritime culture of the Torres Strait Islanders in the north.



(Source: GBRMPA)

The marine and coastal environments have great social and cultural value for the general community.

Importance of marine environment for general community

The remaining chapters describe the social and cultural importance of the marine environment to the general population. Chapter 23 examines the social value, which although obviously great, remains very little documented. Chapters 24 and 25 describe the maritime and coastal cultural heritage, and its protection, and Chapter 26 describes the community and marine conservation.

Chapter 19. Pre-European use of the sea by Aboriginal people: an archaeological perspective[1]

Archaeologists believe that Aboriginal people have inhabited this continent for around 60,000 years. While their origins are not known, the ancestors of the Aboriginal people must have arrived from Asia during the glacial period of lowered sea level. They must have been coastal people, subsisting on shellfish, seabirds, turtles, and fish as well as land animals and plants. On reaching Australia it is thought they initially spread down the coasts and then into the hinterland and desert. The sea remained important for many Aboriginals and the fertile coastal plains and seas of the east supported the continent's largest populations.

The traditional importance of the sea for coastal Aboriginal people may be glimpsed in their own myths and legends; from their dance and art; from the writings by early European explorers; and from modern anthropological and archaeological research. Aboriginal coastal archaeological sites provide a wealth of information on pre-European subsistence patterns. They are also an important part of the Aboriginal cultural heritage, and are important cultural and spiritual links with the past for many dispossessed communities. This chapter briefly discusses archaeological research on pre-contact Aboriginal subsistence patterns and marine resource use, and the Aboriginal archaeological cultural heritage in the coastal zone.

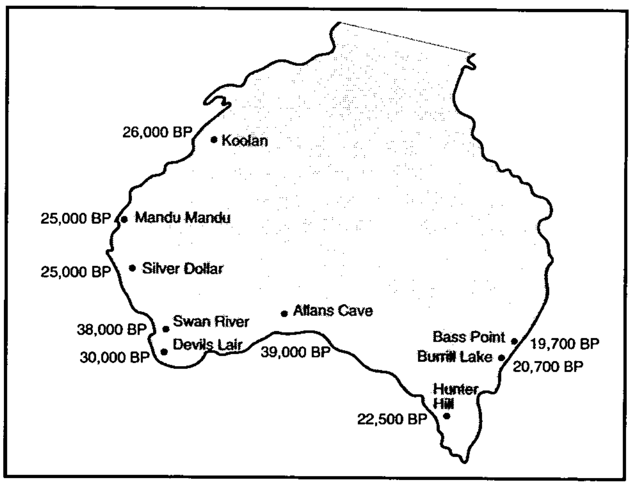


Figure 19.1: Pleistocene Australia showing evidence of coastal settlement. (BP: years before present)

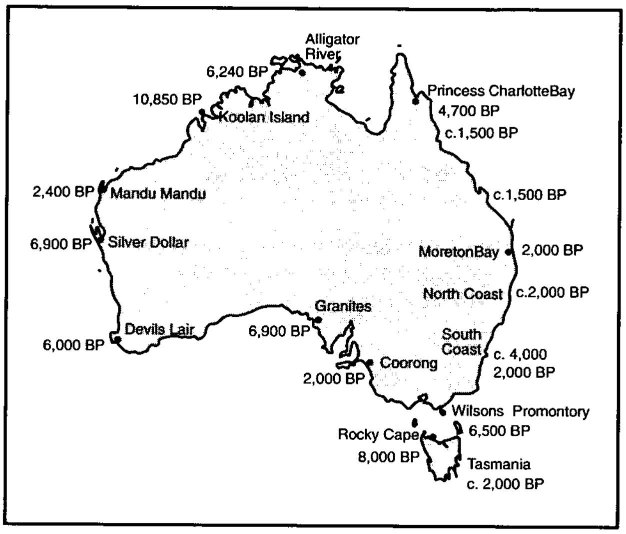


Figure 19.2: Holocene Australia showing evidence of coastal settlement. Older sites now lie submerged on the contental shelf.

Archaeological investigations and general patterns around Australia

Queensland

The coastal lowlands and forests, estuaries, islands, swamps and ocean beaches of the Moreton Bay area provided a rich resource for semi-permanent settlements or 'villages' at a high population density. Seasonal variations in resources appeared less important than in the south, and there was no need for coastal people to move inland in search of food. Moreton Bay formed around 6,000 BP (years before the present) and while the earliest sites are only around 2,000 BP this may only reflect poor preservation conditions.

At Princess Charlotte Bay in the far north, the earliest coastal occupation is around 4,700 BP. Shellfish gathering increased around 2,000 years ago indicating a greater coastal population. Ethnographic evidence

[1]Based on a technical paper by A. Nicholson and Dr S. Cane, Consultants, Narooma, New South Wales.

(Source: L. Zann)

Figure 19.3: Typical coastal midden of bivalves *(Gaffrarium, Crassostrea, Anadara)* and snails *(Melo, Terebra)*, Magnetic Island, (Qld).

indicates that the coastal or 'sand beach people' were relatively sedentary, concentrating foraging activities on marine and estuarine resources. At Weipa, on the western side of Cape York, are a unique series of around 300 large shell middens which have been the subject of recent controversy. A claim that the mounds were formed by scrub fowls rather than people has been discounted by archaeologists.

New South Wales

Stratified midden sites on the south coast show that occupation also began around 6,000 BP and increased around 3,000 BP, possibly as newly formed estuaries, tidal lagoons and rock platforms provided a richer foraging environment, or as more efficient technologies developed. Evidence from Burrill Lake and Currarong show a mixed economy and suggest that the Aborigines seem to have been maximising their economic options by exploiting all available resources. During summer they may have been semi-nomadic around estuaries, and fully nomadic in winter.

(Source: L. Zann)

Figure 19.4: Oyster midden (left, with trees), Evans Head (NSW).

In the rich coastal valleys of the north coast population densities were higher, territories smaller, and the population was more static. There were semi-sedentary settlements around the estuaries of the major rivers. Clarence River Aborigines were concentrated on the coast during spring and summer, and dispersed over the coastal hinterland in winter.

Victoria

The earliest dated coastal occupation was about 6,500 BP (again the time the present sea level stabilised), and once again there was an increase in sites from 2,000 BP. The archaeology is not well known but the earliest site, at Wilson's Promontory, shows different shellfish types between 6,500-3,000 BP than in the last 1,000 years, suggesting changes in adjacent coastal physiography and faunas. Coastal sites comprise temporary camps on the foreshore occupied briefly while gathering shellfish, and base camps further inland which were occupied for longer periods.

Tasmania

The Tasmanian Aboriginal people relied heavily on coastal resources and virtually all groups had some access to the sea. Many middens have been located and excavations provide a detailed picture of occupation and subsistence. On the rugged north west, occupation seems to have been influenced by seasonal variations in resources. Winter was a season of hardship and groups were sedentary and widely spaced to maximise available resources, and shellfish were heavily exploited. During summer the people were more nomadic and seals and muttonbirds were targeted. On the more gentle east coast they were widely dispersed and lived a nomadic existence, exploiting the coast and inland, possibly harvesting shellfish in winter and terrestrial fauna in summer.

The antiquity of coastal occupation has been established at Cave Bay on Hunter Island at 22,500 BP. Sea levels were low at that time and any shore sites would now be submerged. The earliest marine material (molluscs, fish and seals) is at Rocky Cape, and dates to around 8,000 BP. One of the most vexing and intriguing questions in Australian archaeology is the disappearance of fish from the Tasmanian diet around 3,500 BP. Interestingly, most middens date to within the last 2,000 years suggesting that technological changes or changes in population may have influenced coastal exploitation strategies.

South Australia

The western part of this coastline also contains very little evidence of Aboriginal marine exploitation. Shell middens are extremely rare west of the Coorong, but to the east is an almost continuous scatter of midden material. This may reflect a lack of mollusc resources and a greater emphasis on fish, but recent studies indicate that shellfish and other marine foods were abundant but were selectively and minimally harvested. This was possibly because the coastal population was very low (around one per 40 square kilometres in historical times) because of the waterless nature of the landscape, and their desert economic and cultural tradition. The sea became more important along the more fertile east coast from around 2,000-1,300 years BP, consistent with the pattern in the south eastern States.

Recent perspectives on Aboriginal settlement

Marine resources were exploited in Australia from the earliest phases of human occupation. This ancient marine tradition intensified, diversified and became more sophisticated over the last few thousand years. Increased sedimentation, artefact numbers, midden volume and technological sophistication all point to a greater use and reliance on the sea.

While it has been assumed that the initial settlement of Australia occurred around the coast, up the major river systems, and into the mountains and deserts, the difference in coastal archaeology between the east and arid south-west and west suggests a more complex situation. Evidence for a well developed marine economy in arid areas is sparse, reflecting low population densities and a land-based economy; and desert cultural, technological and economic traditions. This indicates that the coastal colonisation was stopped by desert barriers like the Nullarbor Plain, and that the arid coasts were subsequently settled by desert hunter-gatherers who used the sea to supplement their land-based resources.

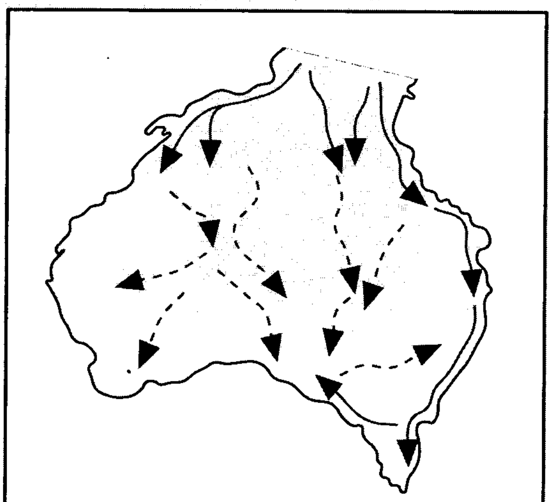


Figure 19.5: Possible routes of colonisation in Pleistocene Australia.

Western Australia

Although coastal archaeological studies are comparatively limited in the west, they are among the most interesting in the country. The earliest occupation from the south-west is from Devil's Lair and the Upper Swan River. The former was occupied intermittently from 33,000 to 5,000 BP and contains shell material, though for most of this period it was some distance from the sea. Small middens are found along the south-west coastline but very few sites show evidence of molluscs, suggesting that fish and the resources of the coastal hinterland, were more important.

A general absence of shell middens is also characteristic of the northern coast. The most significant sites are at Silver Dollar at Shark Bay (18,000-25,000 BP), Mandu Mandu near the Pilbarra (25,200 BP) and Koolan Island in the Kimberley (26,850 BP). The last two sites contain the earliest evidence of marine-based economies in Australia.

(Source: P. Veth)

Figure 19.6: Typical midden within deflated calcareous dunes, Burrup Peninsula (WA). It comprises mainly *Anadara, Syrinx, Terebralia* and *Acanthopleura*. Note the considerable number of stone artefacts and basal food preparation platforms.

Northern Territory

Coastal and estuarine middens have been dated to about 6,500 BP on the northern coastline. An important ethnographic study by Dr B. Meehan of coastal Anbarra in Arnhem Land described coastal subsistence patterns and particularly the role of shellfish, as well as giving an insight into the way of life of other coastal Aborigines in the past. The Anbarra refer to themselves as 'beach people' (as opposed to the inland 'forest people'), and still depend on fish and shellfish from estuaries. Shellfish are very important in the diet and are gathered throughout the year by women. Temporary or 'dinnertime camps' are located close to shell beds while a series of base camps are occupied throughout the year, as described from archaeological sites in Victoria and southern New South Wales.

Patterns of marine resource use

Importance of marine shellfish

In New South Wales extensive middens along river estuaries (e.g. Richmond and Clarence) indicate the large-scale exploitation of shellfish such as oysters, cockles and whelks. Along ocean coasts and rocky shores, middens exhibit a range of molluscs such as cockles, whelks, turbans, abalone, periwinkles and chitons. In South Australia they contain sandy beach species. Many midden sites are located in different littoral environments and contain combinations of species from these, generally in proportion to their natural abundances, but also varying over time. A widespread shift from open coast shellfish to estuarine species occurred between 1,200 and 700 BP, possibly due to the introduction of hook and line fishing.

Fish

Fish were probably of considerable importance in subsistence economies in many areas but do not preserve well in middens. A range of specialised fishing technologies were developed, including poisoning, netting, trapping, spearing, and hook and line. Large schools were sometimes targeted in well organised seasonal fisheries; in a net fishery in Coorong (SA) catches were transported in baskets and preserved by drying. In Moreton Bay (Qld) a curious symbiosis developed between Aborigines and dolphins which were used to herd mullet schools into nets for a share in the catch.

Seabirds, reptiles and marine mammals

Seabirds were a secondary resource and are found in many archaeological deposits in south-eastern Australia. The use of water craft was required as colonies were generally on offshore islands. The use of seabirds on offshore islands by Tasmanians is well documented.

In the north, turtles were important. Eggs and nesting females were taken from rookeries. Turtles and dugongs were also hunted from canoes with harpoons. In the south, seals were important on both sides of Bass Strait and strongly influenced Aboriginal settlement patterns. Seals were taken mainly during summer when the colonies were larger, enabling semi-sedentary base camps to be established.

Evidence of overexploitation

Changes in the patterns of exploitation at some sites suggests overexploitation rather than environmental and economic changes. At Currarong in southern New South Wales the earliest occupants focused on estuarine species but switched to open coast species around 1,500 BP, possibly because of overexploitation. Tasmanian sites also provide evidence of overexploitation of available resources. The abandonment of a site at West Point in north-western Tasmania around 1,000 BP is attributed to the overexploitation, and possible extinction, of elephant seals.

(Source: P. Veth)

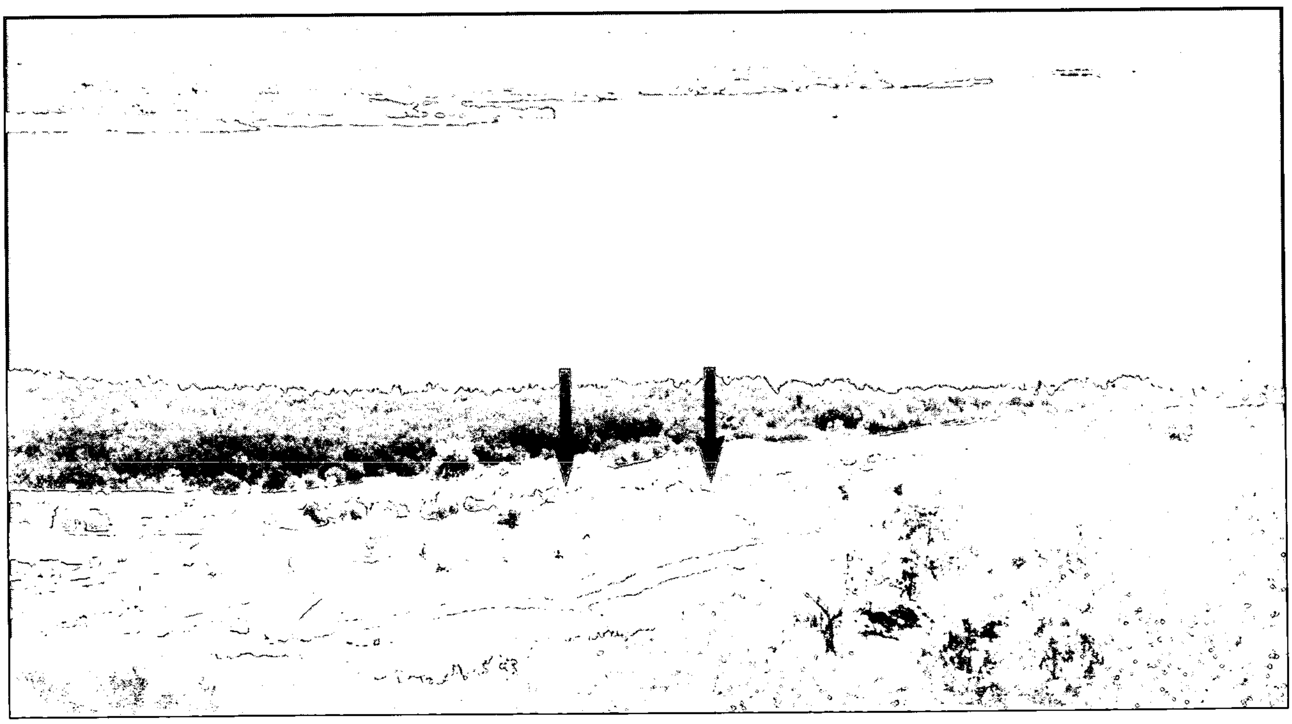


Figure 19.7: Extensive mounded midden behind mangrove flats, Mitchell Plateau, NW Australia. It consists mainly of the bivalve *Tapes hiantina*, and has a basal date of 1,640 +/- 50 yrs BP.

Management of Aboriginal archaeological heritage

The major threats to Aboriginal archaeological sites are: disturbance or destruction by urban expansion, tourist facilities, resorts, roads and other developments, particularly in the south-east; erosion by natural processes such as storms; and vandalism. An enhanced greenhouse effect sea-level change would have a major impact on many coastal sites. Aboriginal archaeological sites are protected under the *Australian Heritage Commission Act* 1975, *Aboriginal and Torres Strait Islander Heritage Protection Act* 1984, and various State and Territory legislation. However, the record of Aboriginal archaeological sites is very incomplete (Chapter 25). Both Aboriginal people and archaeologists consider that the current protection of sites is inadequate.

(Source: GBRMPA/Hopevale Community)

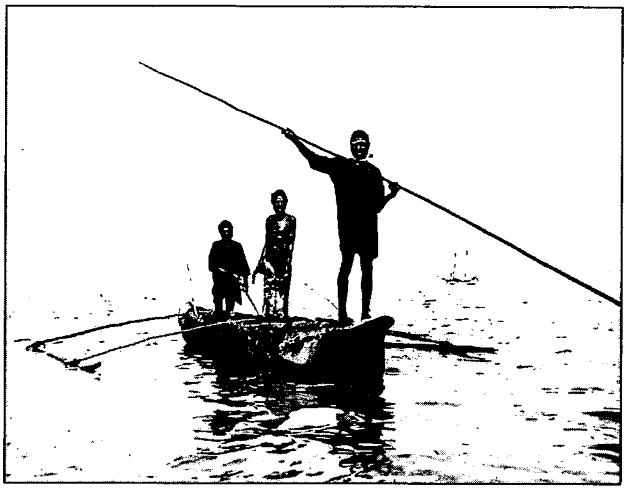


Figure 19.8: Aboriginal people traditionally used a range of water craft for fishing, hunting and coastal travel. A double outrigger (of Torres Strait and Papuan influence), Cape Bedford area (Qld), around 1920.

Summary and conclusions

1. Aboriginal coastal archaeological sites are an important part of the Aboriginal cultural heritage. They are a particularly important part of the contemporary culture of dispossessed Aboriginal peoples.

2. Archaeological studies indicate that marine resources were exploited in Australia from the earliest phase of human occupation of the coast.

3. This ancient marine tradition intensified and diversified, and became more sophisticated over the last few thousand years.

4. The marine economy was more important in the east than south-west and west, suggesting higher human population densities and a greater reliance on resources.

5. The Aboriginal marine economy was diverse, and based on seasonal exploitation of a range of different species from different habitats. This strategy prevented overexploitation of resources but some cases of depletions and local extinctions are suspected.

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The technical paper by A. Nicholson and Dr S. Cane was reviewed by Dr B. Meehan, Aboriginal and Torres Strait Islander Environment Section, Australian Heritage Commission, Canberra, ACT and Dr D. Smyth, Honorary Research Fellow, James Cook University, Townsville, Qld.

Chapter 20. Aboriginal maritime culture[1]

'For Australia's indigenous coastal and island peoples, the relationship and sense of belonging to 'sea country' is as elemental as their affiliations with the land. Knowledge, use and occupation of 'sea countries', whether they are identified as 'home reefs and islands', or shoreline, nearshore or extended regional estates can be subtle and often elusive and enigmatic to outside observers.

'However, it is incontrovertible that the traditional estates of Aboriginal people extend from the land into marine areas or 'salt water country'. Traditional estates do not artificially finish at low water mark. The rights to exploit and control the exploitation of marine resources within traditional estates are an essential component of traditional ownership.'

(From a submission by Northern Land Council to RAC Coastal Zone Inquiry 1992)

This chapter discusses the contemporary relationship between Aboriginal peoples and Australia's marine environment, and the major issues and concerns in this area. This very long and complex relationship is referred to as Aboriginal maritime culture because it embraces both coastal land and sea environments, and because it involves a mix of Aboriginal usage, management and cultural values.

Surprisingly little on Aboriginal maritime culture is documented, and even less is understood by non-indigenous Australians. Much of this chapter was compiled during the Resource Assessment Commission's Coastal Zone Inquiry from discussions with coastal Aboriginal peoples around Australia, and from their formal submissions to the Inquiry. The Commissioners' bold and far-reaching recommendations regarding the interests of Aboriginal peoples in the coastal zone go far beyond the Inquiry's terms of reference, and if implemented, will be important in the reconciliation of Aboriginal people (RAC 1993; Smyth 1993).

A background: precolonial Aboriginal maritime culture and impacts of European settlement

Precolonial maritime culture

Precolonial Aboriginal maritime culture can be inferred from the descriptions of early explorers and anthropologists, and from the continued practice of many aspects of traditional culture in many parts of Australia. While Aboriginal/environment relations differed from place to place according to social structure, technologies and resource use patterns, there are sufficient similarities to describe common elements of Aboriginal maritime culture.

Aboriginal peoples traditionally belong to small, estate-owning descent groups or clans (usually patrilineal). The estates of coastal clans include areas of land and sea over which clan members and their families have rights and responsibilities for use and management.

Traditional knowledge of maritime environments includes not only knowledge of the behaviour and usefulness of individual species, but also an understanding of the connection of environmental processes. Cultural values overlay all observed natural phenomena. Landscapes, seascapes, biodiversity, animal behaviour, weather and so on are incorporated into Aboriginal culture through Dreamtime stories which not only provide explanations for the existence of these phenomena, but also determine the contemporary relationship of people to their environment.

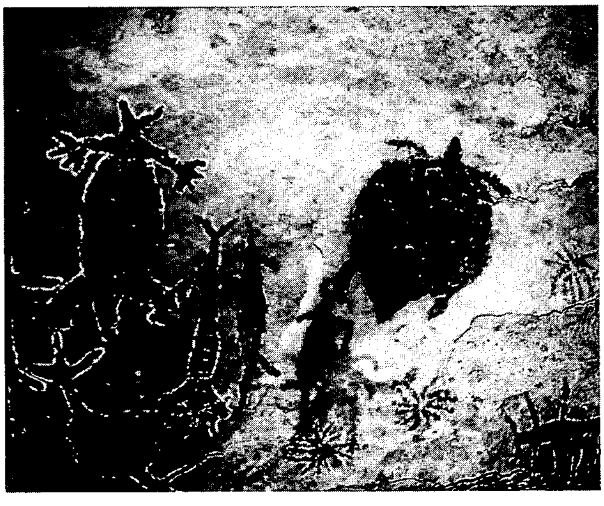
(Source: M. Hartcher, GBRMPA)

Figure 20.1: The sea is of traditional importance for the culture and subsistence of coastal Aboriginal peoples. Turtle, crocodiles, sea urchins in rock painting, Flinders Group (Qld).

[1]Based on a technical paper by Dr D. Smyth, Honorary Research Fellow, James Cook University, Townsville, Queensland.

In pre-European times the Aboriginal populations around Australia were determined in part by the nature and abundance of resources. While the coastal lakes, estuaries and river deltas in southern Australia supported large, stable Aboriginal populations equal to those on the wet tropical coast, more intense European settlement had a proportionally greater impact on southern populations.

Northern Australia

In the north the marine component of coastal estates was extensive. In north-east Queensland there is evidence of some coastal clan estates extending to the outer Great Barrier Reef. In the Northern Territory places of special cultural significance (sacred sites) have been identified by Aboriginal people up to 80 kilometres off the coast. Similar extensive sea territories are reported in the Kimberley area in Western Australia, some of which are currently the subject of native title claim by traditional Aboriginal owners.

Prior to European colonisation, the northern maritime culture was influenced by contact with maritime peoples from present-day Indonesia, including the Macassans, who made seasonal visits to collect trepang (sea cucumbers) between the 1600s and early this century. One of the first acts of the new Commonwealth Government in 1901 was to pass a law which prohibited the seasonal visits.

In the north-east the Cape York people were strongly influenced by Melanesian contact, particularly with Torres Strait Islanders. Aboriginal water craft included outriggers for offshore and interisland travel, and smaller dugouts and bark canoes for more protected waters.

Southern Australia

In the south there is less evidence of large sea territories, and water craft were limited to inshore waters. The apparent lack of occupation during the past 5,000 years of Kangaroo Island seven kilometres off the coast of South Australia indicates limited access to offshore resources in the south. However, the existence of rock fish fences, and the abundance of abalone and other shells in middens (Chapter 19) indicates substantial use of inshore resources and suggests that coastal clan territories extended beyond low water mark. In sheltered waters rich in marine resources, e.g. Moreton Bay, Botany Bay, Jervis Bay, Port Phillip Bay and Shark Bay, it is probable that customary marine tenure similar to those documented in the north was in existence.

Impact of European colonisation

The assault on Aboriginal maritime culture began with the renaming of coastal features by passing seafarers. European names such as Botany Bay, Cape Tribulation and Cape Leeuwin have replaced local Aboriginal names, the antiquity of which may equal that of the coast itself. The renaming set an early precedent for the denial of the pre-existing culture, which was reinforced by the subsequent dispossession of the coastal Aboriginal peoples. The extent and effect of the dispossession varied around Australia.

On the northern coast which was not intensively settled by Europeans, the early bêche-de-mer, pearling, trochus and cattle industries relied on the local, cheap labour of Aboriginal people. Although often harshly treated, many Aboriginal groups survived and remained close to their land and sea estates.

On the more intensively settled southern coast, Aboriginal people were displaced by settlers engaging in industries which did not depend on Aboriginal labour. Dispossessed of their lands and denied the possibility of continued contact with it through work, many southern Aboriginal people also suffered extensive cultural losses, such as languages, ceremonies and sacred sites.

While the European system of land tenure dispossessed Aboriginal people of their land and land-based activities, the European view of the sea as common property enabled the continuation of Aboriginal maritime culture around much of the coastline, including the south. Aboriginal fishing, marine hunting and shellfish collecting which did not compete with the activities of Europeans was ignored, tolerated or even encouraged. On many coastal reserves Aboriginal people were provided with boats and nets to encourage self-sufficiency in food and to engage in fishing enterprises.

More recently however, the growth of the commercial fisheries, depletion of fish stocks and increasing coastal development has brought contemporary Aboriginal maritime culture into conflict with other users of the sea. For example, at Wreck Bay in Jervis

(Source: M. Harcher, GBRMPA)

Figure 20.2: The arrival of Europeans, depicted in this rock painting (Flinders Group, Qld), resulted in the dispossession of Aboriginal people from their land and sea estates.

Bay, Aboriginal people were legally permitted to engage in commercial fishing without a licence until 1967 when this exemption was removed. Whereas most of the community once engaged in commercial fishing, today there is one person with a commercial licence. Requirements for expensive, tradeable licences and quotas have progressively excluded Aboriginal people from commercial fisheries in many parts of Australia over the past 30 years.

case history

The Abalone saga

According to midden deposits, abalone were important in the Aboriginal diet in southern Australia for at least 5,000 years. Since European settlement to recent times, coastal Aboriginal people along the coast would dive for the delicious shellfish. The following submission from the New South Wales Aboriginal Land Council to the Coastal Zone Inquiry tells how they have lost access to this traditional resource.

'Prior to the development of an export market for abalone, virtually the only people involved in taking that species for commercial purposes on the south coast were Aboriginal fishermen. They would gather it by free-diving and shuck (clean) it on the rocks while at the same time collecting food for their families. As Asian markets developed in the late 1960s and 1970s, the commercial values of abalone skyrocketed. As prices rose, non-Aboriginal divers, using surface-supplied air, entered the field. Aboriginal divers, by contrast, continued to free-dive using only snorkelling gear. As stocks began to diminish during the mid-1970s, calls were made for the issuing of commercial abalone permits based on minimum take over the previous three years. Whilst there were over 100 divers in 1979, only 59 were granted permits when regulations were introduced in 1980. Despite the long history and prevalence of Aboriginal divers in the industry, only two of the 59 permits went to Aboriginal people and these were on the basis of a special allocation. The system of allocation discriminated against the low-intensity free-diving Aboriginal people in favour of the more rapacious, capitalised non-Aboriginal divers using artificially supplied air. Since 1980, Aboriginal divers who have continued to earn income from free-diving despite the regulation have been classed as poachers.'

In recent years, many Aboriginal fishermen have been prosecuted and occasionally gaoled for fisheries offences relating to abalone. One of these fishermen appealed against his conviction on the grounds that he was exercising native title right to fish. This appeal was dismissed by the New South Wales Supreme Court in October 1993. An appeal to the High Court is pending.

Contemporary Aboriginal maritime culture

Approximately 120,000 Aboriginal people, or half of Australia's indigenous population, live within 20 kilometres of the coast. Most live in coastal cites and towns and in designated Aboriginal communities, but over the past 20 years many in northern Australia have returned to traditionally-owned clan estates; and semi-permanent settlements, often referred to as 'outstations', have been established.

In modern times the distribution of Aboriginal communities has been influenced by the particular settlement and development history of each region. This has also influenced the nature of contemporary Aboriginal usages, management practices and cultural values associated with the marine environment. Contemporary coastal Aboriginal communities, with links and cultural practices going back to pre-European times, exist in all States and Territories.

Importance of the marine environment

Aboriginal usage of the marine environment is practiced as part of a holistic cultural relationship. The separation of usage from management and cultural values is an entirely artificial construct, as illustrated in the submission by the Northern Land Council quoted in the preamble to this chapter.

(Source: N. Coleman)

Figure 20.3: Aboriginal hunter at Cape Levique (WA) butchering turtle.

Subsistence fishing

Subsistence fishing, hunting and gathering are important contemporary Aboriginal uses of the marine environment. This includes fishing with spear, net and line, as well as harpooning for dugong and turtle, and collecting shellfish and other intertidal and subtidal invertebrates. These are often carried out under a variety of cultural constraints, such as who may hunt, where and when, and who should receive what part of the catch. Even in coastal towns and cities where cultural traditions and obligations may not be strong, these activities are distinct from recreational activities of other user groups as they represent an important cultural link with past traditional ways of life and societies.

No comprehensive data are available on the scale or economic importance of subsistence fishing, although localised surveys indicate a high dependence on seafood in some coastal communities in northern and southern Australia. At an outstation near Maningrida on the Arnhem Land coast, seafood contributed between 27 and 37% of energy, and between 52 and 75% of protein at different times of the year. At Stradbroke Island near Brisbane seafood provided around 20% of the calorific intake.

Commercial fishing

By contrast, there is now little involvement of Aboriginal people in commercial fishing. In Queensland, the Aurukun Aboriginal community in western Cape York Peninsula has established a small-scale commercial barramundi fishing enterprise. On the Kimberley coast of Western Australia, the Kanjiwal Aboriginal community is involved in a commercial fishery with Torres Strait Islanders, and the One Arm Point and Lombadina Aboriginal communities have a commercial fishery for trochus shell, used for the manufacture of buttons. In southern Australia there is a small number of individual Aboriginal licensed fishermen. The Aboriginal involvement in the abalone fishery has been previously described.

Aquaculture

There is currently a limited, but growing interest in aquaculture. The Tiwi Land Council, representing Aboriginal people from Bathurst and Melville Islands, has a 50% share in a pearl farm on the Cobourg Peninsula north-east of Darwin. On Fitzroy Island near Cairns (Qld), and in southern New South Wales and near Port Lincoln (SA) groups have established oyster farms. There is also a widespread interest by other communities in abalone, crayfish, clam and barramundi farming.

While Aboriginal people have a limited involvement in commercial fishing, the fishing industry does have a major impact on many coastal communities. This impact is in the form of direct competition for the subsistence resource, intrusion into traditionally owned sea country, disturbance of marine sacred sites, and social consequences on small, remote communities. During the Coastal Zone Inquiry, Aboriginal people also indicated their particular concerns about wastage of by-catch from commercial fisheries.

Marine cultural sites and customary marine tenure

The coast and sea contains a complex array of places of cultural significance to Aboriginal people. These include archaeological sites such as middens, shell scatters, stone quarries, art sites and fish traps; hunting and fishing areas; the locations of important historical events such as massacre sites and camps; and sacred places such as burial, ceremonial and Dreamtime story sites. These places, together with the stories, knowledge and beliefs associated with them, provide a cultural environment for contemporary Aboriginal peoples that links them with their forebears and the Dreamtime beings that created the land, water, plants, animals and humans.

Coastal and marine cultural sites are also important in determining the existence of customary marine estates. Coastal, reef, island or seabed sites may mark the boundary between neighbouring marine estates, or a marine cultural site may form the focal point of a marine estate. While these sites have been recorded all around the Australian coast, documentation of customary marine tenure has so far focused on far-northern Queensland, the Northern Territory and northern Western Australia.

A consistent feature of cultural sites on land and water is the obligation it confers on traditional custodians to care for them, and to ensure that behavioural restrictions imposed by them are observed. Many cultural sites are known as 'dangerous places', 'storm places', or 'sickness places', in which, according to custom, inappropriate behaviour or disturbances result in very serious consequences, such as storms, cyclones, diseases or death. Some of these sites have been registered as sites of cultural significance by government authorities. In the Northern Territory, some marine sites are marked by buoys and given legal protection from disturbance.

Present participation in coastal and marine management

The extent of involvement of Aboriginal people in management of coastal and marine environments varies greatly around Australia, depending on local legislation and government policies, and whether Aboriginal people have formal title to coastal land. On Aboriginal-owned and leased lands Aboriginal people retain substantial control of local management of cultural sites, tourism and resource utilisation, with local variation on controls over mineral exploration and mining.

In the Northern Territory, Aboriginal land extends to the mean low-water mark, giving some measure of control over tidal lands and resources. Although two areas of 'closed seas' have been declared over adjacent waters, Aboriginal land-holders have no formal management role within these. In northern Queensland and Western Australia there are extensive areas of Aboriginal lands, although title does not

(after Chase 1980)

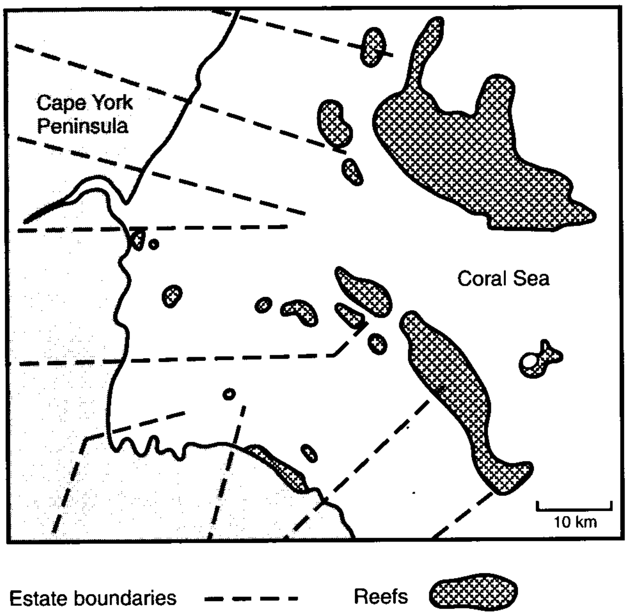

Figure 20.4: An example of customary marine estates in north-eastern Queensland.

extend below the high tide mark. In Queensland the adjacent intertidal land is potentially claimable under the Queensland *Aboriginal Land Act* 1991, although no such claims have yet been heard.

In recent years many Aboriginal communities have been training and employing local people as Community Rangers to assist in environmental management such as management of tourism, recreational fishing and cultural sites, and liaison with national park, fisheries and other agencies. There are now around one hundred Aboriginal Rangers in the north; some southern Aboriginal communities are currently developing proposals for the training and employment of Community Rangers.

Some Aboriginal communities and organisations have also independently established pro-active regional coastal and marine plans, using Ocean Rescue 2000

(Source: GBRMPA)

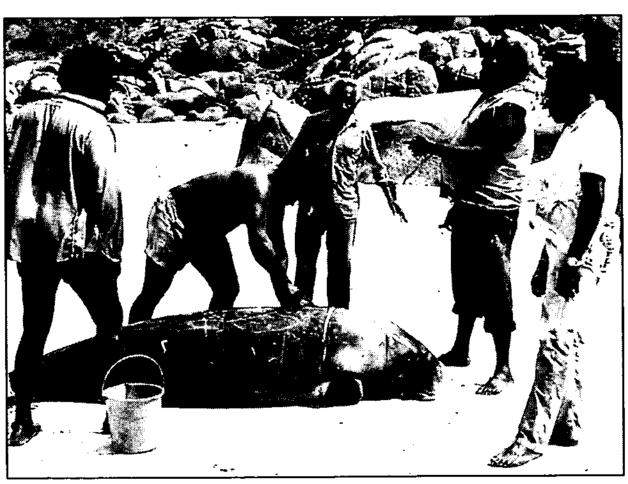

Figure 20.5: Traditional butchering of dugong, Cape York (Qld).

and other funding. The Kowanyama Aboriginal Community Council in western Cape York Peninsula has a Land and Natural Resource Management Office to provide advice on resource management, manage tourism, and monitor fishing. In Nhulunbuy (NT) the Dhimurru organisation represents land and environmental management interests of Aboriginal clans in north-eastern Arnhem Land. The Manbuynga-Rulyapa Interim Council in Galiwin'ku (Elcho Island) has been established to ensure the involvement of Yolngu (Aboriginal people) in all

Involvement of Aboriginal people in management of coastal and marine protected areas

In Queensland there is one Aboriginal member in the Great Barrier Reef (GBR) Marine Park Consultative Committee. In the Queensland Marine Parks Consultative Committee, 'Council of Elders' have recently been established in some areas to assist with the allocation of permits for dugong and turtle hunting in the GBR Marine Park. The involvement of indigenous peoples is stipulated within the 25 year Strategic Plan for the GBR World Heritage Area. A review recommended that Aboriginal Marine Management Areas be established within some areas of the GBR Marine Park, managed under the direction of an Aboriginal-controlled Board of Management (Whitehouse 1993). Reflecting the great importance of indigenous issues in the GBR, in 1994 the three person GBR Marine Park Authority was enlarged to include a person to represent Aboriginal and Torres Strait Islander interests.

In the Northern Territory Aboriginal people are formally involved in management of some coastal national parks, e.g. Kakadu, Gurig.

In Western Australia there is one Aboriginal member of the WA National Parks and Conservation Authority which oversees the operation of the Department of Conservation and Land Management (CALM).

In Victoria and South Australia there is Aboriginal membership in some national park advisory committees, e.g. Wilson Promontory National Park (Vic) and Coorong National Park (SA). In Victoria 20 Aboriginal communities and organisations employ their own Cultural Officers.

There is some limited employment of Aboriginal people in Commonwealth, State and Territory nature conservation, cultural heritage management and planning agencies. The temporary contract employment of Aboriginal people by national and marine park agencies is currently underway in a scheme funded jointly by the Australian Nature Conservation Agency (ANCA) and State and Territory agencies.

aspects of marine management in the area.
The Aboriginal and Torres Strait Island Commission (ATSIC) is currently funding the development of Regional Plans by 49 Regional Councils, 27 of which are on the coast. Many address environmental and resource management issues such as hunting and fishing rights, access to commercial fishing, and greater participation in environmental management. For coastal land not formally controlled by Aboriginal people, and for most marine areas and marine resources, Aboriginal people have a limited role in formal management.

Native Title over land and sea

The Mabo decision

On 3 June 1992 the High Court decided that the Meriam people of Torres Strait hold a common law Native Title to Mer (Murray Island). The court also implied that such common law Native Title continues to exist elsewhere in Australia wherever it has not been explicitly extinguished by governments, providing that the local Aboriginal or Torres Strait Islander people have maintained a relationship with their traditional country based on customary law.

Legislative recognition of this historic High Court decision is contained in the Commonwealth government's *Native Title Act* 1993, which protects any surviving Native Title and set up the National Native Title Tribunal to enable Native Title claims to be registered and determined. Some State governments such as Queensland have passed complementary Native Title legislation.

Native Title differs from other forms of Aboriginal ownership of land in that it does not arise out of a grant from a government, but rather it is recognition of a pre-existing customary ownership of land which has survived since precolonial times. Although the so-called Mabo decision was only made in 1992, the High Court has determined that Native Title has always been a part of Australian common law.

The implications of Native Title

While the full implications of the Native Title High Court decision and legislation will only become clear over time, at least two broad implications are already obvious.

Firstly, there is now an opportunity for at least some Aboriginal and Torres Strait Islander peoples to receive formal, legal recognition of their long-held claims of customary ownership of their traditional country. In practice it may be that such full recognition may only be possible over areas of vacant crown land, national parks and other undeveloped government land, and perhaps only in remote areas of Australia where it has been possible for indigenous people to maintain an association with their land based on customary law.

Secondly, the existence of Native Title in Australian common law has confirmed the status of all Aboriginal and Torres Strait Islander people as the first owners of all of Australia. This in-principle recognition, which replaces the former legal fiction of *terra nulius* (the empty land), considerably strengthens the long-held view of indigenous people that they should be accorded special rights of using and managing Australia's land and sea resources. It might be, therefore, that even Aboriginal and Torres Strait Islander people who may not be able make successful Native Title claims to particular traditional estates, could expect to be accorded a greater role in, and benefit from, the management of Australia's land, sea and resources.

Implications of section 211 of the *Native Title Act* 1993 on protection of marine species

The Commonwealth *Native Title Act* came into force on 1 January 1994. It applies to all of Australia including offshore areas and the external territories.

Further use and management of marine areas is affected by Native Title issues to an extent dependent upon the nature of the Native Title which may be found to exist in that area. Native Title rights may range from the right to exclude all others from an area of sea, to the non-exclusive tight to take marine resources.

Where native title rights are found to exist in respect of marine areas, these interests will have to be accommodated within the planning processes for those areas. This may mean that co- or joint management processes may need to be established in respect of those areas.

Native Title over the sea

The legal and administrative implications of Native Title in the sea are currently less well understood than on land, primarily because the High Court was not required to make a determination on Native Title in the waters surrounding Murray Island in the Mabo case.

In Aboriginal and Torres Strait Island societies, however, there is no such confusion, e.g. in the submission from the Northern Land Council in the preamble to this chapter. The boundaries of traditional clan and tribal countries extend into and include areas of the sea. It follows, therefore, that traditional rights to the resources of clan estates included rights to use and control resources in the sea. The sea also contains sacred sites and Dreaming tracks and was created in the Dreamtime along with all its animals, plants, rocks and currents. From an indigenous perspective, therefore, there is no distinction between Native Title on land or sea.

In Australian law, however, because of the existence of commercial fishing licences, shipping lanes and a long history of common access to the sea by all Australians, the exercise of Native Title in the sea may develop differently than on land. For example, the Native Title Act provides for continued public access to all beaches accessible to the public prior to the recognition of Native Title. The Act also confirms Crown ownership of all minerals, including those in the sea bed.

Several Native Title claims which include claims over areas of sea are currently before the High Court and State Supreme Courts. Meanwhile, some indication of the practical implications of Native Title in the sea may be gained from the following legal opinion, given to the Great Barrier Reef Marine Park Authority by the Attorney General's Office of General Council:

'... any native (title) marine rights in coastal waters are likely to be factually confined to rights of user and probably would not extend to rights analogous to ownership that might exist to land. While there may be a native right to take fish and other marine living resources, this probably would not give rise to ownership of the fish.'

Other legal opinion suggests that more comprehensive recognition of indigenous ownership of customary marine estates may eventuate. It should be noted also that court decisions in New Zealand, Canada and the United States of America have lead to settlements involving indigenous people being granted equity and other interests in commercial fishing enterprises.

Statutory sea rights

Governments have provided far less statutory recognition of sea rights in comparison to land rights. The Commonwealth *Aboriginal Land Rights (NT) Act* 1976 provides Aboriginal ownership of granted coastal land to the mean low water mark. Under separate legislation (the *Aboriginal Land Act* 1979 No. 138) the Northern Territory Government can grant 'sea closures' over areas of coast within two kilometres of mean low-water mark adjacent to Aboriginal land.

Closed seas are not, however, owned by the adjacent Aboriginal land-owners, nor do they have management responsibility for those waters. Closed seas are open to all pre-existing users, including commercial fishers: they are 'closed' only to fishers obtaining licences after the sea has been declared closed, and also to cruising sailors. In practice, since most commercial fishing vessels are owned by companies, new fishers in company boats continue to have access to closed seas.

The Queensland Aboriginal Land Act and *Torres Strait Islander Land Act* 1991 both provide for the possibility of claiming tidal land if it is gazetted as claimable by the Government. Current Aboriginal reserves and Trust Area leases provide Aboriginal control only to the high-water mark. The Native Title to Mer only applies (so far) to the land area of the island. No other land rights Acts or land grants in other States provide control by Aboriginal people below high-water mark.

Towards recognition of interests of Aboriginal people in the coastal zone

The central issue for the future use and management of marine and coastal environments by Aboriginal people is the extent to which Australian governments, and society in general, are prepared to recognise the unique cultural, spiritual, social, economic and historical relationship between Aboriginal people and maritime environments.

Traditional hunting, fishing and gathering rights

Legal recognition of traditional hunting, fishing and gathering practices varies in the different jurisdictions in Australia. In general, there is greater provision made for hunting and fishing in the north than in the south.

In submissions to the RAC Coastal Zone Inquiry, Aboriginal people raised many concerns arising from current legislation relating to hunting and fishing. These include the prohibition of traditional fishing methods (including spears and nets) in most southern States; the requirement to purchase recreational fishing permits in some States; prosecution (including fines and gaol terms) for breaching fisheries legislation in some States; refusal of some property owners and lease-holders (private and government) to grant Aboriginal people access to coastal land and sea; and prohibition of subsistence hunting in national parks.

Participation in protected area management

With the exception of Aboriginal membership in the Western Australian National Park and Conservation Authority and National Park Boards of Management in the Northern Territory, formal Aboriginal participation in coastal and marine management is not enshrined in legislation. Involvement in management is currently at the discretion of individual agencies. For example, the *Great Barrier Reef Marine Park Act* 1975 does not require consultation with Aboriginal people, nor recognise hunting and fishing rights within the Marine Park, but in recent years regulations and zoning plans have been amended to consider Aboriginal cultural interests. The recent establishment of a 'Council of

Elders' to manage hunting permits is also an important initiative. However, these fall short of formal recognition of Aboriginal ownership of customary marine estates, sites or resources as requested by various communities.

(Source: GBRMPA)

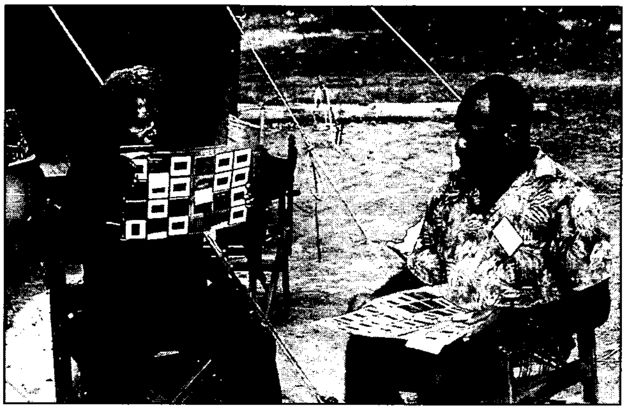

Figure 20.6: Aboriginal liaison officers are employed by the Great Barrier Reef Marine Park Authority to work with Aboriginal communities.

The current formal management arrangements in fisheries remain inadequate. The recommendations of the Ecologically Sustainable Development (ESD) Fisheries Working Group in 1991 to document Aboriginal interests in all commercial fisheries and to ensure the participation of Aboriginal peoples in all levels of fisheries management have not been implemented. Although Aboriginal peoples are exempt from fishery laws in some jurisdictions, no fishery authority recognises the existence of an indigenous subsistence fishery for the purposes of management. There is no Aboriginal membership of any government fisheries agency or advisory committee although the Queensland Fish Management Authority has recently invited Aboriginal membership on all relevant advisory committees. Despite the ESD Working Group's recommendations, the recent reviews of the abalone industry in South Australia and New South Wales make no special provision for Aboriginal subsistence or commercial interests. (But refer to the provisions of s. 211 of the Native Title Act).

Resolution of conflicts

The current marginalisation of, and ignorance about, Aboriginal interests in coastal and marine management, especially in southern Australia, means that many of the existing conflicts between Aboriginal and other interest groups are only experienced by Aboriginal peoples. Commercial fishers, fisheries managers, national parks managers and other agencies may be largely unaware of the conflicts and concerns that are daily realities of Aboriginal peoples.

The recognition of Aboriginal interests will inevitably create conflict with other resource users and even managers, necessitating education on Aboriginal maritime culture for other users, and the development of mechanisms for conflict resolution and paying of compensation.

Conservation of key species

Amongst the existing points of conflict with respect to the accommodation of Aboriginal interests in marine management are the issues surrounding conservation of traditionally hunted, but now endangered, species such as dugong and turtles (refer to discussion of section 211 of the Native Title Act in Chapter 18). This issue is a complex one, and is compounded by the hunting of the same stocks by indigenous peoples in Papua New Guinea, Pacific Islands and Indonesia.

The resolution of these issues will require inclusion of indigenous people in all stages of research, education, planning and management strategies. Indigenous groups have already shown a willingness to engage in this process. The Torres Strait Islander Coordinating Council hosted a workshop in 1993 on the future management of the Strait's marine resources which included representation from Papua New Guinea. Following incursions by Indonesian trochus fishermen on their reefs, the Bardi Aboriginal people in northern Western Australia engaged in their own negotiations with the fishermen, fostering better understanding on both sides and leading to fewer incursions. The Manbuynga-Rulyapa Interim Council has expressed interest in establishing cooperative management arrangements with the neighbouring people in the Indonesian Aru Islands and Irian Jaya.

case history

Submissions by the Wagonga Local Aboriginal Land Council to Resource Assessment Commission

'Over recent years we have witnessed a rapid decline of shellfish on the rocks and estuaries, almost to the point of extinction. This has caused much concern amongst our community members' (p. 1).

'Our kitchen middens were excavated, and the shell deposits used for cement and road base. Homes have been built on middens, and coastal areas that were once frequented by our people, paths have been forged through our campsites and middens that are located on dunes and rocky outcrops. This is our heritage being destroyed, and we have been helpless to stop this destruction. We are downright disgusted and insulted by the disrespect shown by Europeans to our culture and heritage' (p. 2).

(RAC submission 339)

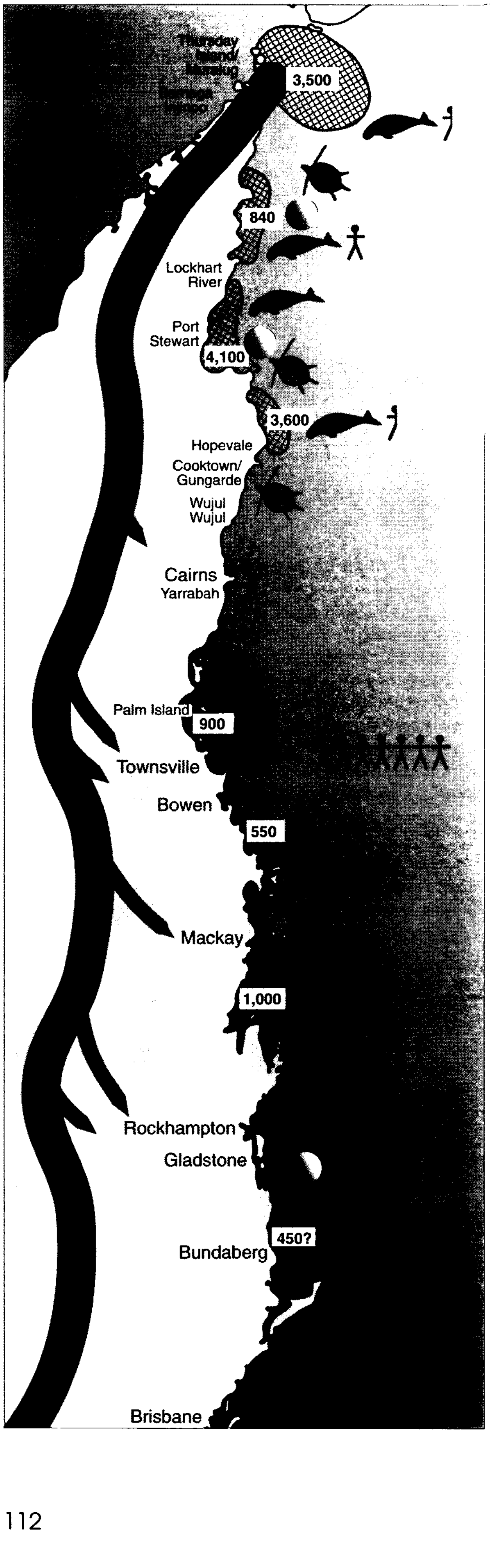

Figure 20.7: Changing patterns of dugong and turtle hunting in Queensland's indigenous communities. This is modified from a poster produced by GBRMPA to explain why hunting may need to be managed.

International context and obligations

Over the past decade the international community has shown increasing recognition of the special place and rights of indigenous peoples within nation states, including recognition of traditional rights with respect to environmental management. Australia has been a strong supporter of these developments.

Australia is a signatory to the International Covenant on Civil and Political Rights (ICCPR) and the International Convention for the Elimination of All Forms of Racial Discrimination are particularly relevant. Article 27 of the ICCPR states that: 'In those states in which ethnic, religious or linguistic minorities exist, persons belonging to such minorities shall not be denied the right, in community with other members of their group, to enjoy their own culture, to profess and practice their own religion, or to use their own language.' This Article has been interpreted by the United Nations Human Rights Committee as including a protection for the economic and cultural dimensions of resource harvesting.

Article 5 of the Racial Discrimination Convention creates an obligation to prohibit and eliminate racial discrimination and to guarantee equity before the law, and special measures 'for the sole purpose of securing adequate advancement of certain racial or ethnic groups requiring such protection ...'. The Commonwealth *Racial Discrimination Act* 1975 partially implements this Convention.

Agenda 21, the world action plan which was agreed to at the United Nations Conference on Environment and Development (UNCED) in 1992, contains many references to the need to respect and involve indigenous people in all spheres of environmental management. Chapter 26 of Agenda 21 (Recognising the Role of Indigenous People and Communities) specifically calls on governments to establish processes which empower indigenous people. The UNCED Declaration on Environment and Development (the Rio Declaration) makes specific reference to the role of indigenous people in environmental management and the need for states to recognise and support their identity, culture and interests and enable their effective participation in the achievement of sustainable development.

The 1982 Convention of the Law of the Sea makes provision for the payment of compensation to indigenous peoples displaced, marginalised or otherwise injured by marine and related developments.

Recommendations of Law Reform Commission

The current inadequate recognition of Aboriginal interests can partially be addressed by legislative reform, as recommended by the Law Reform Commission (1986), and more recently by the Resource Assessment Commission (RAC 1993). It must also be addressed in the establishment of any agreed principles for coastal management, which in turn might be enshrined in legislation.

The Law Reform Commission (1986) made a Statement of Principles with respect to accommodating indigenous interests in environmental management, including coastal and marine management to provide for indigenous hunting, fishing and gathering rights, reasonable access to land and sea for subsistence purposes, indigenous membership of statutory bodies, and the establishment of Aboriginal fishing zones adjacent to Aboriginal land. It recommended the following priorities in making decisions on the allocation of environmental resources:
(1) conservation and certain other identifiable overriding interests; (2) traditional hunting and fishing; and (3) commercial and recreational hunting and fishing. Such principles aim to achieve culturally sustainable development in Australia's coastal and marine environments.

Marine environmental management and indigenous maritime cultures in other countries

The re-building of indigenous societies is now occurring in various first-world countries with a similar colonial background to Australia. The Resource Assessment Commission's Coastal Zone Inquiry examined initiatives in other countries with indigenous populations: Norway, Canada, USA and New Zealand.

It found that there have been no easy solutions but after fumbling trial and error, the national governments of these countries have found that recognising cultural autonomy, confirming land, water and resource rights, and according or recognising some significant self-government powers are essential.

Norway

The Norwegian Constitution has been amended to reflect the 1984 finding of the Government's Sami Rights Committee that Norway is obliged by Article 27 of the International Covenant on Civil and Political Rights to protect the natural resource base of the Sami people, so that Sami culture is protected.

Canada

In 1990 the Supreme Court of Canada, in the Sparrow decision, stated that indigenous communities have a constitutional right (subject to conservation interests) to fish for food, social and ceremonial purposes. It also said that indigenous people must be consulted before governments make resource allocation decisions which affect their rights. Research on traditional ecological knowledge is now being systematically undertaken with indigenous peoples in Canada because of its potentially great relevance to environmental knowledge and management.

United States of America

A series of court decisions have recognised indigenous traditional rights. In Washington State a court decision awarded 50% of the total fish catch to Indians. A co-management structure has been created to resolve fisheries management issues.

New Zealand

In 1983 the New Zealand Parliament amended legislation to effectively recognise traditional fishing rights. Legislation passed in 1989 recognised Maori fishing rights under the Treaty of Waitangi and reserved 10% of the total fishery quota for Maori interests. Further settlements have since negotiated to resolve Maori commercial fishing claims, including government funding of Maori interests in a joint venture purchase of New Zealand's largest seafood company and reservation of 20% of new fishery quotas for the Maori Fisheries Commission.

Recommendations of the Resource Assessment Commission

The Resource Assessment Commission's Coastal Zone Inquiry found that the rights of indigenous peoples in the coastal zone are inadequately recognised in existing arrangements and by law. This extended beyond land rights and encompasses Aboriginal customary laws, especially customary rights to hunt, fish and gather.

(Source: K. McClymont)

Figure 20.8: Koori community beach seining, Jervis Bay (NSW).

The Commissioners urged that the above recommendations of the Law Reform Commission in this area be implemented and incorporated strong recommendations in their proposed National Coastal Action Program to promote the economic interests of indigenous peoples in fisheries, tourism and other commercial activities (RAC 1993).

RAC recommendations on indigenous issues in the coastal zone

Recommendations included:

- development of 'co-management' bodies (that is, with joint indigenous and government representation) for coastal and marine resources in Australia;
- development of a regional 'Tropical Seas' management strategy for Torres Strait (which might be used as a model for other areas);
- joint studies and research in coastal management; establishment of a coastal peoples network (within Australia, and with Pacific Islanders and other indigenous peoples); and
- development of an Australian Indigenous Rights Policy to formalise the legal and political basis of indigenous peoples in the coastal zone.

RAC principles for coastal and marine management include:

Principle 13:
The interests of Australia's indigenous peoples should be recognised and accommodated in resource use decision making. This requires, amongst other things, effective protection of cultural and intellectual property; participation in the management of resources in which people have traditional interests; recognition of traditional rights to hunt, gather and fish, consistent with conservation objectives; and maintenance of the resources upon which these activities are based.

(RAC 1993)

Status of knowledge of Aboriginal maritime culture

In comparison with Aboriginal use and management of the land, Aboriginal maritime culture has been inadequately studied and recorded. Previous reviews on Australia's marine environment have largely ignored indigenous interests, or referred only to past hunting and fishing practices. Similarly, reviews of indigenous interests have generally concentrated on land issues.

In Queensland there have been some studies of traditional Aboriginal fishing rights, the usage of marine resources by Aboriginal communities on Cape York Peninsula, and broader studies of Aboriginal maritime culture within the Great Barrier Reef Marine Park.

In the Northern Territory Aboriginal customary marine tenure has been documented for closures of coastal sea under the Northern Territory *Land Rights Act* 1975.

In Western Australia the Seaman Inquiry into Aboriginal land rights examined Aboriginal customary ownerships of marine estates, particularly off the Kimberley coast.

The first national attempt to describe contemporary Aboriginal marine interests was commissioned by the Commonwealth Department of Primary industry on Aboriginal fishing and ownership of the sea. The next was undertaken in 1991 for the ESD Fisheries Working group on contemporary management of Aboriginal 'sea country'. The most comprehensive national survey was undertaken for the Resource Assessment Commission Coastal Zone Inquiry.

The current poor status of knowledge on Aboriginal maritime culture indicates a pressing need for management-related research. RAC (1993) suggested that: all coastal and marine environmental and social research should include, where appropriate, studies of Aboriginal interests; specific issues relating to

Aboriginal interests should be a high priority; as far as possible, relevant research should be under the control or guidance of the Aboriginal people concerned; and research data obtained should be used and published in accordance with the wishes of the Aboriginal people concerned.

The negotiation processes to obtain Aboriginal consent for, and involvement in research requires development. Research projects should, where possible, include meaningful Aboriginal input and control, advisory bodies, Aboriginal liaison officers, and joint management arrangements. Aboriginal communities are increasingly undertaking their own research on recording of cultural sites and traditional environmental knowledge, using local expertise with and without government assistance.

Summary and conclusions

1. The coastal Aboriginal peoples have been users and custodians of Australia's marine environment for around 60,000 years. The sea was (and in many communities, still remains) an indistinguishable part of the clan estate and culture of Aboriginal peoples.

2. The maritime culture of coastal Aboriginal peoples in both northern and southern Australia remains strong, even in many areas where they have been historically dispossessed.

3. Aboriginal maritime culture is very poorly documented and very little understood by non-indigenous Australians.

4. Major issues and concerns of Aboriginal peoples in the coastal zone include dispossession from the land/sea; alienation of cultural sites; loss of fishing and hunting rights; loss of commercial fishing opportunities; and general lack of participation in environmental planning and management.

5. The rights of Aboriginal people in the coastal zone are inadequately recognised by law. Both the Law Reform Commission (1986) and the Resource Assessment Commission (1993) strongly recommended that indigenous interests in environmental management be accommodated. The special rights of indigenous peoples, including recognition of traditional rights with respect to environmental management, have also been affirmed under international law.

6. While native title in the sea was not tested in the historic Mabo decision of the High Court in 1992, claims are currently before the High Court and State Supreme Courts. Sea rights currently exist in the Northern Territory. Early legal opinions suggest that native sea rights may apply elsewhere.

7. All marine conservation and management plans should recognise the special interests of the Aboriginal peoples.

A research program is initially required to document Aboriginal maritime cultures, region by region, around Australia. The ESD Fisheries Working Group (1991) recommended that: 'governments undertake a comprehensive evaluation of government relationships to indigenous coastal communities, with fisheries management issues and arrangements, laws, obligations, local needs and customs, and traditional environmental knowledge'. This recommendation has been endorsed by the findings of the Resource Assessment Commission which further recommend the development of a National Aboriginal Fisheries Strategy (RAC 1993).

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Chapter 21. *Case study:* Aboriginal use of the coastal environment in northern New South Wales[1]

In the dreamtime, before there were people, there was a giant serpent that came from the sea. It came through the mouth of the Clarence River and started to make its way up river. Every twenty miles or so it would shake off some of the small barnacle-like creatures that were attached to its body. The further it went up the river, the smaller it became as it shook these barnacles off. These small barnacle-like creatures became the different tribal groups: the Yaygir people at the lower reaches of the Clarence, the Gumbayngir people in the Grafton area, and the Bundjalung people up river at Baryulgil and Tabulam. By the time the serpent reached Tabulam it was too small to go any further.

(from a creation story of the Aboriginal people of the Clarence River. Source: Ferguson, in Heron 1991).

On a sea voyage north, the Three Brothers left their grandmother at Evans Head ... She went up to the top of the Goanna Headland and called out to the water. The water rose, and these were the first waves made on the North Coast. The three brothers and their wives struggled to keep their canoes from sinking in the great waves ... They took a long time to find her. She returned with them ... The brothers decided they had to populate the land. They would leave each other, so one brother went north, one went south, and one to the west. It was through these brothers that the area was populated, and that the laws were passed on.

(from Nayutah and Finlay 1988a)

Aboriginal people have lived on the Far North Coast of New South Wales since the Dreamtime and their creation stories tell of the rising of the sea and formation of the coastline. Coastal and marine resources were - and continue to be - important for their culture and subsistence.

The previous chapter outlined the general issues affecting Aboriginal people in Australia's coastal zone and gave a range of examples around Australia. This chapter provides a more detailed case study of coastal and marine environmental issues affecting the coastal Aboriginal people of the Far North Coast of New South Wales. It is from a longer paper written by Aboriginal people who are experts, in their own rights, in both coastal zone management and Aboriginal issues. It is largely based on interviews with representatives from communities and peak Aboriginal bodies in the region.

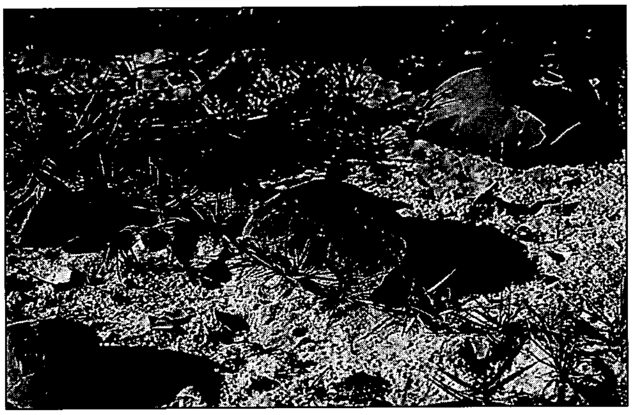

Figure 21.1: Aboriginal stone tools workshop, Goanna Headland, Evans Head (NSW).

The setting

The coastal region from Coffs Harbour to Tweed Heads in the north is commonly referred to as the Far North Coast of New South Wales (Figure 21.2). This region is noted for its natural beauty, in particular the beaches, rivers and rainforests. The climate can be described as warm temperate to subtropical.

Along the coastal plain are long white beaches punctuated by numerous rocky headlands and estuaries. Features include the unique lakes of Yuraygir National Park at Minnie Waters and the Bundjalung National Park near Evans Head. Behind the plains is a continuous mountain range forming part of the Great Dividing Range.

[1]Based on a paper by Associate Professor S. Schnierer, S. Robinson, R. Heron and J. Nayutah, Gungil Jindibah Centre, Southern Cross University, Lismore, New South Wales.

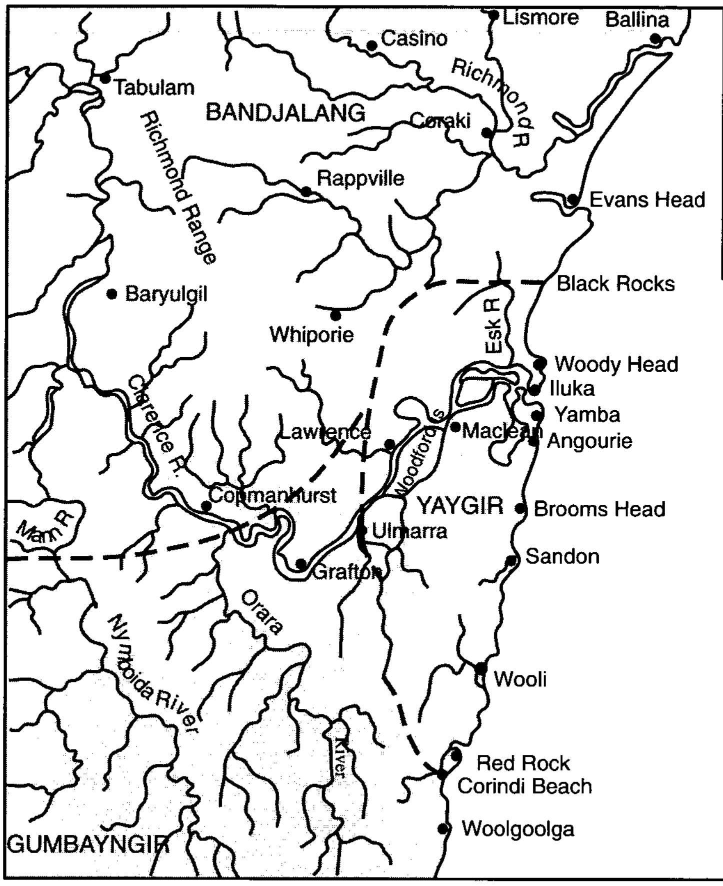

Figure 21.2: Far North Coast of New South Wales, showing the boundaries of the major Aboriginal groups.

Commercial and recreational fisheries are prominent on the Far North Coast of New South Wales. Commercial fisheries include beach haul, river mesh, trawl, and line and trap. Species taken in the beach haul fishery include sea mullet, bream, luderick, pilchards, garfish and tailor. In the rivers and estuaries mullet, flathead, whiting, bream and luderick are taken in the mesh fishery.

The Clarence River has one of the largest estuarine fisheries in New South Wales with the Tweed and Richmond of lesser importance. Trawlers operate in the Clarence River taking prawns and crabs. Offshore along the coast trawlers take prawns, crabs, lobster, fish, squid and octopus. The trap and line fisheries target snapper, jewfish, hapuku, tuna, kingfish, mackerel, shark and leatherjackets.

The recreational fisheries on the Far North Coast are large and growing rapidly. Most recreational fishing occurs on the rivers, estuaries, beaches and headlands. Species targeted include tailor, whiting, bream, luderick, flathead, turrum, jewfish, swallowtail, and Australian bass. Offshore, a variety of demersal and pelagic species are taken including snapper, kingfish, mackerel, perch, morwong and jewfish. The overlap in species taken by commercial and recreational fishermen has led to heated exchanges in recent years between each group over the depletion of stocks. Oysters are farmed in a number of the rivers including the Tweed, Brunswick, Richmond and Clarence. There are some prawn farms operating near the Richmond and Clarence estuaries.

Coastal ecosystems in the region include; mangroves, heath, swamp, paperbark (ti-tree) swamps on the coastal plain and remnant littoral rainforests on some headlands. Rainforest lines some riverbanks and behind that are open eucalypt and casuarina forests. On the volcanic soils are remnant subtropical rainforests.

The Far North Coast is today one of the fastest growing regions in Australia in terms of population and buildings. Tourism is also growing rapidly both in terms of domestic and international visitors. This growth is putting more pressure on the environment and increasing the risks of pollution, habitat destruction, fish stock depletion and cultural heritage loss.

Coastal resources

The first European industry in the region centred on timber, in particular cedar. Settlers later cleared the land and introduced dairy and beef farming. Near the coast and along the rivers are sugar cane farms while bananas are farmed on the slopes in the Tweed, Brunswick and Coffs Harbour districts. Sand mining for zircon, rutile, monazite and ilmenite was important around the Tweed-Byron area. Currently the operations are restricted to a few areas.

Aboriginal demography

Based on the 1986 census, approximately 5,500 Aboriginal people reside on the Far North Coast of New South Wales. Aboriginal people of the Clarence and Richmond valleys identify with three distinct tribal groups. The Bundjalung people occupied an area north and west of the Clarence River up to the headwaters as well as the Richmond River area. The Yaygir people occupied an area between Black Rocks (south of Evans Head) and Corindi, and west to Ulmarra, while Gumbayngir country included Grafton and the south-western tributaries of the Clarence. Early attempts to record linguistic groupings in the region were inaccurate so dialect names and boundaries remain uncertain. There are around 12 Bundjalung dialects, including Gidabal, Galibal, Waalubal, Biriin, and Bundjalung. The Gumbayngir people spoke two dialects, while theYaygir people were a unified linguistic unit.

The impact of European invasion

The first recorded contact between Aboriginal people in northern New South Wales and Europeans occurred in 1799 when Matthew Flinders was met with wary avoidance by the Yaygir people at the mouth of the Clarence River. In the early 1820s numerous escapees from Moreton Bay in south-eastern Queensland lived with Aboriginal people in the Clarence region. In 1839 Captain Perry sailed up the Clarence River and his crew committed the first atrocities in the region.

Following the initial invasion of the Clarence and Richmond valleys, colonisation increased rapidly as cedar-getters, pastoralists, and finally gold miners arrived. By clearing, the colonists destroyed the traditional economic base for Aboriginal people. Faced with a vanishing source of food, Aboriginal people took cattle and vegetables from the settlers, leading to reprisals. The colonists also encroached on sacred sites, destroying many. Aboriginal people defended their territories by guerilla warfare and used payback for the massacres and other atrocities committed by the settlers. The infamous Black Troopers from southern Queensland were also used to push Aboriginal people off their land. Aboriginal people were also poisoned by some settlers who left flour laced with arsenic lying around. There are numerous sites on the Far North Coast where these acts occurred and are still remembered. Introduced diseases also took their toll on the Aboriginal population from the 1850s onward.

Estimates of the Aboriginal population in the mid 1800s range from 3,000-4,000. In the Clarence and Richmond regions the population had fallen to around 1,200 by 1881.

Settlement under the *Crown Land Alienation and Occupation Act* 1862, forced Aboriginal people off their land. In the Clarence region the Aboriginal Protection Board, established in 1881, set up reserves at Baryulgil, Ulagandhi Island, Nymboida, Grafton and other areas. Aboriginal people were registered and confined to these reserves, requiring authorised consent to leave them for any reason. Families were broken up and moved to different reserves while many children were taken from their natural families and adopted out to 'white' families throughout the state.

Aboriginal people were thus marginalised and imprisoned in a regime of institutionalised oppression. Dispossession has left a legacy of poor health, education and employment levels. Despite this, Aboriginal culture continues to survive in the region.

Traditional uses of the coastal zone

The land and sea of the coastal zone belonged to Aboriginal people of the Far North Coast. It was spiritually and economically important to people in that it defined their existence and provided them with the means to survive. Evidence of the spiritual link with the coast is obvious in the number of sacred sites and sites of significance on the Far North Coast.

Early reports about the Far North Coast indicate that the coastal zone was a rich source of food, medicines and tools for Aboriginal people. By all accounts the nearshore, estuarine and river waters teemed with fish, waterbirds and plants while the lush rainforests were also a rich source of plants and animals.

Fishing, hunting and gathering were practised throughout the region. Some groups moved between the various environs, spending winter inland gathering food and then moving to the coast when the fish were running. Aquatic organisms were of central importance to coastal people as evidenced by the numerous middens found on the coast. Some species were totems. For example, dolphins were a totem for the Yaygir, and were therefore never hunted.

(Source: A. Zann)

Figure 21.3: Goanna Headland, Evans Head area.

Seafoods

Access to the sea, estuaries and rivers meant that a wide range of aquatic organisms were also used for food. These included fish such as bream, mullet, flathead, bass, eels, catfish, whiting, flounder, blackfish and jewfish, as well as invertebrates such as prawns, shrimps, mudcrabs, oysters, pipis, mussels, periwinkles, teredo worms and cockles. Fishing methods included hook and lines, spears, nets, fish traps and poisons. Lines were made with Kurrajong pith and hooks from bone. Nets were woven with twine made from fibres stripped from tree bark or coarse grass. The nets were hung from a small bow and used to scoop fish. Fishing often occurred from canoes.

Fish traps or weirs were constructed on estuarine mudflats using rock walls. On the ebb tide fish would be trapped behind the wall and easily collected. Fish poisons from plants such as the smartweed were used in rivers to stun fish. Bundles of the weed were tied together and then individuals would swim through the water with the bundles to disseminate the poison. The poison forced fish to the surface where they were speared or scooped up.

During the drier months of the year eels were caught in the shrinking melaleuca swamps. In some cases, when important gatherings were looming, fish were caught and kept alive in rock pools to supply the visitors.

Various intertidal invertebrates were simply collected, cooked on open fires and eaten on the spot. Evidence of these activities can be found in the numerous large middens found all along the north coast of New South Wales. Aboriginal people on the coast hunted various animals, and gathered plants and their fruits.

Current use of coastal resources

Aboriginal people on the Far North Coast of New South Wales still retain a spiritual and economic connection with the coastal zone. Older people in the community are quite clear about the significance of their cultural heritage. Most are concerned about protecting fishing and gathering rights as well as significant sites.

Fishing and hunting

Communities still utilise the coast as a source of food, with seafoods providing an important dietary supplement. Seafood is regarded with enthusiasm, particularly pippis, periwinkles and fish. Currently seafood makes up as much as 30% of the diet of people in the lower Clarence.

Fishing is done on a casual basis and the catch is shared with family and the community. The species targeted are similar to the ones sought by recreational and professional fishers. Fishing methods are similar to those used by non-Aboriginal fishers but on a different scale, for example lines are used but large boats are not.

Issues of concern for Aboriginal people in the coastal zone

Aboriginal people on the North Coast believe they are entitled to rights over coastal land and sea and the resources therein. Specific concerns in the coastal zone relate to fishing rights and royalties, site protection, tourism and environmental degradation.

Fisheries management

A major concern for Aboriginal people is regaining unfettered access to all types of traditional foods found in the coastal zone, particularly those targeted by fisheries. Related to this is the lack of consultation with Aboriginal communities by the New South Wales Fisheries Department in relation to fisheries management. Aboriginal people want to have effective input in the fisheries management process in New South Wales.

Presently decisions are made that impact coastal communities without their effective input. For example, most Aboriginal people interviewed for this report had not heard of the new bag limits on intertidal invertebrates in New South Wales. Those aware of the regulations described them as ridiculous laws arguing that 'you couldn't feed many people based on the maximum catch of 50 pippis.'

Some people interviewed said 'there should not be a limit on the right of Aboriginal people to dig pippis from the beach.' There were indications that Aboriginal people in local communities would refuse to abide by the new regulations because they restricted access to traditional foods. All those interviewed criticised the lack of consultation with the community by the State Fisheries Department.

Aboriginal people are also concerned about the ongoing depletion of fish stocks. They believe that overfishing is to blame and that interim restrictions should be placed on fishing in rivers, estuaries and lakes.

Commercial fishing

Aboriginal people would like more involvement in the commercial fishing industry both in its management and as operators. This is based on the knowledge that Aboriginal people were the owners of the coast and its resources - a position they never ceded. Some Aboriginal people suggested that funds be provided from fishing royalties to communities to purchase commercial licences and fishing equipment and provide the necessary training.

Management of sacred sites

The protection and management of sacred sites and sites of significance in the coastal zone is also of concern to Aboriginal people. The high population growth in this region and increasing tourist developments have led to a number of recent conflicts at Byron Bay, Ballina and Tweed Heads.

Management of Aboriginal sites rests with the New South Wales National Parks and Wildlife Service (NPWS) and Aboriginal people feel that this agency does not consult enough with communities in relation to site identification and management. There have been cases of mismanagement, for example, the covering-up of the Stone Turtle site at Shelly Beach. A rock fish trap and several middens on the coast near Ballina were unregistered, and some were destroyed by sand mining in 1988. Many blame local governments for not being aware of the real issues of concern to Aboriginal people.

Some Aboriginal people interviewed proposed that an Aboriginal organisation be set up to look after all the sites on the north coast. In the interim there should be more Aboriginal rangers employed by NPWS but chosen by the community to ensure that local people with the knowledge are employed.

Tourism

Many of the Aboriginal people interviewed see tourism as an untapped resource with potential for Aboriginal business enterprise provided that Aboriginal culture and the environment is protected. Others stressed that they did not want 'Gold Coast style' development near them. The protection of certain 'very, very sacred' sites was of paramount importance; these areas need to be closed completely.

Native Title

Aboriginal people are still not sure what impact the *Native Title Act* 1993 will have for them in terms of claiming land or protecting traditional fishing rights in Far Northern New South Wales. What is clear is that native title is an important issue for the future of fisheries management (Pearson 1994).

Empowering Aboriginal communities

In Far Northern New South Wales the Gungil Jindibah Centre (Centre for Aboriginal and Torres Strait Islander Education and Research) at the Southern Cross University in Lismore is committed to providing an education for Aboriginal people which is both relevant and empowering. The Centre is advised by a committee comprising Bundjalung elders. The Centre offers courses in health, paralegal studies and in community development. It is also becoming more involved in research and consulting.

Discussion

There is no hesitancy on the part of Aboriginal people from the Far North Coast of New South Wales to declare their intimate relationship with the coastal and marine environment. Aboriginal people on the Far North Coast were the first owners of coastal lands and seas and all the resources contained in this region. They believe that their rights to utilise coastal resources were never forfeited. They believe that fishing, hunting and gathering activities need to be recognised as a right and protected by legislation. Their major concerns reflect those expressed by other Aboriginal communities around Australia (see Chapter 20).

In relation to the current economic benefits gained from coastal zone resources and enjoyed by all Australians, Aboriginal people would like more equitable access to, and share, in them. Thus fishing royalties from commercial operations could be payable to the communities to help fund Aboriginal involvement in the industry. For example, funds could be used to purchase fishing gear and provide training for Aboriginal people.

Of similar importance is the establishment of greater consultation and Aboriginal 'hands on' involvement in the protection of sacred sites in the coastal zone, especially in areas targeted for tourism development. Co-management is another possibility for the resolution of the issue. Some Aboriginal people interviewed suggested that 'we could together work on some type of management scheme ... even with the fisheries.' This option also requires further study.

Summary and conclusions

1. Before the European invasion, the land and sea of the coastal zone of Far Northern New South Wales belonged to Aboriginal people and was spiritually and economically important for them.

2. Despite their dispossession, Aboriginal people here have maintained an intimate relationship with the coastal and marine environment.

3. Aboriginal people believe that their rights to utilise coastal resources were never forfeited. They believe that fishing, hunting and gathering activities need to be recognised as a traditional right and protected by legislation.

4. The Aboriginal people would like more equitable access to coastal and marine resources. Fishing royalties from commercial operations could be payable to the communities to help fund Aboriginal involvement in the industry. Funds could be used to purchase fishing gear and provide training for Aboriginal people.

5. Of similar importance is the need for greater consultation and Aboriginal involvement in the protection of sacred sites in the coastal zone, especially in areas targeted for tourism and building development.

6. Research is required into Aboriginal fisheries involvement, management and protection of Aboriginal sites and places of significance, and the impact of tourism on Aboriginal culture. This research should serve first and foremost to empower Aboriginal communities on the Far North Coast of New South Wales.

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Chapter 22. Torres Strait Islander maritime culture[1]

The Torres Strait Islanders, maritime people of Melanesian origin, live on the small, scattered islands lying between Cape York and Papua New Guinea. Torres Strait Islander culture is rich in reference to islands, reefs, marine animals and the sea itself, and is manifested in their songs and dances, and myths and legends. Islanders living in mainland Queensland cities and towns, today the majority in number, retain strong feelings of association with their home islands.

Geographically, and to some extent culturally, the Torres Strait Islands may be divided into four groups: eastern, central, western and 'top' western. Torres Strait Islander culture has been strongly influenced by long-term contact, intermarriage and trade with the coastal Papuan people to the north, and to a lesser extent with Australian Aboriginal people from Cape York to the south. The population prior to European contact has been estimated at 4,000-5,000. The current Torres Strait Islander population in Queensland is approximately 13,000 of whom approximately 4,000 still live in the Torres Strait islands, including Thursday Island.

Many of the issues discussed in Chapter 20 on Aboriginal maritime culture, and particularly matters relating to land and sea rights and hunting of protected species, also relate to the Torres Strait Islanders. This chapter describes the specific importance of the sea in the culture and way of life of the Torres Strait Islanders, and some of the other major issues and concerns relating to the marine environment. Environmental issues relating to the Torres Strait Protected Zone are described in Chapter 74.

Pre-European importance of marine resources

Prior to the 1860s, the subsistence economy of the Torres Strait Islanders was based on fishing, horticulture, gathering of wild foods and marine hunting of dugong and sea turtle. Subsistence strategies varied depending on location, size and population density of individual islands, the relationship of one island community to another, and access to natural resources.

The Torres Strait Islanders were bound together into small-scale allied socioeconomic groups. In the west were the Muralag group; Moa and Nagi; and Badu and Mabuiag. In the 'top' west were Boigu, Dauan and Saibai. In the central area were Yam, Tudu and Masig. In the east were Mer, Erub and Ugar.

Seafoods were important in customary exchange, and as part of ceremonial feastings. In order to exploit these marine resources the Islanders and coastal Papuans required sophisticated marine technology in the form of large, stable and seaworthy outrigger canoes. These could remain at sea for long periods and carry large numbers of people and goods, such as dugongs and turtles. A well developed maritime technology was also necessary to maintain both the inter- and intra-insular subsistence and exchange system which operated across the Torres Strait and between the islands and coastal Papua. Canoe hulls, for example, were obtained from the Fly estuary region in Papua.

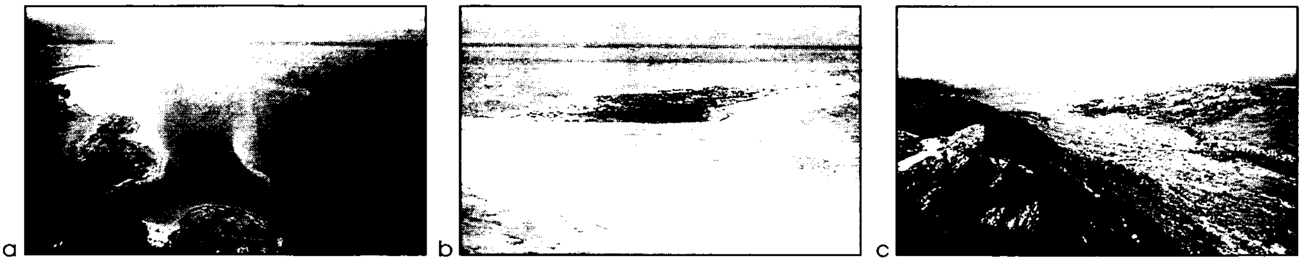
Post-European contact importance of marine resources

After regular European contact began in the 1860s, Torres Strait became the centre of the northern bêche-de-mer and pearling industries. Within 20 years there were thriving commercial fisheries in the Torres Strait, outside the limited legal jurisdiction of the Queensland colonial government. Uncontrolled exploitation of marine resources and lawlessness characterised this period of early European contact.

Indentured labour was used throughout the region and the first shore station for the preparation of bêche-de-mer, and later pearl shell, was established at Warrior Island in 1868 by Captain Banner. By the end of the 1870s almost one quarter of the population of the Torres Strait was engaged in the pearling industry and stations were established on Erub, Ugar, Mer, Mabuiag, Badu and Moa.

After 1871 missionaries helped regulate the lawlessness in the region and provided protection for the Islanders from bêche-de-mer and pearling crews. In return Islanders came under the paternalistic control of the missions and later the colonial administration. By the 1890s the subsistence economy had been profoundly altered, but not eliminated, by

[1]Based on a paper by Dr D. Lawrence, Great Barrier Reef Marine Park Authority, Townsville, Queensland.



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(Source: all L. Zann)

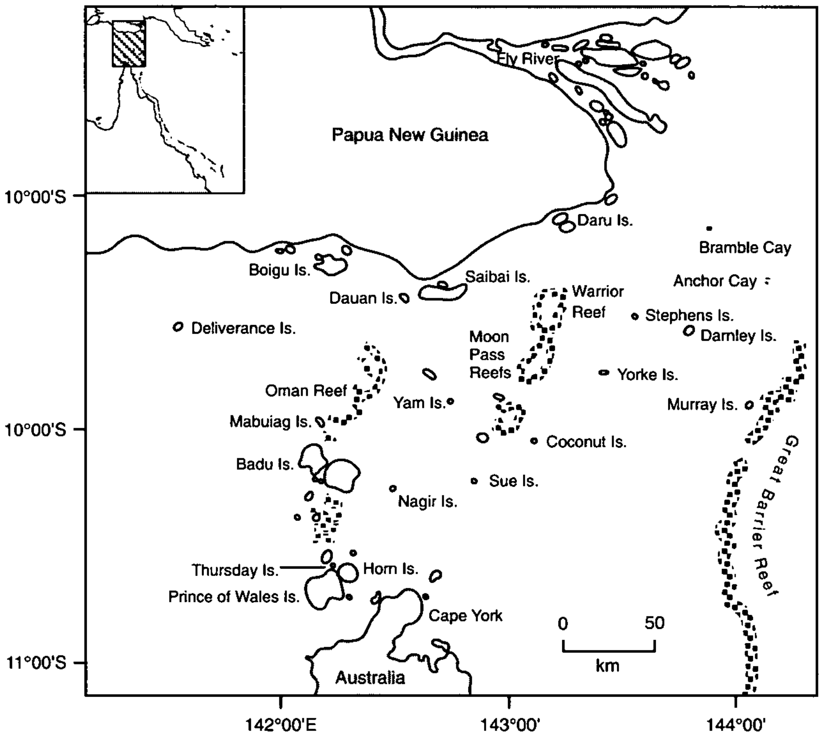

Figure 22.1: Torres Strait, showing major reefs and islands. (a) Prince of Wales Group. (b) Warrior Cay, Central Group. (c) Murray Island, Eastern Group.

the introduction of a European cash economy. The patterns of Islander participation in commercial fisheries, clearly noticeable today, were established during the late nineteenth and early twentieth centuries at the height of the pearling and bêche-de-mer fisheries.

The Torres Strait Protected Zone

The Torres Strait Treaty was ratified by Australia and Papua New Guinea in 1985. The treaty, which formalised sovereignty of the Torres Strait islands and established a Torres Strait Protected Zone north of 10°50', provides for bilateral arrangements for the protection of the Torres Strait marine environment and for the maintenance of the traditional way of life and livelihood of the Islander and coastal Papuan people. The treaty permits free movement for traditional inhabitants across the Protected Zone as well as establishing a complex system of commercial catch-sharing arrangements between Australia and Papua New Guinea (Chapter 74).

Traditional fisheries in the Torres Strait

The subsistence economy today is a mix of subsistence, cash-generating and commercial production activities and it is arbitrary to separate fishing from general domestic and community economic activities. Fishing is a subset of patterns of resource utilisation which includes foraging, collecting, and hunting.

Some problems arise with the use of terms such as 'traditional' in reference to the operation of the subsistence economy in Torres Strait. There is a tendency for resource managers and environmentalists to view the use of European technology, such as nets, aluminium dinghies and outboard motors, as evidence of fundamental changes to traditional customs, or the complete breakdown of the traditional patterns of resource exploitation. Many people do not appreciate that 'tradition' is an evolving, living concept.

The marine hunting of dugong and sea turtles, commonly referred to as traditional hunting, continues to be of major importance to the Torres Strait Islander communities, both in Torres Strait and on the Australian mainland.

(Source: W. Gladstone, GBRMPA)

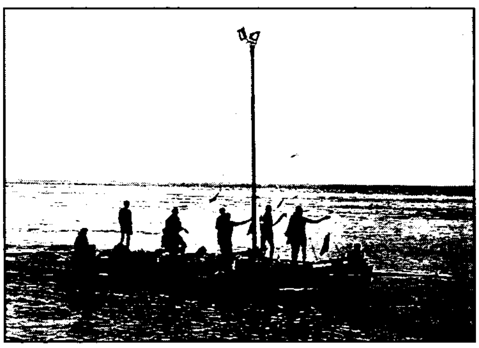

Figure 22.2: Traditional Torres Strait outrigger canoes traded from Papua are used for fishing and travel.

Dugongs

The dugong, *Dugong dugon*, ranks high among Torres Strait Islanders as food. Culturally, dugong and turtle meat are important in gift giving and ceremonial feasting. The dugong is listed as vulnerable to extinction by the International Union for the Conservation of Nature and Natural Resources (IUCN) (Chapter 18).

The dugong population in the Torres Strait is comparable to that of the entire Great Barrier Reef Marine Park (Chapter 18). Dugongs are more common in the Cape York to Mabuiag region during the north-west monsoon (summer) season. The highest density is on the seagrass beds near Badu and extending across the Orman Reef complex to Buru and east to Gabba. The next highest density is on the Warrior Reef complex. Densities are lowest in the eastern section of the Torres Strait, along the Papua New Guinea coast and in the northern part of the Great Barrier Reef Marine Park.

Conservation concerns over an apparent decline in dugong population numbers in recent years are the result of a decrease in numbers passing through the commercial market at Daru, in Papua New Guinea. Between 1975 and 1983 it is estimated that the annual Torres Strait catch was 500 to 1,000 animals. In 1987 it was estimated that the population of dugong in Torres Strait was 12,500, and that this could sustain a catch rate of 750 animals per year. However, as the catch in the Torres Strait is biased in favour of females, the sustainable harvest is lower, probably in the order of 300 animals per year.

In the absence of adequate catch statistics and information on dugong life histories in the Torres Strait, it is not possible to establish whether the current harvest in the Torres Strait, including the harvest by coastal Papuans from the Kiwai villages in the Daru region, is sustainable.

A dugong sanctuary of approximately 800 square nautical miles has been established in the south-western portion of the Torres Strait. However, if distribution areas and density figures are correct, the sanctuary area is required in an area around Buru between Mabuiag and Boigu.

Sea turtles

Six species of sea turtles occur in the Torres Strait: hawksbill *(Eretmochelys imbricata)*, flatback *(Natator depressa)*, loggerhead *(Caretta caretta)*, green *(Chelonia mydas)*, and occasionally, olive ridley *(Lepidochelys olivacea)* and leatherback *(Dermochelys coriacea)*.

Three species, the green, flatback and the hawksbill, breed in Torres Strait. The rookeries for the flatback and the hawksbill are of international significance. The harvest of eggs of the hawksbill turtle remains unquantified but concerns have been expressed over excessive collecting. The rookeries of the flatback include Crab, Deliverance, Turu Caỳ and Kerr Islands. Crab Island is an egg collecting site for people from the Bamaga region. Bramble Cay is the largest green turtle rookery in the Torres Strait. However green turtles also nest at Dowar and other islands in the eastern Torres Strait.

Sea turtles, predominantly the green sea turtle, constitute an important component of the diet of Torres Strait Islander and coastal Papuans. Estimates are that the annual harvest rates of green turtle may be between 2,100 and 4,150 animals. The mean consumption rate is approximately one turtle per person per year. Research suggests that Torres Strait Islanders are among the highest seafood consumers in the world, and that a high proportion of that consumption, perhaps over 60%, is green sea turtle meat.

Despite intensive hunting, there is no reported decline in turtle numbers in the Torres Strait. However, concerns about overexploitation have been raised. As dugong hunting has shown some decline in recent years, turtle is seen as a logical substitute for dugong. Low dugong catches may therefore result in a higher turtle catch. Harvesting of turtle eggs is also a matter of some concern as eggs are taken by both Islanders and Papuans. Adult turtles also migrate from Torres Strait to Papua New Guinea and Indonesia, necessitating an international approach to their management.

(Source: L. Zann)

Figure 22.3: Torres Strait Islanders have a rich maritime culture. The characteristic head-dresses and dances draw inspiration from the sea.

Current issues relating to the marine environment

Land and sea rights

The implications of the Murray Island land case (called the Mabo case) are of great interest in the Torres Strait. The Mabo case was a legal challenge by three inhabitants of the Murray Islands for traditional title over land handed down to them from their ancestors, and for recognition of those rights under common law. The Murray Islanders claimed that they owned plots of land as individuals, or as members of family groups, and have supported this by reference to local land court decisions. This system is claimed to have persisted well into the colonial period and contests the argument that native title was extinguished by annexation.

The High Court order stated that land in the Murray Islands is not crown land, and that the Meriam people are entitled to possession, occupation, use and enjoyment of the lands on Mer (putting aside the islands of Waier and Dauar and apart from land leased for administrative and religious purposes). The title held by the Meriam people is however, subject to the power of Parliament in Queensland provided the exercise is not inconsistent with the laws of the Commonwealth. The implications for future land rights issues in the Torres Strait is not yet clear but it is expected to generate further claims on other islands.

Sea tenure

The decision supports the claim that customary tenure existed over all islands and reefs in the Torres Strait prior to sustained European contact. Customary marine tenure also played an important role in the maintenance of cultural identity, for it is impossible to isolate the sea from the total fabric of Torres Strait Islander culture and life. In the Torres Strait this tenure existed in two basic forms: home reef tenure extending over reefs, mostly fringing reefs, around home islands; and extended marine tenure, referring to wider sea rights over waters, submerged reefs and sand banks beyond the immediate home reef.

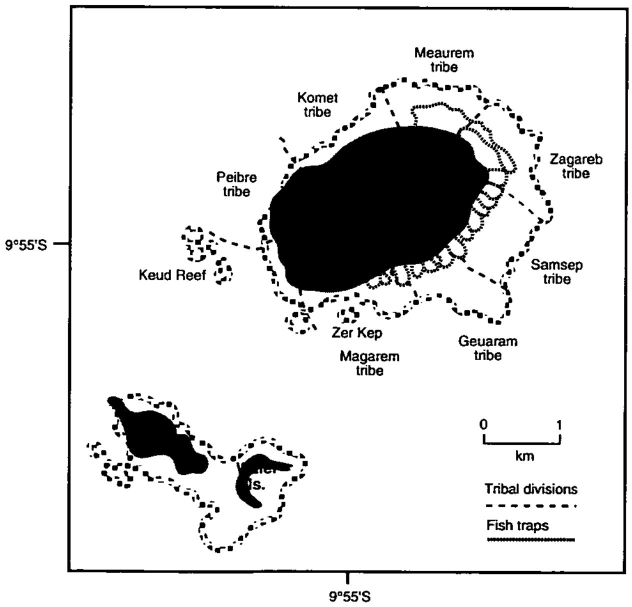

Figure 22.4: Tribal lands and home reefs, Murray Island.
(After Johannes and MacFarlane 1991)

Islanders continue to claim home reef rights and these are commonly recognised by custom, if not in law. However, loss of control over extended reef rights occurred as the result of the effects of government and mission control over Islander resources and restrictions on movements. Uncontrolled commercial exploitation of the marine resources in the late nineteenth century by Europeans who did not recognise, nor understand, customary tenure principles seriously weakened the position of Islanders in the active management of the marine resources of the Torres Strait. As a result the practices associated with customary marine tenure in the Torres Strait are rarely observed today. The tenure boundaries are only poorly remembered, if at all. The resurrection of customary marine tenure may not contribute to more effective management of subsistence fisheries in the region and may be inconsistent with current Queensland and Commonwealth legal jurisdictions and with the provisions of the Torres Strait Treaty.

(Source: GBRMPA)

Figure 22.5: Fish traps on fringing reef, Murray Island.

However, this is not to say that home reef control has weakened. Customary control over resource use and access rights to areas of home reefs continues to be exercised in varying degrees across the Torres Strait. The total area involved is around 300 square kilometres, or 11% of the shallow reef and sand bank area of the Torres Strait. Commercial fishing does not impinge on home reef areas. Current land rights issues may in fact strengthen Islander claims to inshore areas and nearby islands but the legal issues will have to be decided on an island by island basis.

Climate change

Possible effects of global warming, and sea level rise, on the Torres Strait region may be coastal inundation, coastal flooding caused by increased storm activity, salt water intrusion into ground water supplies, water table elevation, and changes to coastal land formations particularly as a result of the rise of sea water, and effects on coral reefs.

Socioeconomic effects may be caused by the inundation of coastal village areas, gardens and community service areas such as ports, boat ramps and power supplies, resettlement and migration of people, and the destruction of sites of cultural and community significance.

The low lying swampy islands of Boigu and Saibai are potentially at greatest risk. People from Saibai were resettled as early as 1947 on Cape York, and later at Bamaga, as the result of flooding and property destruction on Saibai. The central islands, particularly Warraber and Puruma which are typical coral cays, would also be highly vulnerable.

Summary and conclusions

1. The Torres Strait Islanders continue to identify strongly with the sea. Islander culture is rich in reference to islands, reefs, marine animals and the sea itself. Despite the influences of missionaries and paternalistic administrations, Torres Strait Islanders have had continuous residence on most of their home islands.

2. Control of marine resources has been removed from direct Islander management, although the administrative arrangements under the Torres Strait Treaty recognise Islander participation in the consultative processes.

3. To a marine based indigenous culture, the protection of the marine environment and the maintenance of the subsistence economy, with its focus on exploitation of marine resources, remains vitally important.

4. Dugongs and turtles are important subsistence foods for Torres Strait Islanders and seafood consumption is amongst the highest in the world. Populations of dugongs may be affected by overhunting. Management of dugongs and turtles requires international arrangements with Papua New Guinea and Indonesia.

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Chapter 23. The social values and perceptions of Australians concerning the marine environment[1]

Of all of our environment types, Australians value coastal areas the most. Despite the vast area of this island continent, over a quarter of our population is crowded into a three kilometre strip around its edge. The great social value of the coast is no more evident than in the high real estate value of land with water frontage or even a glimpse of the sea, or on a trip to the beach on a summer Sunday. Coastal settings are also the place for our most popular leisure activities, and the beach is one of our national icons. With the exception of Antarctica, Australia is the only continent without significant inland settlement.

Australia is today a complex, dynamic, multicultural society of largely coastal, urban dwellers. Non-indigenous Australians, most of whom know little about the vast and inhospitable interior, still remain clinging to the coast. Despite various policies over almost two centuries to encourage settlement of the inland, Australians from this area are retreating to the coast at a high rate. In many ways our national icon of 'the bush' is being replaced by 'the beach'.

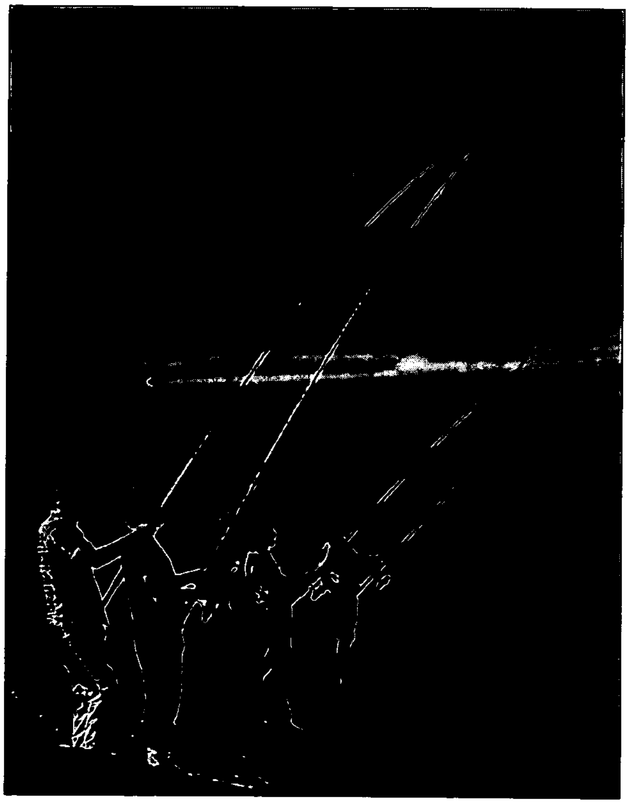
People are an integral part of the environment, and a major objective of environmental management should be to optimise the benefits to people - social and cultural, as well as economic. A sound understanding of the sociological values and perceptions of the natural environment by people is therefore essential in environmental planning and management. This chapter examines the sparse information on the social value of the coast and sea to Australians, and examines some concerns Australians have for coastal and marine environments.

The social value of the coastal zone for Australians

Australia's population is concentrated in the coastal zone of the east south-east and south-west. This can be attributed to a number of historic, climatic, geographic, economic, social and cultural factors.

The south-eastern estuaries and bays were the first areas colonised because of their temperate climate and moderate rainfall, sheltered harbours, fresh water and arable land. Ports and coastal towns later grew up around the coastline in order to service the primary industries in the interior. Secondary industries to process agricultural and mineral products were also established near ports. However, inland populations remained low because many of Australia's primary industries have never been greatly labour intensive other than at seasonal peaks.

Urban drift to coastal towns and cities began this century as agriculture and mining were progressively mechanised, and as many rural industries declined. This drift has continued during the rural crisis of recent decades and many inland towns are being depopulated.



(Source: SA Tourism)

Figure 23.1: Australians like to be by the sea. Fishing in South Australia.

[1]By Dr L. Zann, SOMER Coordinator; and I. Dutton, Southern Cross University, Lismore, New South Wales.

The influx of rural dwellers, the limited dispersal of the post-war immigrants outside cities, the baby boom and 'the dream of the quarter acre block' have reinforced the primacy of Australia's coastal cities and contributed to the urban sprawl and the emergence of commuter centres and coastal satellite towns. Growth in city suburbs was so rapid in the 1950s and 60s that the basic services of water and sewerage could not keep up, and many new housing estates were unsewered.

The last two decades have witnessed another major change in Australia's demography as seaside retirement centres and tourist resorts have mushroomed along much of the south-eastern coastline, and in northern New South Wales and south-east Queensland in particular. Dubbed the 'sunbelt migration phenomena' by Cardew (1986), this has resulted in unprecedented urban coastal growth, due largely to immigration from other regions of Australia.

The lure of the sea

Considering humans are terrestrial creatures, the sea has a strange, compelling magnetism for most of us. To even gaze upon the sea seems to satisfy some primitive instinct.

While the social and cultural importance of the sea to humans is widely recognised, there have been few psychological studies of the reasons. Water has always been a powerful symbol for human beings. Water is critical to life. The human foetus grows bathed in the saline amniotic fluid and our tears are salty.

Watson (1990) views our relationship with the sea as fundamental to the very evolution of human culture and argued an aquatic origin for mankind: 'all of human history is a succession of important contacts with, and immersions in, the tides of the coastal zone - our twentieth century migration back to the shores of the sea is no historical accident.' It has even been suggested that *Homo sapiens* may have evolved as primates adapted to a semiaquatic environment.

The sea in Australian art and culture

The sea has provided inspiration for countless Australian artists, from the ancient Aboriginal artists who depicted fish and other marine life in rock shelters, to dramatic Victorian seascapes, to Ken Done's multicoloured fish and coral prints.
The beach and sea also provide the settings for many Australian novels. Neville Shute's internationally renowned novel 'On the Beach' was placed in post-nuclear war Australia. Robert Drewe's short stories and features depict Australian 'beach culture'. Tim Winton's novels and essays are often set on Western Australia's deserted coast.

The sea provides many different aesthetic, psychological and physiological attractions.

The sea's beauty has inspired generations of artists, poets and lovers ... varying shades of blues, greens and greys ... shimmering reflections of sun and moon ... motion and energy ... glassy tranquility ... regular trains of harmonic waves ... explosive, chaotic turbulence.

The sea's mystery attracts us ... foreign and unseen worlds which lie under the waves, or over the horizon ... a sea so vast it seems to meet the sky.

The sea's freshness invigorates us ... fresh washed sand ... foaming waves ... regular, renewing tides ... cool breezes ... tear-drops of salt spray ... that invigorating freedom as we plunge into the water, and swim and dive ... the surge of breaking waves ... the warming, relaxing sun on the beach ... nostalgic memories of a childhood holiday or first love.

The sea's dangers challenge the more adventurous of us ... pitting ourselves against its crashing waves when body surfing, board riding, and ocean sailing ... the satisfaction of our primitive hunting instincts as we fish and enjoy the fresh air ... the renewing contact with nature.

(Source: Australian National Maritime Museum)

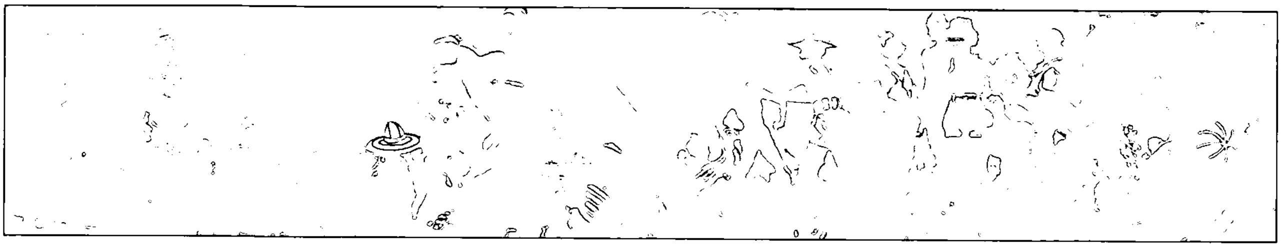


Figure 23.2: Australia's characteristic beach culture had emerged by the 1930s. Bondi Beach, from a mural by commercial artist and surf life saver D.H. Souter.

The Great Barrier Reef is eulogised in some of Judith Wright's poems while the poems of Oodgeroo tell of the sealife around her home on Stradbroke Island in southern Queensland. Many of the works of both women contain strong conservation messages.

The sea has also inspired music and film. A generation of us was brought up on Californian beach music. Another is hooked on 'Baywatch'. More serious television documentaries on life under the sea are regular features on both national and commercial television channels.

Australian clothing designers have produced a range of distinctive beach wear, from bikinis to the bright, loose, casual wear, which might be our national costume, and the rubber thong.

The symbolism of the sea in Australian culture

The coast of the island nation of Australia has been our interface with the outside world, and a symbol of both threat and promise. Europeans came from the sea, dispossessing the Aboriginal people. Fortifications still ring the coast, reminders of past fears of Russian, German and Japanese invasion.

As Blainey (1982) put it, European settlements in the early colony stuck to the coast, as *'barnacles to a rock'*. In the penal settlements the sea became a symbol of isolation and imprisonment.

Times have changed. In modern Australia the sea is viewed more as a source of pleasure, a symbol of freedom, hedonism and of joyful memories.

The beach in Australian culture

'The beach', the primary place for recreation for Australians, has become a national icon in this country. Dutton (1985) argued that sometime during the second half of this century the mythical 'beach' began to replace the 'bush' as the national symbol for Australians, and the bronzed lifesaver began to replace the bushman.

Along the same theme, in an essay introducing a Coastal Zone Inquiry report, McGregor (1992) wrote *the Bronzed Aussie image has seemed to sum up much of what Australian life is all about - leisure, hedonism, sport, good times, mateship and the slogan you see on so many t-shirts at Bondi: LIFE IS A BEACH.*

Although 'the beach' has been a focus of Australian life and culture for several generations, its social significance has rarely been studied by sociologists. Few studies of the recreational use of beaches have been published in Australian academic journals in the past 20 years.

There are however some popular descriptions on Australia's beach culture. For example, a whimsical description of the sociology of 'the beach' is contained in the popular 'Myths of Oz'. This argues that the Australian icon of 'the beach' *is not the palm fringed tropical hideaway (that is reserved for holidays for the lucky), but the suburban beach, places like Bondi Beach and Manly in New South Wales, Surfers Paradise in Queensland, and Yanchep Sun City in Western Australia. 'The beach' is not the safe harbour beaches of Sydney or the bay beaches of Adelaide, Brisbane or Melbourne, it is the surfing beach on the open coast, for like the outback, the surf is a challenge.* (Fiske et al. 1987)

(Source: Coffs Harbour Visitors Bureau)

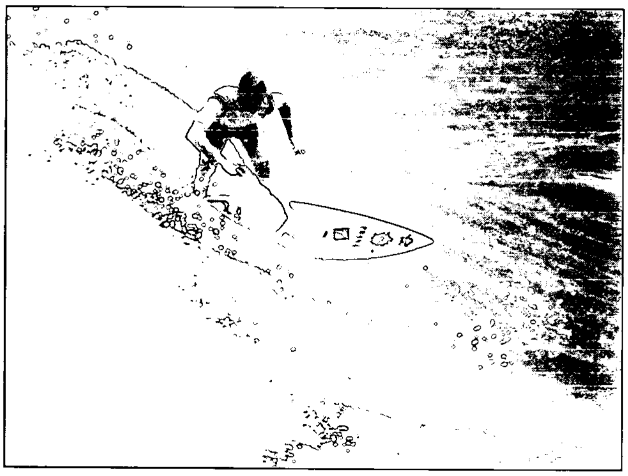


Figure 23.3: For many, the surf is a challenge.

'The Australian beach is urban and natural, civilised and primitive, spiritual and physical, culture and nature. The beach symbolises the ideal of Australian society - classless, matey, basic and natural.'
(Fiske et al. 1987)

This is even more apparent once we discard our work clothes. As Ellis (1993) describes: *The paring down to the essentials is a great leveller. I cannot think of another* *place where egalitarianism, that modern virtue we Australians like to think we invented, is more at home. No one is excluded from the beach. Not by age, experience, money, background, race or physique. As a rule, even by behaviour. The beach is a season for all men* (and women) *- democratic, cosmopolitan and a champion of tolerance.*

Drewe (1992) has observed, 'the beach' is also entwined in the rights of passage of Australians: warm weather, and the scent of coconut oil arouse certain nostalgic and sensual feelings in many of us.

So is it surprising that most Australians see the beach in a sensual and nostalgic light? .... After those early physical displays and datings and fumblings in the sandhills or holiday cottages or tents most Australians do mature and generally marry, and invariably honeymoon on the beach ... Later, as parents they take their families on holiday to the beach, often to the same one where earlier, raunchier events occurred.... The next stage of course, is retirement. In increasing numbers, Australians retire to the particular piece of coastline befitting their class and superannuation, from Cairns down through Hervey Bay, Noosa and the Gold Coast, Byron Bay, the markedly different New South Wales central and south coasts, to Victoria.
(Drewe 1992).

Social value and amenity of the marine environment

A 'social value' is our identity as individuals and members of a community. 'Amenity' is the social value humans place on things outside the necessities of survival. It is often overlooked by environmental managers but it is critical to our culture and spirit.

What are places of social value?

According to the Australian Heritage Commission, places of social value:

- **provide a spiritual or traditional connection between past and present;**
- **tie the past affectionately to the present;**
- **help give a disempowered group back its history;**
- **provide an essential reference point in a community's identity or sense of itself or historical grounding;**
- **loom large in the daily way of life;**
- **have shaped some aspect of community behaviour and attitudes;**
- **are distinctive in nature or have special meaning;**
- **are accessible to the public; and**
- **are where people gather and act as a community, such as places of public ritual, meeting or congregation.**

The amenity value includes not only the importance and consequences of economic and recreational usage, but also of the social and cultural meanings and values which are basic to our civilisation.

The social value of the environment for Australians is not well understood. Sociologists generally consider our interpersonal relationships rather than our relationship with our natural environment. Ecologists and environmental managers on the other hand generally consider the non-human environment: humans are regarded as intruders whose impacts have to be managed. But clearly the natural environment is an essential part of all humans' existence, and the coast and sea are particularly important in the culture of Australians.

Is 'the beach' becoming a tarnished icon?

As we drift into the twenty-first century even the icon of 'the beach' is getting rather tarnished. The sun is now a health hazard. The hole in the ozone layer and climate change are looming. Australians have the highest incidence of skin cancer in the world ('slip-slop-slap'). The urban beach is littered with plastic containers and other junk ... and in cases even with semi-treated sewage and syringes. Bondi, Manly and other national treasures were regularly closed during the late 1980s as health hazards.

The halcyon period of 'the (urban) beach' may be dimming, although continued growth of the Gold Coast and other tourist meccas suggests that their appeal remains strong.

Beaches away from urban areas are less spoilt. One of the side effects of the beach culture has been the opening up of previously unused areas, not always remote.

Today, more and more beachgoers are expressing their concerns about the marine environment. Board riders, seaside residents and recreational fishers are martialling their numbers to form environmentally aware, and politically powerful lobby groups to protect their beaches.

The young surfers of the Australian Surf-Riders Foundation have conducted their own national survey of beaches, the 'State of the Surf' and established their own database (Chapter 40).

A group of concerned retired people in a New South Wales beach village formed a 'dune care' group. The idea has spread to many other areas around Australia.

Historic and cultural values of the sea

The sea has a particular historical and cultural value to non-indigenous Australians who originate from 'overseas'. The early European explorers came by sea. That most illustrious navigator, Captain James Cook, is a national hero to many Australians but is an anti-hero to many aboriginal peoples. The maritime tradition was firmly set when the British Navy established the penal colony at Sydney Cove. As the settlement grew, ships brought colonists and goods, and took primary produce to market. The sea was our connection to our European homelands and markets for most of our history. Marine and coastal cultural heritage values are described in detail in Chapters 24 and 25.

A source of national pride ... and concern

The marine environment also provides a source for Australia's national pride. We refer to the Great Barrier Reef as 'nature's eighth wonder', and Sydney Harbour as 'the most beautiful harbour in the world'. Bondi Beach is a national treasure. Bells Beach, Victoria's surfing mecca, is on the Register of the National Estate.

Australians can become easily aroused by threats to such places. Community concerns about oil drilling on the Great Barrier Reef lead to its protection. Sewage on beaches has aroused public outcry.

'New Age' focus on the sea

Amongst the environmentally aware and the people of the 'new age', the graceful, smiling dolphin has become a symbol of human threats to the environment. Efforts to save a stranded whale or rehabilitate an orphaned dolphin have become national news. Cans of tuna in our supermarkets are labelled 'dolphin friendly' to reassure us that no dolphins perished in order to bring us this meal. Paradoxically, some of the tunas are more threatened than the dolphins.

(Source: GBRMPA)

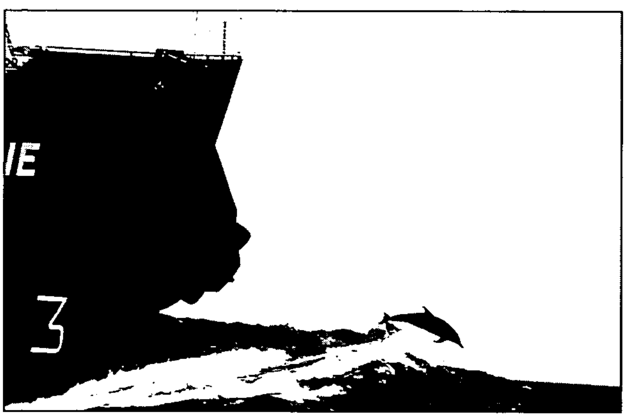


Figure 23.4: The dolphin is a symbol of a 'new age'.

Australians' values and attitudes, and concerns on the environment

A literature review undertaken by social scientists for SOMER found that there had been no specific studies on values and attitudes concerning the marine environment in this country, and there were few relevant peripheral studies (Hamilton-Smith and Scherl 1993).

Despite this dearth of information, coastal and marine resource management agencies have had to make many judgements about the relative value of coastal and marine resources. For example, only in recent years have mangroves become strictly protected. Prior to the 1980s, the conversion of mangrove forests for alternative land uses was considered by the community as socially and ecologically acceptable. The changing public perception of the importance of such areas was indicated in a public survey of attitudes towards wetland conservation in the Brisbane area in which most respondents strongly supported increased wetland conservation initiatives (CCM 1990).

Recent studies of social values and perceptions in the coastal zone and their relevance to planning have been undertaken in the Perth metropolitan area and in the Great Barrier Reef Marine Park.

case study 1

Consideration of values and attitudes in planning of the Perth coastline

There has been limited sociological research into perceptions and attitudes toward coastal environments. One of the few undertaken in Australia was produced for the Western Australian State Planning Commission because of considerable debate within the community and among planning professionals on coastal development on the Perth metropolitan coast, and the need to preserve areas of conservation value. Here the major issues were dune erosion, marina developments at Hillarys, high-rise at Scarborough, and industrial development at Kwinana.

A survey of 509 residents assessed knowledge of the metropolitan coast; the acceptability of industrial and commercial high-rise and marina developments; and community perceptions of the planning criteria for coastal development. It found that only marina and low-rise (one- or two-storey) developments were seen as acceptable forms of coastal development. The study emphasised that planners should consider the kinds of community perceptions of development proposals.

(Source: Fenton and Syme 1989)

case study 2

The social and economic value of the Great Barrier Reef

Attempts have been made to determine both the social and economic values of the Great Barrier Reef (GBR).

Social values
Attitudinal surveys were undertaken on visitors to North Queensland in 1986. These indicated that most came for 'the weather' (31%) and 'the Reef' (20%). When asked about the dislikes in their holidays, 42% said 'nothing', 11% said 'stingers', 9% said 'humidity' and 6% said 'overdevelopment'.

Overseas visitors were more concerned about overdevelopment and commercialisation than Australians. Australians were more concerned about too many tourists and pollution. There was uniform agreement that 'there should be strict controls to stop people harming the Reef in any way'.

Economic values
The opinions and perceptions of visitors are ultimately reflected in economic values: willingness to pay or willingness to accept compensation. Tourists pay for their accommodation, food and transport, but not the amenity and other natural values. There are also vicarious users who value the Reef without visiting it.

Tourists spend around $650 million pa in the Reef region. The total economic value of the coral sites has been estimated at over $50 million pa, and their vicarious value estimated at $393 million (discount time period 10 years, discount rate 8). This study was used to assess the economic impacts of the crown-of-thorns starfish and has been used to estimate a hypothetical 'entry fee' to the GBR Marine Park.

(Source: Hundloe 1990)

Figure 23.5: Attitudinal surveys indicate that overseas tourists to the Reef are largely concerned about overdevelopment and commercialisation; Australian tourists are more concerned about too many tourists and pollution.

Values and attitudes Australians place on the coastal zone were described in some detail in the Resource Assessment Commission's Coastal Zone Inquiry (RAC 1993). However, most of these relate to the coastal strip (usually to 'the beach', above) and represent only formal submissions by motivated users.

Australian's concerns on the coastal zone: breakdown of Resource Assessment Commission (RAC) submissions

Australians have many different concerns regarding the coastal zone, varying greatly amongst user groups. The following were the main groups which made submissions to RAC: indigenous people, industry, local community groups, environmental groups, specialists, recreation groups and individuals.

The submissions to RAC fell into eight main groups:

ecological issues: biodiversity, ecological functioning, and pollution; aesthetic and experiential issues: the variety of pleasures obtained from a particular landscape or locale (e.g. recreational or wilderness values);

commercial issues: the capacity of the coastal zone to generate monetary benefits for particular users (e.g. value of tourism, mining, commercial fishing);

cultural heritage issues: the meaning attributed to particular places or artefacts in our cultures;

planning and coordination issues: roles of various levels of government in planning (e.g. concerning duplication of functions, role of information in planning and management; effectiveness of government policies);

sustainability and stewardship issues: balanced use and sustainable development (e.g. ESD), and the need for long-term perspective in management;

access and property rights: ways in which public and private access is regulated, including the allocation of property rights (e.g. public access to foreshores; access to companies to coastal resources);

consultation and education issues: refer to community participation in decision making processes.

General environmental concerns of Australians

Recent surveys show most Australians are very concerned about the environment, and are particularly concerned about ocean and beach pollution. A survey undertaken for the Commonwealth Government at the depth of the economic recession in 1991 found that the most immediate concern of Australians was unemployment (38%) and the economy (24%), while the environment ranked third in concern (12%). However, in the long-term ('importance in 10 years time') the environment was ranked of greatest concern (24%) (ANOP 1992).

A 1992 survey by the Australian Bureau of Statistics found that 75% of people were concerned about the environment. Three of the top five concerns related to pollution: air pollution (40.2%); destruction of trees and ecosystems (32.4%); ocean pollution (32.3%); fresh water pollution (29.9%) and destruction of the ozone layer (28.6%). One in ten people had taken some action to register their concerns (for example, by writing or calling a relevant agency). Some 70% of people rated protection of the environment and growth of the economy as being of equal importance (7% rated the economy higher, while 19% rated the environment higher) (ABS 1993).

Consideration of social values in environmental management

Despite the great social value of the coast and sea to Australians, planning schemes and development control measures generally do not adequately consider social issues and the human environment. This is evident by the frequency of conflicts between users of the coastal zone, particularly between developers and local residents or conservation groups. The public participation process which is now a common part of environmental planning is typically reactive to specific issues and generally does not provide the type of information on social values and perceptions required for strategic environmental planning (Chapter 29).

The integration of social values in decision making is feasible and has, in several instances, proven workable. For example, the Great Barrier Reef Marine Park Authority planning model places very strong emphasis on public involvement in all stages of the planning process. An integrated coastal management study in Trinity Inlet in Cairns included both social and ecological values to form a basis for development of a contractual management scheme. Public involvement is of a great benefit to planners. However, it requires extra effort and resources which are typically limited, or is not seen as necessarily a high priority in traditional approaches to resource allocation.

Status of knowledge and monitoring of social values and perceptions

As emphasised above, the social values and perception of Australia's coastal and marine environments are not well documented. The importance of 'the beach' as a national icon has been described in several descriptive works and essays, but has not been definitively explored by sociologists or environmental psychologists.

Management of marine and coastal resources must give greater attention to the factors which shape values and to the types of values which are traditionally (in non-market systems) overlooked. Only with full recognition of the great social values of these resources and the development of a framework for value definition that is linked to decision making processes, are we likely to develop sustainable approaches to marine resource management.

In the absence of authoritative sociological studies and regular national polls, financial indicators may give some idea of the value Australians place on the sea. Australians pay to see and enjoy the sea. A residential block with a sea frontage or even a sea view sells for much more than one around the corner. The seaside holiday to the Gold Coast or other beach resort is one of the Australian family's major annual expenses. However, such financial indicators provide only a limited indication of the broader value Australians place on the coast and sea.

Summary and conclusions

1. The marine environment is important to the Australian way of life. The beach in particular is the centre for recreation, and a national icon.

2. People are an intrinsic part of the environment and a knowledge of social values is essential for environmental management. In Australia there have been no detailed studies of the social values and perceptions of the marine environment.

3. Australians are concerned about the environment. In 1991 the environment was given as the third most important immediate concern for Australians (behind unemployment and the economy). It was given as the most important long-term concern. In 1992 the majority of people (70%) said they were concerned about the environment; the state of the ocean was given as the third most important area of environmental concern.

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Chapter 24. Protecting maritime cultural heritage[1]

Australia's marine environment contains important cultural resources as well as natural ones. The sea has played an important part in all aspects of the social and economic history of Australia. The coastal Aboriginal and Torres Strait Islanders harvested the sea and it was important in their cultures. The early European exploration of Australia occurred by sea. The British colonisation was a maritime enterprise conducted by the Royal Navy and largely motivated by the potential of Australia as a supply base for merchant and naval vessels. The import and export of all goods occurred by sea. Immigration to Australia is an important maritime influence on our history and provides a continuing story linking the experiences of convicts, 19th century settlers, post-World War II refugees, and most recently, Indo-Chinese boat people. The sea is also a major focus in our sport and recreation, and has been a rich source of national imagery.

Maritime cultural heritage is the material record of the history of interaction between people and the marine environment. It includes material remains underwater (e.g. shipwrecks), movable items in museums and private collections (e.g. vessels, equipment, paintings), and historical and archaeological sites beside the ocean (e.g. middens, lighthouses, coastal buildings: see Chapter 25).

Major issues in the conservation of Australia's maritime heritage include: damage incurred to valuable archaeological sites by treasure hunters; lack of protection of movable heritage; excavation versus non-excavation; community access versus professional control; and professional qualification standards for archaeologists. This chapter focuses on the management of underwater heritage, and in particular, the protection of movable heritage.

Underwater cultural heritage

Underwater cultural heritage refers to artefact assemblages, sites and structures associated with past human activity which now lie beneath the sea. The earliest known shipwreck in Australian waters is the English East India Company ship *Tryal* wrecked off Western Australia in 1622. Over the following four centuries more than 6,000 ships - of which fewer than 1,000 have been located - were wrecked in storms, on coastlines, in warfare and in collisions. Shipwrecks may be relatively intact or scattered by the sea. They may be historically important 'time capsules', revealing important information about past cultural and commercial activities, as well as have symbolic importance as monuments to human tragedy.

Until the introduction of scuba in the 1950s, underwater cultural material remained largely inaccessible and forgotten but since then increasing numbers of Australians have been able to explore shipwrecks and other underwater cultural material. It has also created very serious problems of indiscriminate 'souveniring' or looting of culturally important sites before they could be systematically excavated.

(Source: P. Gesner, Queensland Museum)

Figure 24.1: There are around 6,000 shipwrecks lying beneath Australia's seas, many of which are of great historical and archaeological value. The wreck of the *HMS Pandora*, being excavated here, lies in 35 metres of water off Pandora Entrance on the northern Great Barrier Reef. It is regarded as one of the most significant wrecks in the Pacific because of historic context (it was dispatched to arrest the infamous Bounty mutineers) and its good state of preservation. It also contains a range of South Pacific Islander artefacts and a complete refit set for the Bounty.

[1]Based on a paper by M. Staniforth and K. Jones, Australian National Maritime Museum, Sydney, New South Wales.

Protective legislation and management

Government involvement in the protection of shipwrecks stemmed from the discovery of two 17th century shipwrecks in Western Australia in 1963: the Dutch East India Company ships *Vergulde Draeck* (wrecked in 1656), and *Batavia* (1629). Concern that bullion and artefacts were being salvaged for private sale led to the Western Australian government's listing these sites under the *Museum Act (Amendment Act)* 1964. In 1970 a maritime archaeology program was established in Western Australia to excavate these vessels and later shipwrecks of the colonial period, and in 1973 special legislation was enacted to protect shipwreck sites, the *Maritime Archaeology Act* 1973. An international agreement was signed regarding the four Dutch East India Company shipwrecks and the Australia-Netherlands Committee on Old Dutch Shipwrecks (ANCODS) was formed to decide on the disposition of recovered artefacts.

Commonwealth legislation followed with the *Historic Shipwrecks Act* 1976 which incorporated the ANCODS agreement and applies to historic wrecks and other cultural material in waters below the high tide line in all States and Territories. Specific shipwrecks legislation now exists in Western Australia, South Australia and Victoria, whilst they are protected under more general heritage legislation in the other States and Territories. By February 1993 a total of 161 wrecks had been protected. While wrecks of historic significance were declared, the Historic Shipwrecks Act was amended in 1993 to include blanket protection for all wrecks over 75 years old. Declaration permits only scuba diving for recreational and educational purposes and prohibits interference with the site or associated artefacts. Education programs encourage scuba divers to visit and enjoy shipwreck sites without interfering with them, but where necessary surveillance and enforcement programs employ the powers of the legislation to

(Source: L. Zann)

Public access guidelines to shipwrecks

Scuba diving on shipwrecks is a popular recreational activity in Australia. Improved equipment has brought deeper wrecks within the reach of divers. Some, like the *Yongala* off Townsville have become the centre of a significant local tourist industry. Land-based and underwater shipwreck trails have been created in Victoria, South Australia and Western Australia.

Every shipwreck, regardless of age, should be treated with respect and not damaged or plundered. Shipwrecks are a vital historical record and should be preserved intact as part of the nation's heritage. Guidelines on public access to shipwrecks have been produced by the Commonwealth Department of Art and Administrative Services to prevent damage to sites.

Access
In general, people may visit an historic shipwreck site as long as their activities do not disturb the material remains of the wreck. Access to a protected zone for any purpose, whether related to the wreck or not, requires a permit.

Look - but don't touch
Removal of relics from a historic shipwreck site without a permit is an offence which may incur a heavy penalty.

Permission to retain recovered material
Under section 9 of the Historic Shipwrecks Act, a museum or agency must advise the Minster of the location of any material it has recovered under the guidelines. These may be lent to community groups for public, and not private, use. They must never be sold or otherwise disposed of.

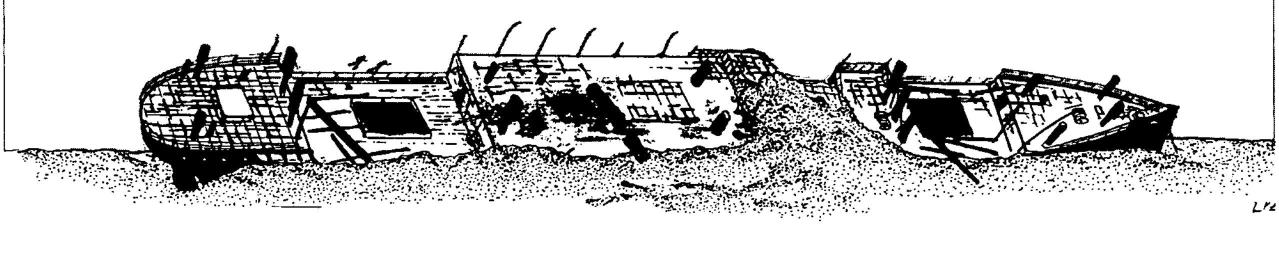


Figure 24.2: The wreck of the steamer *Yongala* is the focus of a major dive industry on the Great Barrier Reef. A United States magazine rated it as one of the two best wreck dives in the world.

discourage and prevent looting. Protected zones up to 800 metres in radius are imposed on some wrecks to limit potentially destructive activities (i.e. *Pandora, Yongala, Aarhus* and *Foam* (Qld); *Zuytdorp* (WA); *Emden* (Cocos Island); *Duckenfield* (NSW); Japanese submarine *I-124* (NT); and *Cato* and *Porpoise* (Coral Sea Territory)).

State responsibilities

The Commonwealth has delegated responsibility for the administration of the Historic Shipwrecks Act to a specified authority in each State/Northern Territory to: survey, identify and assess shipwrecks; recommend protection under the Act; issue permits to applicants wishing to dive on shipwrecks protected by prohibited entry zones; arrange protection for declared historic shipwrecks; devise management plans for historic shipwrecks; oversee the recovery, conservation and exhibition of relics from historic shipwrecks; and provide publicity for historic shipwrecks and maritime archaeology matters generally.

Each State and the Northern Territory employs at least one maritime archaeologist, and has established a program for the protection of historic shipwrecks and the administration of the Act. Western Australia, Queensland and the Northern Territory have maritime archaeology programs based in state museums, while the others have programs in State departments. In addition, the Australian National Maritime Museum in Sydney conserves and exhibits artefacts from shipwrecks and supports maritime archaeological work throughout Australia.

Education programs

Education programs are necessary to inform scuba divers and the general public of the legislation, and to change perceptions of shipwrecks from being sources of underwater 'treasure' to be plundered, to underwater 'heritage' to be cherished.

Education material includes displays, touring exhibitions, publications, videos and computer interactives for schools. Specialist maritime museums or displays now exist in the capitals and larger ports (e.g. Western Australian Maritime Museum, Launceston Maritime Museum, Queensland Museum). The 'Shipwreck!' Bicentennial exhibition toured Australia in 1988, and the 'Time and Tide' exhibition of the Victoria Archaeological Survey (VAS) toured that State recently.

The National Historic Shipwrecks Program and the State delegated authorities produce brochures, pamphlets, posters, videos, and formal and informal educational courses. VAS has produced a brochure 'Underwater Shipwreck Discovery Trail', and NSW Department of Planning has produced 'Historic Shipwreck Atlas'. VAS has also produced an underwater video on maritime archaeology. In Western Australia a unit on underwater archaeology is offered at Fremantle Senior High School. The Australian National Maritime Museum conducts a tour 'Check out the Wrecks' while the Queensland Museum offers field courses on 'Maritime Archaeological Survey Techniques'.

International management

The great cultural importance of shipwrecks has only recently been widely recognised. In 1992 the International Council for Monuments and Sites (ICOMOS), the body which advises UNESCO on matters relating to the built environment, established a new body to specifically advise on underwater aspects. The ICOMOS International Committee on Underwater Cultural Heritage is to develop international conventions, and submissions for World Heritage Listing of underwater cultural heritage. The committee is chaired by Mr Graeme Henderson, the Interim Director of the Western Australian Maritime Museum, indicating international recognition of Australia's pre-eminence in underwater archaeology.

The problem of the movable maritime cultural heritage

A great deal of maritime heritage is movable, such as vessels, fishing equipment, or objects such as paintings or documents which portray a maritime experience. However, heritage legislation and management in Australia focuses on immovable buildings, shipwrecks and archaeological sites, and does not protect movable heritage such as historic vessels.

The collection of vessels is a matter of some debate within maritime museums because of the very high cost of maintenance. Most maritime museums do collect some craft because of their importance in communicating maritime experiences to the public but there are serious limitations on the number which can be held. The Australian National Maritime Museum currently has a collection of about 25 vessels, ranging from rowing dinghies to a naval destroyer, and the Western Australian Maritime Museum at Fremantle maintains a large collection of small craft. Most museums collect only a representative sample of historic craft, and rely more on paintings, photographs and models, and recorded information about historic craft. The National Maritime Museum is establishing a register of historic vessels which will record technical details, illustrations and plans, and information about the historical significance of vessels.

(Source: Australian National Maritime Museum)

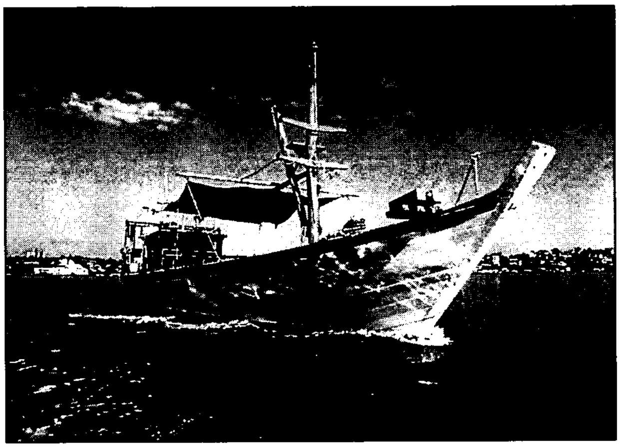


Figure 24.3: The Australian National Maritime Museum in Sydney has a major collection of movable items of maritime cultural heritage. The *Tu Do* brought Vietnamese refugees to Darwin in 1977.

Commonwealth legislation

The Committee of Inquiry into the National Estate (1974) whose report led to the establishment of the Australian Heritage Commission, focused on heritage sites but did recommend that the definition of the National Estate be expanded to include movable cultural property, including museum collections, industrial artefacts, archives and Aboriginal artefacts. The adoption of the expanded definition would have afforded movable cultural heritage legislative protection against destruction and made it eligible for national estate grants to contribute to the costs of conservation.

Legislation relevant to movable maritime heritage includes the *Australian Heritage Commission Act* 1975, the *Historic Shipwrecks Act* 1976 and the *Protection of Movable Cultural Heritage Act* 1986. While the last protects against export, none encourages the conservation of movable heritage within Australia.

State/Territory legislation

State/Territory legislation has largely followed the Commonwealth heritage legislation in focusing on immovable heritage such as buildings and sites. The only exception is the New South Wales *Heritage Act* 1987 which defined cultural heritage as: 'the environmental heritage ... buildings, works, relics or places of historic, scientific, cultural, social, archaeological, architectural, natural or aesthetic significance for the state.' Permanent conservation orders have been placed on a number of movable items in New South Wales, one of which is a vessel, the former Manly ferry *South Steyne*.

case study

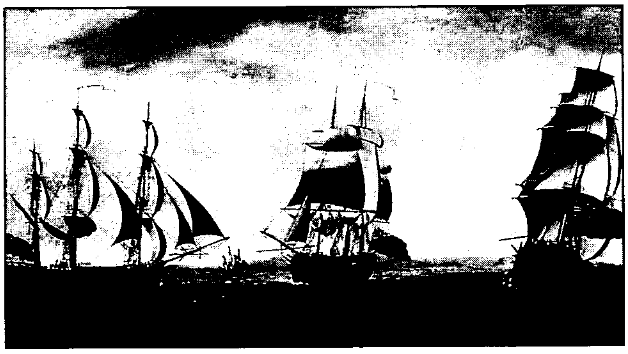
The *South Steyne*

The well known ferry *South Steyne* was purchased for use as a tourist vessel and restaurant. The owner, seeking its long-term protection, applied to the Heritage Council of New South Wales for a permanent conservation order against any future changes or any subsequent neglect. The Council subsequently assessed the vessel as a significant piece of Australian heritage. Built in 1938, it was the best known vessel from the Manly ferry line, and an important part of the imagery of Sydney for over 50 years. A permanent conservation order issued by the New South Wales Minister for Planning in 1992 requires the present and future owners to seek the permission of the Heritage Council to modify the vessel, and a grant was made contributing to the conservation of the vessel.

Status of knowledge, databases and monitoring

The major emphasis on marine cultural heritage has been on shipwrecks. Around 1,000 of the 6,000 shipwrecks in Australian waters have been located. Relatively few historic shipwrecks have been excavated. The National Maritime Museum has established a register of historic vessels.

The documentation of other objects of marine cultural heritage is poor. There has been virtually no monitoring of either the condition of historic shipwrecks or the location or condition of movable marine heritage.



(Source: Australian National Maritime Museum)

Figure 24.4: Australia's portable maritime heritage is less protected than its wrecks. Three views of the *Borrowdale*, a merchant ship from the First Fleet, by Francis Holman around 1787.

Summary and conclusions

1. Australia has a rich maritime cultural heritage. It includes over 6,000 shipwrecks (of which fewer than 1,000 have been located); movable heritage (historic vessels and maritime objects); and maritime infrastructure (lights, wharves etc).

2. Historical shipwrecks are now well protected by Commonwealth and State/Territory legislation. Australia is considered a world leader in the protection of underwater heritage.

3. Important issues in the conservation of Australia's maritime heritage include damage incurred to valuable archaeological sites by treasure hunters and the lack of protection of movable heritage.

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Chapter 25. Protecting the coast's cultural heritage[1]

The coast is an important part of Australia's cultural heritage. There are a large number and variety of important cultural places on the coastal strip: Aboriginal and Torres Strait Islander middens and burial sites; landing places of the early European explorers; early colonial penal settlements and coastal towns; lighthouses and signal stations; jetties and wharves, customs houses and bond stores; famous surfing beaches and scenic areas; and modern works such as the Sydney Opera House.

(Source: G. Abraham)

Figure 25.1: The scenic, historic, social and cultural values of the coast are great. Great Ocean Road (Vic).

However much of the development in Australia has occurred without adequate consideration to cultural heritage matters, and the rapid and unplanned coastal development of recent decades has resulted in the destruction of many sites of historic and cultural significance. This chapter describes the sites of cultural heritage in the coastal strip, the threats to these, and their current management.

Cultural sites on the coastal strip

The pre-history and history of Australia are written in the scenic, and biologically diverse coastal zone.

Cultural heritage sites include areas of archaeological, historic, social and aesthetic values. In Australia these can be grouped into a number of major categories or themes.

Aboriginal and Torres Strait Islander

The most common Aboriginal sites are middens composed primarily of shellfish remains with smaller amounts of stone, bone and heath material, dating from times of the sea level stand (around 5,000 years ago), to European settlement. These range in size from small scatters representing a meal, to large mounds metres in thickness representing many centuries of use and contain a wealth of information on past lives and use of the marine environment (Chapter 19). Other sites include scarred trees, stone artefact scatters, campsites, stone quarries, burials, historic period sites such as missions and reserves, and natural features of spiritual significance.

Macassan

The Macassans from present Indonesia visited northern Australia from the 1600s to the 1800s for trepang (sea cucumbers), a Chinese delicacy. Their camps, often marked by ancient tamarind trees, contain Asian pottery shards and stone fireplaces.

Exploration and early settlement

The landing places of the early Dutch and English explorers and first settlers are important to Australians of European descent, for example, Dirk Hartog's landing place in Shark Bay, Western Australia (1616); Cook's landing place in Botany Bay (1770); the site of Victoria's first settlement in Sorrento (1803); and Tasmania's first official settlement at Sullivan's Cove, (1804).

Convict transportation and penal settlements

Many of the early European settlements were associated with convict transport and penal confinement, for example, Port Arthur in Tasmania, and Norfolk Island.

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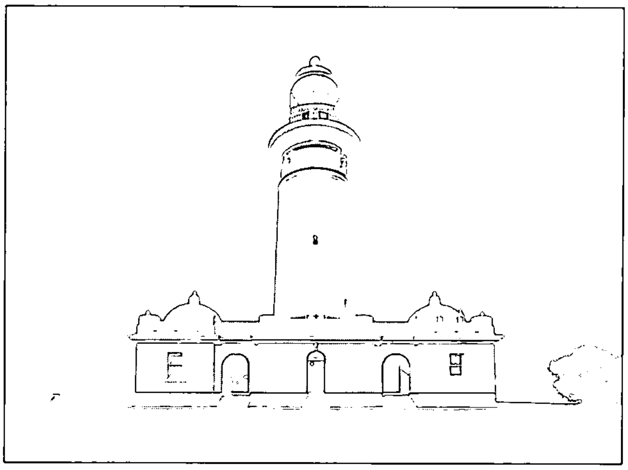
1 Based on a paper by M.L. Walkington and A. Marsden, Australian Heritage Commission, Canberra, Australian Capital Territory.

Navigation
Navigation aids were essential in a country which has relied entirely on sea transport for most of its history. Their remains are historically important, as they cover a long period of colonial history and symbolise the hazards faced by mariners and settlers. There are over 100 lightstations currently on the Register of the National Estate.



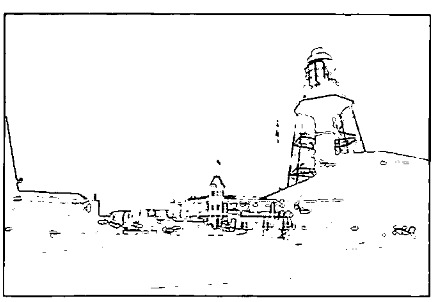
(Source: Australian National Maritime Museum)

Figure 25.2: The Macquarie Lighthouse on Sydney's treacherous South Head is an important part of the nation's coastal heritage. It is actually a copy of Greenway's 1818 original.

Shipwrecks
Throughout Australia's history, vessels fell victim to the rugged shoreline and unpredictable storms. Shipwrecks are testimonies to the perils of the sea and monuments to those who perished, as well as invaluable time-capsules (Chapter 24).

Sealing and whaling
Sealing and whaling are two of Australia's earliest industries, and historical sites are scattered around the southern States, and on Heard and Macquarie Islands.

Transport and commerce
Reflecting the great importance of sea transport in the commercial development of Australia is a vast range of historic, industrial structures around harbours and ports, dockyards and factories, and places of high architectural style and prestige such as Customs Houses.



(Source: G. Abraham)

Figure 25.3: The Port Adelaide Lighthouse was first lit in 1869. It has been relocated to the Port Adelaide Historic Precinct (SA).

Coastal towns
Many coastal towns developed around ports. Some have grown to modern metropolises while others have remained small, and retained their original character.

Defence facilities
Most of the early military facilities were concentrated along the coast. Coastal fortifications were established as primary defences against invasion by imagined and real foes, French and Russians, and Germans and Japanese.

Fisheries and aquaculture
Historical structures associated with ocean-based activities include wharves, jetties, sheds and factories. The pearling sites of Broome are particularly significant as a reminder of the boom industry, and of the multi-racial character of the town.

Social and recreational
Places that reflect the importance of the coast for the recreation of Australians include the icon of beach culture Bondi Beach, and the famous surfing beach of Bells Beach.

State of knowledge of coastal cultural heritage

Lists of cultural places with heritage values are compiled by the State and Territory heritage agencies responsible for their management, the National Trust of Australia, local government bodies, and by smaller organisations such as the Australian Institute of Architects, but without any explicit criteria. The Australian Heritage Commission (AHC) compiles the Register of the National Estate, a national inventory of significant heritage places, using criteria set out in the *Australian Heritage Commission Act* 1975. These remain very incomplete.

Indigenous sites
While many sites are listed around Australia, Aboriginal sites have not been systematically identified and are biased towards places where previous research has been undertaken. The AHC is now systematically identifying sites, and is prioritising areas under threat.

The sites also have a European bias as until recently very few Aboriginal or Torres Strait Islander people have nominated cultural places, and sacred sites are a major gap in the Register. To address this, AHC launched the Aboriginal Awareness Raising program in 1990 which has increased the indigenous nominations.

Other sites

Sites outside metropolitan areas are also poorly represented in the register because of an early bias towards fine buildings and isolated, grand mansions. Efforts are being made to assess values of vernacular buildings and social places, and coastal landscapes such as beaches, cliffs, forests and rural settings with aesthetic, social, scenic and recreational values.

Protection of coastal places

While the Heritage Register is an evolving process, current listings already provide a strong basis for management decisions. Protection for cultural heritage places is provided by a range of legislation with varying jurisdiction.

World Heritage sites

Places with exceptional natural and/or cultural heritage significance are protected under the Commonwealth *World Heritage Properties Conservation Act* 1983. There are currently ten Australian properties on the World Heritage list on the basis of natural and/or Aboriginal cultural values. These include The Great Barrier Reef, Fraser Island, Lord Howe Island, and Shark Bay.

Australian Heritage Commission Act 1975

The AHC was created under the Act to develop a register of significant places of natural, historic or indigenous environments, as assessed by criteria under the Act. There are currently 248 coastal Aboriginal and Torres Strait Islander places listed in the Register of the National Estate, and 150-300 other places in coastal areas of each State/NT. The primary purpose of the Register is to alert and educate all Australians, particularly planners and decision makers, to places of national estate significance, so that areas are not needlessly or inadvertently destroyed or degraded. It relates only to Commonwealth Government activities, and State/Territory Local Governments. Private owners are not affected.

Aboriginal and Torres Strait Islander Heritage Protection Act 1984

This Act requires for the Commonwealth to act to prevent significant Aboriginal and Torres Strait Islander places where the State or Territory does not provide protection, or there is an unwillingness to enforce the protection. The Act is usually enforced in land management disputes.

Historic Shipwrecks Act 1976

This Act provides for the protection of shipwrecks in Australian waters below low water mark and is administered by the States or Territory (previous chapter). Historic shipwrecks can also be listed on the Register of the National Estate.

State/Territory legislation

All States and the Northern Territory, other than Tasmania, have heritage legislation which provide some measure of protection to cultural places through conservation orders, heritage agreements, environmental impact assessments, and review procedures or restrictive covenants attached to land or property titles. The nature of the Acts, extent of resources and purposes of heritage lists vary. Most emphasise the visually impressive places and neglect other places (e.g. industrial sites), making listings inconsistent.

Role of local government

The protection of heritage places is best achieved through local action. Local governments play important roles in identification and management of cultural places. In some States they are required to produce heritage inventories and develop strategies for long-term management of these places.

(Source: J. Forbes)

a

(Source: WA CALM)

b

Figure 25.4: Lord Howe Island in the Tasman Sea (a) and Shark Bay in Western Australia (b) (here showing the bay's unique stromatolytes), are listed in the World Heritage because of their high natural values.

Threats to coastal cultural sites

Natural processes

The coastal climate is particularly harsh on cultural remains, particularly on storm-prone areas on coasts and islands. Christmas Island has lost a number of early structures in high seas, while Heard Island has lost some historical sealing sites through erosion. Coastal erosion has had a major impact on Aboriginal and Torres Strait Islander middens, sometimes washing away whole sites. Rising sea levels through the greenhouse effect would greatly accelerate this loss. Storms and salt have a cumulative effect on buildings, accelerating rust and fretting brickwork. Lighthouses are particularly prone to deterioration.

Urban expansion

Ribbon development along the coast has destroyed many unrecorded Aboriginal sites, changed the character of rural lands, and significantly altered the natural landscape.

Redevelopment of historic towns

The popularity of coastal towns for recreation and retirement has resulted in many small towns, villages and hamlets with particular style architecture and small town layouts being redeveloped or engulfed by modern buildings.

Management to conserve heritage values often conflicts with the amenities and services required by new residents and tourists. New roads, car parks, and fringe businesses benefiting from a historic place change the cultural landscape. Access to cultural places may increase vandalism and looting, particularly in abandoned sites and shipwrecks.

Tourism

Tourism can be both important and beneficial to heritage conservation, and detrimental. Negative effects include clearance or alteration for visitor facilities and associated infrastructure; disturbance by visitors (especially to fragile archaeological remains); increased vandalism and looting; and loss of landscape, context and aesthetic values.

Cumulative effects in planning and management

A key management issue is early and comprehensive planning. For places with historic, aesthetic and social value, cumulative impacts occur because the present system of planning and management results in gradual change over a period of time without consideration to the overall effects. Thus individual buildings in an historic area may be gradually modified, ultimately reducing the heritage value of the area. The large number of government agencies involved in coastal zone management - many with conflicting goals - increases the difficulties of strategic planning.

Some principles for coastal tourist and recreational development

The most suitable areas for development should have low environmental, cultural or historical value.

Development and use of an area should be at a level that does not lead to permanent reduction of cultural values.

Guidelines should be developed to avoid impact to visual amenity and disruption to ecological processes.

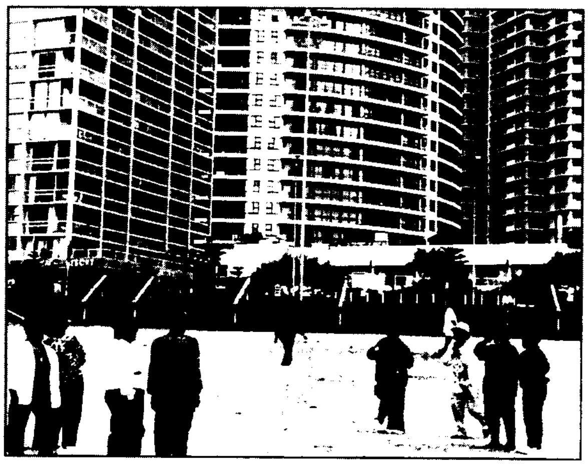
The magnitude and incidence of impacts and effectiveness of mitigating measures should be monitored.

Regulatory measures should include the 'user pays' principle and pricing mechanisms.

The use of permits and appropriate siting of tourist facilities should be considered to control access to sensitive areas.

Relevant Aboriginal and Torres Strait Islanders and other local communities should be consulted concerning proposed developments, land use planning or identification of social values.

Public exhibition, objection and appeal procedures should be provided to ensure accountability and objectivity.



(Source: L. Zann)

Figure 25.5: Tourist development along the coastal strip may affect visual amenity and disrupt ecological processes.

Management of coastal cultural heritage

The future protection of the coastal heritage will require a more coordinated approach to heritage identification and conservation.

Coordination of databases

Because Commonwealth and State/Territory heritage listings are inconsistent, Australian Heritage Ministers requested at their meeting in 1992 the development of compatible criteria and assessment and listing processes, and linked databases. The AHC is currently redesigning the register of the National Estate for the development of a single national database of heritage places.

Systematic surveys

Systematic surveys are necessary to address the gaps in knowledge about the coastal cultural heritage, with a thematic or regional focus to provide the necessary context for assessing significance.

Coordination of management

In order to improve decision making processes, legislative and administrative procedures require cumulative impacts of development to be assessed, and avoided or mitigated. Regional and land management authorities should assess and manage cultural sites on a uniform manner. Principles and guidelines for future tourist and recreational use of the coastline are also needed.

Selected references

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Acknowledgments:
The technical paper by M.L. Walkington and A. Marsden was reviewed by J. Lennon, Heritage Consultant, Brisbane, Qld.

Databases, monitoring and reporting

The Register of the National Estate is very incomplete. Major gaps in knowledge exist in Aboriginal and Torres Strait Islander cultural sites, non-metropolitan areas, and vernacular sites. Databases of listed sites exist in the States, Territories and Commonwealth, but criteria for listing are often incompatible and databases are not currently linked.

The development of indicators for monitoring the effectiveness of coastal heritage planning and management, and mechanisms for regular reporting on the state of cultural heritage, are required. Possible indicators include number of registered places on both State/Territory and national registers, the completion of local Environment Plans which include cultural heritage values, and the progress in adopting integrated assessment of heritage values.

Summary and conclusions

1. Australia's coastal zone contains a large, varied and very valuable heritage resource.

2. The listing of places of cultural heritage remains very incomplete. Aboriginal cultural sites are particularly incomplete.

3. Much of Australia's coastal heritage resource is under threat from incompatible uses or through poor planning and management. Many of these threats result from cumulative impacts which are currently inadequately addressed by impact assessment processes.

4. The design, size, style and location of coastal tourist or recreational facilities should be planned so that heritage sites and their tourist values are not unnecessarily degraded.

5. Research priorities include: identification and documentation of significance of coastal sites; greater emphasis on non-metropolitan sites; nineteenth century sites; and places no longer in use; and development of indicators for monitoring.

6. Criteria are needed to identify all coastal heritage resources and integrate their protection within comprehensive planning and management systems.

Chapter 26: The community and marine conservation[1]

Community conservation groups in Australia have been prominent in marine environmental conservation and in raising public awareness on issues affecting the marine environment. These groups have led public campaigning on marine conservation and management issues such as the Great Barrier Reef, whale conservation, water pollution, beach litter, establishment of marine protected areas and control of coastal development. Community conservation groups are committed, energetic and make good use of political media and legal opportunities to achieve their goals.

Many non-government organisations (NGOs) in Australia have particular interests in the coastal and marine environments. According to the Marine and Coastal Community Network there are over 2,600 such groups including user groups such as fishing and dive clubs, industry and utility agencies, and community groups with a primarily conservation focus.

This chapter briefly describes a range of community conservation organisations, the major issues they have identified in the marine and coastal environments, and their policies and activities in these areas. The functions of the Marine and Coastal Community Network, a part of the Ocean Rescue 2000 program, are described in some detail.

Major conservation groups: aims, issues and policies

There are over 200 community conservation groups in Australia with a primary interest in conservation (Green Guide 1994). These include small community associations formed in response to a local issue, natural history groups, professional organisations, and large national and international organisations. The groups span philosophies ranging from strongly preservationist and confrontory, to technical interest groups. A few organisations produce and distribute high quality magazines, newsletters, education kits, books, videos and brochures.

Australian Conservation Foundation (ACF)

(Membership 15,900; Support base 90,000)

Aims:

To protect all of Australia's environment; its land, water, wildlife and atmosphere. Primary concerns include endangered species, greenhouse effect, and the preservation of Antarctica and the Great Barrier Reef. ACF has an active coastal program. The ACF is active in education and environmental politics.

(Source: T. Flaherty)

Figure 26.1: Many community groups in Australia have been active in marine conservation. Ocean Care Day clean-up, Henley Beach (SA).

Interests in the marine and coastal environments:

The ACF considers the present and future state of the marine environment in Australia to be an issue of key importance for governments, planners, environmental managers and the community. Concern about the marine environment led the ACF to establish a Coastal Campaign team in 1992, which included the Melbourne to Sydney Coast Walk in 1993-94 to highlight coastal degradation in the south-east.

[1]By Dr L. Zann, SOMER Coordinator; and D. Alcock, Great Barrier Reef Marine Park Authority, Townsville, Queensland.

Major issues in the marine and coastal environment identified by ACF

ACF (1994) produced a paper for SOMER identifying what it considered to be the key issues. These are:

- **Mining and exploration**
  General problems stem from a lack of a national coastal conservation strategy; flaws in environmental impact assessment processes; lack of consistency amongst governments in environmental protection legislation; inadequate rehabilitation; highly destructive nature of coastal zone mining; and developments in environmentally sensitive areas.

  Marine oil production can pose special problems through exploration, production, disposal of by-products and transportation (see Chapter 38). Oil spills often occur in remote areas and in bad weather, making containment difficult. Nearshore ecosystems such as coral reefs, seagrass and mangroves are most at threat.

  Particular concerns exist with sand mining in the coastal strip, and the impacts on wilderness, recreation and landscape values; introduction of weeds; erosion; loss of soil and sand profiles; and impacts on fauna and on archaeological sites. Numerous inquiries have found rehabilitation programs to be deficient, and complex ecosystems have been permanently altered.

- **Forestry and agriculture**
  Unsustainable forestry and agricultural practices have led to increased sediments and high nutrients flowing into estuaries, and toxicants from pesticides. There has also been a reduction in freshwater flow into estuaries because of dams, river regulation and irrigation.

- **Fisheries and mariculture**
  ACF supports the adoption of the Ecologically Sustainable Development Fisheries Working Group's recognition that fisheries management needs to be based within the broader context of total ecosystem management. It considers that the Commonwealth/State jurisdiction over fisheries has always hampered management. Direct and indirect effects of fishing on ecosystems, particularly on predator-prey relationships are of concern.

  Environmental impacts of mariculture are of concern, particularly demand for coastal sites; introductions of exotic species; and elevated nutrients. For Australia's indigenous coastal and island peoples, the sense of belonging to sea country is as fundamental as their relationship to land. Indigenous fishing rights are supported.

- **Coastal zone pollution**
  Particular concerns include sewage outfalls to estuaries, bays and oceans; untreated stormwater discharges; and agricultural run-off. Because little is known of effects of pollutants on ecosystem health, ACF advocates a precautionary approach to pollution with a long-term goal of pollution prevention.

- **Tourism**
  The impacts of tourism in the coastal zone is of concern. Development of mega-resorts on lands with high aesthetic appeal such as beaches, headlands, islands, estuaries and lakes is a problem. There are shortcomings in environmental impact assessments, and these result in cumulative impacts of developments.

- **Urban planning**
  Urban fringe development, real estate speculation, urban sprawl and coastal strip development are issues. Government urban planning is seldom effectively coordinated. Housing developments have often been located in ecologically or aesthetically sensitive areas, with concomitant waste disposal problems, habitat loss and degradation, erosion and displeasing views.

ACF coastal zone management policy:
Based on the above concerns, ACF has developed a policy on the marine and coastal environments: 'The management of Australia's coastal zone must embody the principles of ecologically sustainable development, must be strategic (that is, based on long-term goals) and must integrate resource uses with each other and with conservation on a regional basis. A National Coastal Zone Management Strategy should be established by the Commonwealth Government to achieve this' (ACF Policy Statement No. 56, ACF 1993)

The policy specifically calls for regional management plans; evaluation of national coastal zone management strategy; and marine protected areas (MPAs). The National MPA network should preserve wilderness areas as Marine Reserves, and conservation of areas of high biological value as National Parks; provide for multiple ecologically sustainable uses of all other areas through a system of zoning; and be cooperatively managed by scientists, government agencies and the public.

Greenpeace Australia

(Membership 90,000)

Aims:

The preservation of the earth and the life it supports. Goals include a healthy and sustainable marine environment, extending from terrestrial catchments to the high seas. Greenpeace is international, and politically active.

Interests in the marine and coastal environments:

Greenpeace has been active in marine environmental issues in Australia. The 'Adopt-a-Beach' campaign was particularly successful in focusing public attention on the highly visible issue of beach litter, and through this onto general marine environmental issues.

Greenpeace's concerns on the marine environment were developed at a workshop in 1990. It considered 'from the outset that it must be accepted that the marine environment around Australia is grossly mismanaged and is suffering as a consequence.' Greenpeace was particularly concerned on the policy for offshore exploration for petroleum (Crew and Fry 1993, p. 61) (Chapter 38).

Major issues identified by Greenpeace

Greenpeace has identified the major threats to the marine environment as:

- Resource extraction, because of oil exploration and extraction and offshore mineral sands development.
- Fishing, because of overexploitation (commercial and amateur) of common stock species; by-catch (non-targeted fish, birds, reptiles etc); interactions with marine mammals (e.g. shooting seals); habitat modification (e.g. bottom trawling); ghost fishing (by lost gear) and loss of top predators.
- Land use, because of suspended sediments; nutrient run-off; agricultural and industrial chemicals; bioaccumulation; physical modifications of coastlines, catchments, rivers; stormwater run-off (pollutants, debris); habitat destruction and loss of biodiversity; alteration of water inputs; and multiplicity of, and lack of coordination between, management agencies.
- Recreation-tourism, because of insidious encroachment of coastal resources (e.g. ribbon development).
- Other issues include introduction of exotic species; marine debris from dumping at sea; bilge and ballast water dumping; deterioration of atmosphere; and public and government ignorance and apathy.

Greenpeace's marine and coastal policy:

Greenpeace has recommended that the Commonwealth develop an integrated national management strategy for all resources in its maritime area, and an Australian Marine Environment Protection Authority to implement the strategy.

Some activities by conservation groups in the marine environment

The nature of the conservation groups' marine programs are determined by the specific objectives of their organisations, and the concerns of their members. The following briefly describes some of the recent national activities and programs.

Greenpeace's 'Adopt-a-Beach' campaign

One of the most successful NGO conservation campaigns in recent years was the 'Adopt-a-Beach Program' mounted by Greenpeace, one of the most active conservation organisations in Australia. It began in 1990 to focus community attention on litter in the marine environment, identify sources of pollution and increase community awareness of marine consideration issues. The program was officially launched in major centres around the coast, and local volunteers teams were formed to survey and clean urban recreational beaches. Around 300 km of coast were cleaned and over 210,000 items of debris were recorded. But more importantly, the campaign was highly successful in developing a concern for the marine environment amongst a wide section of the community. Beach litter and this program are described in detail in Chapter 46.

'Clean up Australia': a model for community activity

'Clean up Australia', which organises an annual clean up of waterways, parks and road sides, has been highly successful in raising the awareness of marine pollution issues in this country, and around the world. The annual Clean Up was the brainchild of yachtsman Ian Kiernan who, during a single-handed trip around the world in 1986, was disturbed at the amount of litter in the sea.

Kiernan's first Clean Up was 'Clean Up Sydney Harbour' in 1989 when some 40,000 Sydneysiders removed 5,000 tonnes of waste from the Harbour. In the following year it was 'Clean Up Australia'. In 1990, 211 cities and towns were involved in planning and 300,000 volunteers removed an estimated 15,000 tonnes of rubbish from their local environments. By 1993 the annual Clean Up had spread around the world. This first Clean Up the World involved 79 countries and 30 million participants!

Today there are 700 organising committees in Australia, and it is estimated that around 1.5 million

Australians have participated in the program. Ian Kiernan, a self-proclaimed 'ordinary bloke', was awarded the United Nations Environment Programme's Global 500 award in Beijing in 1994 for his Clean Up programs.

Clean up Day

The goals of Clean Up Australia are to:

- help rid our waterways, parklands and roadsides of litter;
- raise community awareness on the need for positive and practical action to save our environment;
- assist in the education of the community about sound environment practices;
- create community-driven activity in which all Australians can participate; and
- demonstrate to the rest of the world that Australia is prepared to take positive action and do something to assist the preservation of the environment.

(Source: L. Zann, GBRMPA)

Figure 26.2: Clean Up Day. Divers with underwater rubbish on Magnetic Island (Qld).

Surfrider Foundation's 'State of Our Surf' (SOS)

Surfriders have evolved from a sub-culture of youth in the 1960s, to a powerful lobby group for the conservation and management of the marine environment. The Surfrider Foundation was established in 1991 as a non-profit environmental organisation dedicated to the protection of Australia's oceans, waves and beaches for all people through research, conservation, education and community development. Over 80 Surfrider teams have been established nationally. A 'Blue Water Task Force' has been established to act as pollution watchdogs.

The 'State of Our Surf' (SOS) was began in 1993 as a baseline survey to determine the extent of adverse development and pollution of Australia's 600 popular surfing beaches. The survey was partially funded by SOMER. Preliminary findings are presented in Chapter 40.

Some local conservation NGOs

Most of the remaining conservation organisations are State or local in charter, and have relatively small memberships. However, the importance of the grass-roots groups in their communities cannot be overstated. Many have been extremely effective watchdogs on coastal and marine issues, and lobbyists at the local and state government levels. Some local conservation groups with marine interests include:

Fraser Island Defenders Organisation (Qld)

Aim: To ensure the wisest use of Fraser Island.
This group, under its president John Sinclair, has staunchly protected the environment of the island for 20 years, and was instrumental in its nomination for World Heritage.

Coast and Wetland Society (NSW)

Aim: To protect and increase knowledge of coastal and wetland habitats.
This group provides advice on management issues concerning the coast. It works with local groups such as the Narabeen Lagoon Society and the Shortlands Wetlands Centre.

Bellerie/Howard Coast Care Group (Tas)

Aim: To care for the coast.
In a joint project with the local council this group organises working bees to stabilise dunes, and produces educational material for schools.

Saunders Beach Action Group (Qld)

Aim: To stop construction of a nickel ore loading wharf in Halifax Bay.
This group was involved in a successful challenge to the construction of a major wharf facility north of Townsville.

Environment Centre (N.T.)
Aim: To increase public awareness of environmental issues in the Northern Territory.
This group is active in mangrove protection and community education and has campaigned against major reclamations of mangroves in Darwin Harbour.

Increasing recognition of NGOs and involvement by government

The importance of conservation groups is well recognised by government. For example, the Commonwealth Report 'Supporting Community Conservation Action in Australia' noted that voluntary conservation organisations 'are more cost-effective, more responsive, more innovative, have excellent community networks and are more trusted by the Australian community than governments and the private sector'.

Because of the importance of marine environmental conservation and other groups (NGOs), a network of marine environmental organisations within Australia has been established in the Ocean Rescue 2000 program.

The Marine and Coastal Community Network, which commenced operations in 1993, serves as a node for over 2,500 NGOs. It has a full-time National Coordinator and six Regional Coordinators covering each State and the Northern Territory. The Network's role is a coordinating one and it produces a regular news bulletin ('Waves') and is establishing an electronic bulletin board. It also organises workshops and coordinates the annual Ocean Care Day.

Public 'enthusiastic but not well informed'

Network coordinators have found that there is a great deal of interest and enthusiasm in the marine environment in the Australian community but knowledge on marine conservation is very limited. They found that members of the public are confused about responsibilities regarding the marine environment and invariably express their frustration when trying to report a problem to the 'appropriate authorities'.

As the Network has expanded and strengthened, participating organisations are increasingly interested in 'hands-on' projects such as rehabilitation, monitoring and clean-ups.

Wide range of community groups and interests

The Network's database comprises (in Feb 1995) 2,523 organisations, in categories from Aboriginal and Torres Strait Islander groups, academics, alternative lifestylers and amusement groups, to tourist operators, transport affiliations (harbours and shipping), whale watchers, wildlife rescuers and yachtspeople.

A very wide range of interests and issues were identified by member groups. These include ocean

Ocean Rescue 2000 Marine and Coastal Community Network

Aim and goals of the Network

The Network's primary aim is to encourage and facilitate community support for the conservation and ecologically sustainable use of Australia's marine and coastal environments.

The Network's goals are:

- to promote understanding and awareness throughout the community of current and potential impacts on marine and coastal ecosystems, and of the need to manage human activities;
- identify, and encourage liaison amongst community, industry and other user groups and individuals with interests in marine and coastal environments;
- provide information to all spheres of government;
- encourage community consultation and participation in marine and coastal initiatives;
- encourage government agencies to consult with coastal communities; and
- provide a forum for free discussion and community input into decision making processes.

The principles under which the Network operates are that:

- the community has a right to be involved in decision making;
- good decision making relies on relevant, accessible, up-to-date information that is clearly understandable;
- there is a need to manage human activities to ensure that long-term sustainable use of marine ecosystems can be achieved, and detrimental environmental impacts are minimised; and
- everyone has a right to their point of view, but decisions that affect whole communities should be based on informed and considered opinions.

NEW SOUTH WALES	
South West Rocks Dive Centre	Beach clean-up
Threatened Species Network, QLD	Stall at Shelley Beach dive at Manly
SF, Sydney	Events planned for Cronulla and Narrabeen
	Launch of OR2000 Pittwater Community Awareness Program on Rock Platform Protection
Bicentennial Park	Coastal Walk/Mangrove boardwalk (3 volunteers to do guided walks)
SF, Sydney Nth Beaches	Informal rally/concerts/speeches at Styne Beach
ATCV	Shelley Beach display
Manly Environment Centre	Involved in Shelley Beach/Manly event
SF, Sydney Sth Beaches	Beach Clean in cooperation with Cronulla Residents Association
SF, Central Coast South	Storm water drain awareness/stencilling
Whale Rescue 2000	Memorial Park, The Entrance, Display of beach litter, display of wooden whale and children's activities being planned
Terrigal Underwater Group	"Caring for Our Ghosts", underwater survey of SS Maitland. Beach clean-up project
Sussex Inlet Resident Action Group	Dune Care. Cudmirrah Beach clean-up and 'Bashing Bitou Bush"
Burwood Beach Dunecare Group	Dune restoration and beach clean-up
Lk Macquarie Catchment Management Committee	Stencilling drain inlets with "Drains to the Sea"
SF, Newcastle	Beach clean, dune regeneration and awareness activities
VICTORIA	
Williamstown & Newport Anglers Club and Fish Protection Society	Beach clean-ups
Indiv	U/water clean-up, marine clean-up and invasive species clearance
Gould League of Victoria	Will publicise OCD through their contacts
Point Cook Coastal Park	Seafestival. Seafood stalls and educational displays
Aust. Trust for Consv. Volunteers	Beach clean-up at Sandringham Beach
Mordialloc Boating and Angling Club	Various activities that clubs are already doing are to come under OCD
Friends of Port Melbourne Foreshore	Dune replanting starting at 11am
Queenscliffe Primary School	Dune restoration on the Monday after OCD
Torquay North Coast Action Group	Beach survey at Whites Beach, Torquay
SE Peninsula Residents Assoc.	Foreshore bush regeneration
SF, Phillip Island	Tree Planting
Tooraddin Marine Life Centre	Mangrove clean-up day
SOUTH AUSTRALIA	
KESAB	On-going Patawalonga catchment education
Henley and Grange Beaches	Beach clean on Friday 2/12, selected pieces of rubbish will be used for museum environmental sculpture
Marion Coastal Working Party	Interpretive display and coastal walks
St. Kilda Mangrove Trail	Environmental walks, activities and display of litter Environmental
	Sculptures
Victor Harbour Public Library	Coastal display
Sthn Districts Env Grp & Moana L'care	Beach clean-up and drainage awareness
SF, South Australia	Beach Clean, Middleton Beach. Stormwater drain protest
Surf Life Saving SA	Surf Life Saving Carnival and Beach Clean-up at Aldinga Beach
WESTERN AUSTRALIA	
Indiv	Coastal Walk/Clean-up
Mandurah City Council	Assorted events
Friends of Woodman Point	Beach walk and displays
Broome Coastal Land Consv District	Cable Beach clean-up and planting suitable native plants
SF, Broome	Beach clean-up
SF, Cape to Cape	Litter clean-up & media focus on ocean outfalls, Smiths Beach & Yallingup
SF, Albany	Litter clean-up, Princess Royal Harbour/Middleton

Figure 26.3: Ocean Care Day program, 1994, around Australia.

sewage outfalls, oil exploration and production, mining, overfishing of fish stocks, effects of trawling, water quality, stormwater and urban run-off, beach litter, loss of habitat, marinas, shack development, canal estates, acid soils, environmental impact assessment quality, threatened marine species, whales and whaling, ballast water introductions, declines in seagrass, indigenous sea rights, marine reserves, dune rehabilitation, total catchment management, private use of foreshores and other issues.

A selection of Marine and Coastal Community Network projects in 1994

Habitat surveys in New South Wales

The NSW Network has commenced an underwater survey, the 'Divespot Habitat Survey', involving dive clubs, scuba schools, dive shops, Clean Up Australia, NSW Fisheries and other organisations.

The survey aims to encourage the involvement of divers in marine conservation issues and to increase their knowledge of the marine environment as they survey the marine environment; to systematically collect data on the marine environments of New South Wales which will used by the diving community and marine research and planning bodies; and to promote marine conservation issues and explode the myth 'out of sight, out of mind'.

Protecting grey nurse sharks in New South Wales

Although grey nurse sharks are protected in New South Wales, divers at South West Rocks have been increasingly concerned about declining numbers of the shark, and sightings of sharks with fishing hooks embedded in their mouths.

The divers took their concerns to the Network who facilitated a meeting of local recreational and commercial fishers and divers, the Maritime Services Board, NSW Fisheries and the local Chamber of Commerce. The meeting discussed ways of further protecting the sharks, and unanimously called for the closure of a 500 metre radius around a well known shark refuge, Fish Rock. This proposal is now before the managing agency, NSW Fisheries.

Raising concern on exotic marine species in Victoria

Following concerns about the introduction of exotic species in ships' ballast waters, the Victorian branch of the Network has organised an alliance of groups with common interests in the problem: the dive industry and community, recreational fisher clubs, commercial shell fishers including aquaculturists and seafood processors, conservation groups, and peak State bodies. The initiative has successfully increased awareness of the issue and traditionally polarised groups have cooperated in a cross-sectoral approach to the problem.

Monitoring seadragons in South Australia

Because of concerns on the status of endangered seadragons, the Marine Life Society of South Australia, the Threatened Species Network and the Marine and Coastal Network are developing a database of seadragon sightings.

Divers are being encouraged to record and submit sightings, together with habitat information, in order to develop baseline information on these. This may then help define important seadragon habitat areas in South Australia, to assist in the establishment of marine protected areas in significant habitats, to prevent poaching of seadragons, and possibly assist local ecotourism industries based on seadragons. The survey also aims to involve divers in marine conservation issues and to heighten awareness for habitat protection.

Community attitudes changing

The 'green movement', once considered a 'fringe group' by most Australians, has had a profound effect on attitudes of the community. Many Australian sports, recreational, tourist, business and professional organisations now perceive themselves as 'green', and are actively involved in environmental programs such as waste reduction and recycling.

For example, the Surfrider Fundation has been active in surveys of marine pollution. Commercial and recreational fishing organisations are concerned about loss of fish habitats and some have full-time environment officers working for their organisations.

Perhaps most symbolic of community attitude changes has been a change in the way many Australians perceive that long-time nemesis of Australian beach culture, the shark. In some places dive tourism businesses are now focusing on sharks: for example, on great white sharks in South Australia; on grey nurse sharks in New South Wales; on whale sharks in Western Australia; and on shark feeding on the Great Barrier Reef. Two decades after 'Jaws', some community groups are even pressing for protection of the great white shark.

Summary and conclusions

1. Community conservation groups in Australia have been prominent in raising public awareness on issues affecting the marine environment, and in marine environmental conservation. They are considered more cost-effective, more responsive, more innovative, have excellent community networks and are more trusted by the Australian community than governments and the private sector. The importance of conservation groups is now well recognised by government.

2. There are over 2,600 groups in Australia with interests in the marine environment. Several hundred have a particular interest in coastal and marine conservation.

3. Issues identified by major conservation groups are essentially similar and include: extraction of minerals (sand mining and offshore petroleum); coastal zone development (urban sprawl, coastal strip development); land use and clearing of catchments; pollution; effects of fishing (direct and indirect); degradation of beaches; and effects of tourism.

4. Some conservation associations have developed policies on marine environmental conservation. These are also essentially similar and include: ecologically sustainable development; networks of marine protected areas including multiple-use zoning; intergated catchment and marine management; control of point-source effluents, eventually leading to no discharges of toxicants; the necessity of controlling diffuse sources by as yet undefined strategies; a national marine conservation strategy (various names) established by legislation and developed and implemented by specific expert agencies; the particular recognition of indigenous interests and their inclusion in decision making processes; and widespread public consultation and involvement.

5. Because of the great importance of marine environmental conservation and other non-government organisations (NGOs) in the community, the Marine and Coastal Community Network has been established through the Ocean Rescue 2000 program to promote understanding and awareness of marine issues and conservation; liaise with community groups; provide information to government; encourage community participation in marine and coastal initiatives; and provide a forum for community input into decision making processes. The network currently serves as a node for over 2,600 interest groups.

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Part 4
Uses of coastal and marine environments, and their impacts

Coastal and marine tourism, recreational and commercial fisheries, ports and shipping, and offshore oil and gas are major industries in Australia, and are estimated to be worth in excess of $17 billion per year. However, although these industries contribute greatly to Australia's economy, they may also have adverse environmental effects.

Tourism is, in theory, non-extractive and environmentally sustainable but often involves considerable disturbances to the natural and human environments. Fisheries, while also sustainable in theory, are often not so in practice, and their indirect impacts on marine ecosystems are suspected to be great. Marine transport is also a non-extractive industry but does involve considerable disturbances of shorelines for ports, and poses serious hazards of oil and chemical spills, sources of ocean litter and a means for the introduction of exotic marine species. Offshore petroleum extraction is a non-renewable industry and may cause environmental disturbances during exploration and production, and the risk of oil spills.

The chapters in this Part describe Australia's major coastal and marine industries, their economic values, and their known and potential environmental impacts.

Economic values

Chapter 27 describes measurable dollar values of uses currently made of Australia's marine environment, and discusses marine environmental economics, a vital tool in addressing ways to achieve ecologically sustainable development.

Tourism and recreation

Coastal and marine tourism is one of Australia's largest and fastest growing industries. Chapter 28 describes coastal and marine tourism and recreation, economic values and recent trends - the positive side of tourism. Chapter 29 critically examines environmental and social impacts of tourism - the negative side of tourism.

Fisheries

Fisheries are of great recreational and commercial importance in this country. Fishing is one of the most important outdoors recreational activity for Australians. Around five to six million Australians - over a quarter of the population - go fishing each year. The commercial industry supplies fish to other Australians, and is a valuable export industry.

Fisheries are covered in some detail because fishing is the major use of Australia's marine environment and the largest recreation activity by Australians, and because fished species are intrinsic and important parts of marine ecosystems. Chapter 30 describes the commercial fisheries and Chapter 31 critically reviews the problems in the management of coastal fisheries. Chapter 32 discusses the environmental effects of trawling, and the 'by-catch' issue. Chapter 33 describes Australia's huge, but relatively little-documented recreational fisheries, and the conflicts between commercial and recreational fisheries. Chapter 34 describes shoreline harvesting, an increasing problem along developed coastlines. Chapter 35 describes the rapidly growing aquaculture industry, and its environmental impacts.

Transport and energy

Marine transport is vital to the island-nation of Australia, and the offshore petroleum industry provides most of our hydrocarbon fuel requirements. Chapter 36 describes Australia's shipping and ports, and their environmental impacts. Chapter 37 describes the offshore petroleum and exploration industries, and their environmental impacts. The latter has been a controversial subject amongst many conservationists in Australia, and Chapter 38 attempts to outline, without bias, the varying viewpoints of industry, conservationists and management.

The final Chapter (39) specifically examines the issue of oil pollution and oil spills, and their prevention and control.

Chapter 27: Marine environmental economics[1]

The gross financial value of Australia's fisheries, offshore petroleum and tourism is estimated to be around $16-17 billion per year, and that of marine transport is a further $3.5 billion per year. The economic value of the marine environment is, of course, far greater. It provides not only consumable natural resources such as fish and minerals, but also waste assimilation services to disperse and breakdown discharges, amenity resources to visitors and others, and life support systems for human and other life on earth. Only some of these functions are able to be valued in dollars in existing markets.

It is our economic system, that is the system of production and exchange, which largely determines the pattern by which we consume the various goods and services provided by the marine environment. The economic system determines whether we make the most of the potential for marine resources to contribute to the wellbeing of society or whether our use overshoots into unsustainable practices.

This chapter examines measurable dollar values of uses currently made of Australia's marine environment. It also discusses approaches available from the field of environmental economics that may be used in incorporating non-market values of the natural environment into economic analysis. Environmental economics is a vital tool in addressing ways to achieve ecologically sustainable development (Chapter 61).

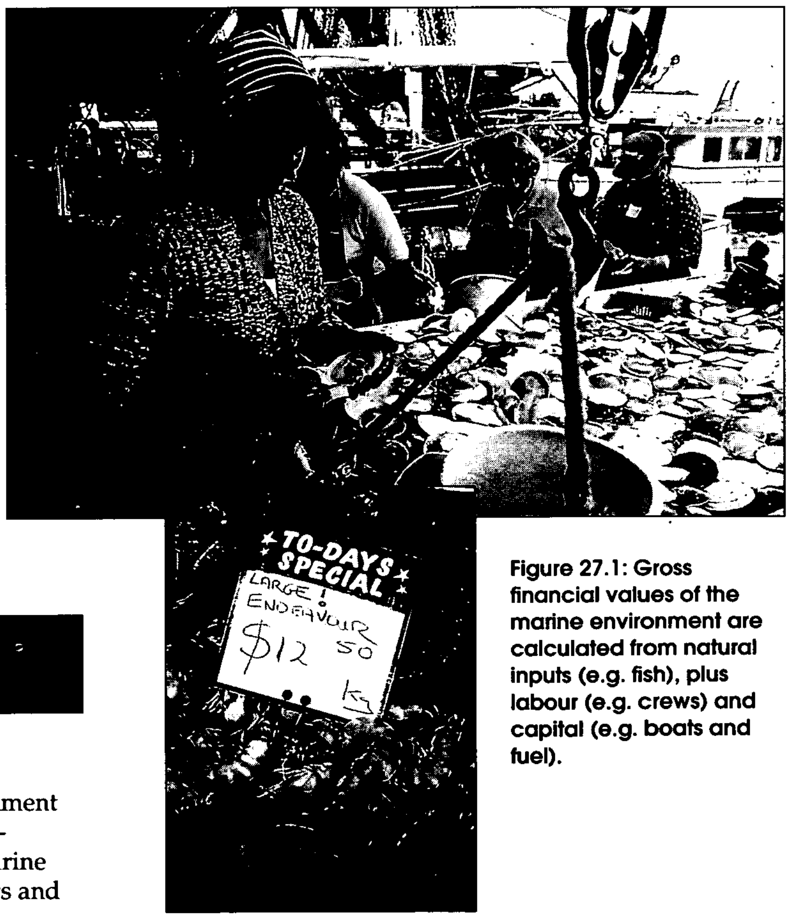
Economics of the marine environment

Economic value

The 'economic value' of the marine environment includes the financial returns from revenue-generating, direct use of elements of the marine environment such as fisheries, sites for ports and tourist attractions. In addition, the marine environment provides services that are not normally measured in dollars, but nevertheless contribute greatly to our wellbeing, and would constitute a loss if no longer available. The former are called 'market goods', the latter are 'non-market goods'. Maximising the total value of goods and services of natural environments over the long-term means recognising both market and non-market values.

Market values

Some of the important money values associated with the marine environment are shown in Table 27.1. These values are all gross financial values of output of goods and services traded in markets. Importantly, these uses support direct employment and economic activity and employment in associated industries. More information on some of these industries is given in Chapters 28, 30, 33, 35, 36 and 37.



(Source: GBRMPA)

Figure 27.1: Gross financial values of the marine environment are calculated from natural inputs (e.g. fish), plus labour (e.g. crews) and capital (e.g. boats and fuel).

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[1] Based on a paper by S. Driml, Australian National University, Canberra, Australian Capital Territory.

Gross financial value of goods and services at their point of export or consumption by Australian households (minus intermediate purchases) is the measure used in calculating Gross Domestic Product (GDP). Gross financial values incorporate the value of inputs from the natural environment (e.g. fish), plus labour (e.g. fishing crew) and capital (e.g. fishing boats and fuel) used in producing goods and services for sale. The net contribution of the marine environment *per se* is a proportion of the gross financial value. Of the industries listed below, only fishing, aquaculture and tourism are directly dependant on the quality of the marine environment.

Table 27.1: Output Values of some Australian marine industries, 1992/93 ($ million)

Industry	Output Value	Exports
Fishing	1,374	1,085
Aquaculture	258	159
Offshore oil and gas	6,979	3,258
Tourism - foreign	1,463	1,463
Tourism - domestic	7,360	-
Subtotal	16,434	5,965
Civil ship building	237	195
Naval ship building	1,233	-
Boat building	294	258
Shipping - coastal	647	-
Shipping - international	1,158	-
Total	20,003	6 ,418

(Source: McKinnon 1993)

Conventional economic indicators are not sufficient indicators of sustainable resource use. Gross financial values do not document any negative impacts of an activity on other market or non-market values. They do not indicate changes in the state of resource stocks. It is only after the resource base is depleted, that reductions in gross financial values become evident, and these can be significant. For example, the value of the catch of southern bluefin tuna in 1988-89 was $40 million. This dropped to $25 million the following year as quotas were reduced to account for stock depletion.

Environmental economics

Environmental economics has evolved to deal with some of the obvious shortcomings of conventional economics with respect to natural environment resources. For the most part, environmental economics uses principles and techniques from conventional neoclassical economics, and extends these to explicit recognition of goods and services from natural environments.

The Australian economic system is a mixed economy. Markets are the predominant means of exchange, but there is significant government intervention to direct processes to more socially desirable outcomes. In theory, the market system works to produce an efficient allocation of goods and services, so long as certain conditions are met. The breakdown of these conditions is termed 'market failure'. Government intervention is necessary to address market failure, but without precise knowledge of the effects of the problem, (e.g. pollution) and how people will respond to the intervention, it is difficult for governments to achieve desired outcomes.

Many attributes of natural environments are subject to market failure, and are thus not effectively dealt with in markets, or fall outside market processes altogether. This leads to a tendency to overuse and deplete natural environments. Many environmental services have 'public good' attributes. They are not able to be divided into separate parcels for trade, and if left to private markets, would be undersupplied. Water quality, biodiversity and ecological system functioning all have 'public good' attributes.
Many of our natural environments are held in common. Unrestricted access to common property resources can lead to overuse, as has occurred in many of the world's fisheries.

The encompassing concept for market failure in relation to natural environments is the existence of 'externalities', that is, effects outside the private financial dealings of players in the market. Pollution caused by the free discharge of wastes, and the effects of overfishing on other users of marine resources are examples of negative externalities.

Environmental economics can be used on a number of levels to bring a greater range of values of natural environments into resource allocation decisions, whether these are at the level of planning and policy making, or the day-to-day functioning of markets. Generally, this requires, as far as possible, identifying the interactions between resource users and the environment, and placing money values on these effects.

Possibly the most valuable use of economics in resource management is in illustrating trade-offs. Although there is potential for considerable complementary, multiple-use of environmental resources, most resource use issues ultimately involve trade-offs. Examples include a direct use (such as fishing versus conservation); one use versus another (such as mining versus tourism); or levels of use now, against future use (for example, the effect of current fish catch on future fish availability).

The extended Benefit Cost Analysis methodology requires the trade-offs to be explicitly described, and environmental effects to be taken into account. The accurate financial valuation of those things that can be

(Source: L. Zann, GBRMPA)

b

a

Figure 27.2: Australia's coastal and marine environments have great market and non-market values. Environmental economics is useful in illustrating trade-offs in multiple-use management of resources. The Gold Coast (a) and Northern NSW (b). Undeveloped and highly developed coastlines.

valued in dollars, placed in context with descriptions of what is not valued in dollars, makes clear what trade-offs need to be made.

On one level, governments make decisions on resource allocation on a broad scale through land use planning, and by decisions to allow major public or private sector projects such as the construction of a shipping port. Often these decisions will be informed by economic analysis that sets out the costs and benefits of alternatives. In Benefit Cost Analysis, the 'opportunity costs' of going ahead with any option are the benefits of reasonable alternatives. The evaluation process can include ecological/economic modelling to predict impacts, and measurement of effects that are able to be valued in money terms but are not captured in market prices.

At another level, governments may adjust markets to account for environmental values in their day-to-day operations. Approaches used include regulations and 'economic instruments' including taxes and subsidies, performance bonds, and tradeable permits, quotas or licences.

Environmental economics methods

There are a number of uses to which the tools of environmental economics may be put to assist in informing resource use decisions (see box below). One approach to measuring non-market values is to survey people to ask about their 'willingness to pay' for public goods from natural environments. This approach relies on the proposition that people can, and should, express their preferences for the maintenance of the range of 'public good' values of the natural environments the same way they do for private goods that they may consume. Weaknesses in this approach include assuming that individuals have appropriate knowledge of environmental systems to make decisions which will realise the outcomes they wish, and that people of the present generation can express preferences on behalf of future generations.

An alternative approach to incorporating the value of public goods is a form of the 'safe minimum standards' (SMS) approach, whereby constraints are set on the use of natural environment resources to maintain public good benefits, and action is taken to maximise net economic benefits within these limits. Within specified standards, conventional market systems can operate and regulations and economic instruments can be used to make further adjustments where necessary. This requires close cooperation between economics and science in incorporating SMSs in economic appraisals (James 1993). Examples of the SMS approach include some Australian commercial fisheries where overall catch limits have been set and the rights to fish are allocated via Individual Tradeable Catch Quotas (Chapter 30).

Future directions for environmental economics include greater emphasis on ecological/economic modelling in order to better understand links between economies and ecosystems. Environmental economics approaches could be of great benefit to analysis of resource use in Australia's marine environment if the aim is to maximise sustainable benefits. The use of environmental economics as a tool to better inform managers of the Great Barrier Reef is illustrated in the case study below.

Applications of environmental economics:

Optimising the financial values of resources
The use of ecological/economic modelling to optimise fish catches has been a feature of fisheries research and management for some of Australia's fisheries. Potential exists to extend this to more fisheries, to account for effects on non-target species, and to consider maximum economic yield (MEY) as well as maximum sustainable yield (MSY) (Industry Commission 1992).

Identifying the value of environmental services
The value of certain services of natural environments can be measured as the cost of alternative means of providing the same services. For example, services of marine areas include, amongst others, providing the habitat for commercial harvested fish. This service can be valued at the cost of raising equivalent volumes of fish via aquaculture.

Measuring damage costs
The dollar value of damage costs caused by one economic activity on another may be measured. For example, the reductions in fish catch due to clearing of wetlands for urban development can be valued. The effects of disposal of excess nutrients on reefs, which damages coral, could potentially be measured in terms of reductions of earnings from tourism. Often the impacts are distant from the source and considerable knowledge of the functioning of the system is required to trace effects.

Measures of non-market direct use values
It is possible to place a dollar value on the value to direct users of access to natural environments, by asking what they are willing to pay for access ('contingent valuation method') or using information on their travel patterns ('travel cost analysis'). This is especially useful for valuing tourism and recreation where zero or only minimal entry fees are charged. For example willingness to pay for recreational fishing in the Great Barrier Reef has been estimated and a travel cost analysis of recreation in Kakadu National Park has been undertaken .

Measures of defensive expenditures
It is possible to calculate what needs to be spent on avoidance of environmental impact, rehabilitation of reversible impacts or monitoring to reduce the risk of impacts, in order to allow an activity to proceed with minimal impact. For example, the Great Barrier Reef Marine Park Authority requires tourist operators to fund monitoring programs and lodge performance bonds. This is especially relevant to designing ecologically sustainable use regimes.

Design of instruments
Economic information and principles can be used to design regulations and economic instruments that will effectively adjust market operations to avoid unintended environmental impact. Instruments in use in the marine environment include Individual Tradeable Catch Quotas in fisheries. The Resource Assessment Commission recently advocated greater use of 'user pays' and other economic instruments for coastal zone management (RAC 1993).

Identification of distributional issues
Many policy actions are aimed at redistributing costs and benefits of resource use. Identification of the magnitude of gains and losses from resource use decisions and who is likely to experience them allows more informed policy development. Information on employment generated and regional economic impacts ('multiplier effects') is used.

Case study: Financial and economic values of the Great Barrier Reef

Some studies have been undertaken on identifying the market and non-market values of uses of the Great Barrier Reef World Heritage Area (Driml 1994). The uses of the Great Barrier Reef include the over-riding primary use of conservation of the environment plus direct uses. The major direct uses are commercial tourism, commercial fishing, private recreation, shipping, research and education, while the waters of the area provide waste disposal services for mainland activities.

The application of principles of ESD to the Great Barrier Reef can be interpreted as aiming to maximise the economic values of the combined multiple uses within the SMSs set by the conservation objective. There is potential for conflict to occur between any of the direct uses and the conservation objective or amongst any of the direct uses. The direct uses are currently being managed, according to the best available knowledge, at levels compatible with the conservation objective. Research and monitoring of uses and their impacts is continuing and use levels could be altered in the future based on results of this research. Economic information may assist in finding solutions to overuse or conflicts between users.

Research so far has measured the gross financial values of some of the direct uses. Commercial fishing generated sales worth around $128 million in 1991/92. Recreational fishing and boating can be valued at the expenditure by recreationalists on equipment and trip costs and this was $94 million in 1991/92. The financial value of commercial tourism is measured as expenditure by tourists. In 1991/92, tourists spent $365 million on stays at island resorts and trips on commercial passenger vessels in the Great Barrier Reef World Heritage Area. In addition, tourists spent an estimated $326 million on accommodation on the adjacent mainland directly associated with their visits to the reef, resulting in a gross expenditure of $682 million in the region. Expenditure on research was approximately $19 million in 1991/92.

Together, these activities generate close to $1 billion in gross financial value each year. This illustrates the significant commercial activity generated due to the resources of the Great Barrier Reef, activity which clearly depends upon a healthy natural environment producing the aesthetic and fisheries resources used by these industries and activities. This information does not however tell us whether use at these levels is sustainable, and further research would be required to predict future returns given the likelihood of increasing demands for use.

There has been one attempt to measure part of the value to people of conservation of the Great Barrier Reef (Hundloe et al. 1987). This measured willingness to pay to maintain a certain quality of the reef environment which at the time was threatened by damage from crown-of-thorns starfish. A figure equivalent to $86 million per year in 1991/92 dollars was derived to represent willingness to pay by the Australian population. This should be interpreted as an order of magnitude estimate only (and does not include values held by people outside Australia), but it does indicate significant ongoing support for conservation.

Summary and conclusions

1. Australia's marine environment supports industries generating considerable dollar values and employment. The value of coastal and marine tourism, fisheries and offshore petroleum is $16-17 billion per annum; ship building and shipping is valued at around $3.5 billion per annum.

2. In addition, the marine environment provides services such as recreational and waste disposal sites, not measured in conventional markets.

3. Natural environment resources are subject to failure of conventional markets to value them properly, leading to depletion and degradation.

4. Techniques from environmental economics can be used to determine non-market values.

5. Economic instruments can be used to adjust markets for sustainable resource use.

6. Environmental economics approaches are important in maximising sustainable use of Australia's marine environment.

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Chapter 28. Coastal and marine tourism and recreation[1]

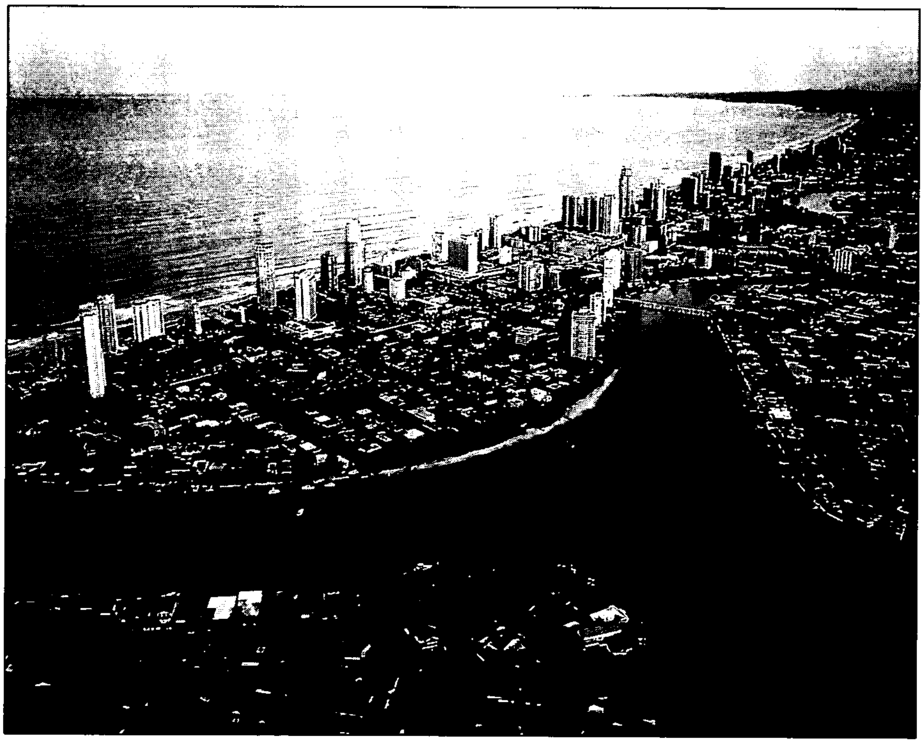
Australia's coastal and marine environments provide the premier natural recreation resources for Australians and for millions of visitors to this country. Most of Australia's population lives near the coast and most holiday trips are made to coastal areas. Most international visitors also stay on the coast. The marine environment provides a stimulating challenge for active recreation, as well as a source of uplifting of the spirits. While at the coast, visitors swim, dive or fish in the sea, cruise and sail on the sea, or just enjoy walking by the sea, sunbathing or simply looking at the sea.

While home-based activities such as watching television, reading, and gardening are Australians' most popular recreation activities, 'the beach' is the most frequently used recreation facility outside the family home. Tourism and recreation in coastal and marine areas has been characterised by continual growth in numbers due to increases in population, migration to coastal areas, increased leisure time and increases in tourists from overseas. It has also been characterised in many areas by change due to greater concentrations of people and infrastructure, increased capital investment, changes in technology, and changes in social values.

This chapter examines the different types of tourism and recreation in coastal and marine areas around Australia, trends in development and economic values, and environmental considerations. The negative effects of tourism on the environment are specifically examined in the next chapter (Chapter 29).

Growth trends in recreation and tourism

The coast and sea are the focus of recreation by coastal dwellers - the majority of Australians - and both domestic and international tourists. (Note: 'Recreation' includes all the leisure activities engaged in by tourists and local residents. 'Tourists' are defined as people who visit a place more than 40 kilometres away, and stay away from home for more than one night.)



(Source: QTTC)

Figure 28.1: Coastal and marine tourism in Australia is valued at over $10 billion per year. The Gold Coast, Australia's tourist mecca.

Increasing domestic use of coastal environment

The coastal areas outside capital cities are the fastest growing areas in Australia (Chapter 1). Of the total Australian population in 1991, 10 million resided in the capitals (all except Canberra, on the coast), and 4.1

[1]Based on a paper by S. Driml, Centre for Resource and Environmental Studies, The Australian National University, Canberra, Australian Capital Territory.

million lived in other coastal areas. The latter has doubled over the previous two decades, and accounts for half the national population increase. The reasons for the strong growth, expected to continue at 22% in the next decade, include natural population increases, spills from cities, and migration for retirement and work.

International tourism growth

Australia's natural environment is a major drawcard for overseas visitors. In 1991 there were 2,370,400 overseas visitors, the vast majority of whom came for recreational purposes. International visitors spend over 65 million nights in Australia, 87% of which are in coastal areas.

Around half the international visitors participated in some sport or outside activity whilst in Australia. For example, 700,000 swam or surfed, around 300,000 snorkelled or scuba dived, and 100,000 went sailing and fishing. Sydney was the most popular destination (64% of visitors), followed by Brisbane (29%), the Gold Coast (28%) and Melbourne (28%).

Table 28.1: Major coastal locations visited by international tourists in 1991, showing % of total visitors and total numbers

New South Wales		
Sydney	64%	1,524,600
Sydney beaches	34%	810,000
Sydney Harbour cruises	30%	714,700
Beaches outside Sydney	7%	174,700
Victoria		
Melbourne	28%	668,500
Phillip Island	9%	220,400
Great Ocean Road	4%	99,600
Queensland		
Brisbane	29%	697,800
Gold Coast	28%	665,100
Sea World	14%	338,000
Sunshine Coast	9%	218,000
Port Douglas	7%	174,500
Whitsunday Islands	5%	119,900
South Australia		
Adelaide	9%	215,700
Victor Harbour	2%	47,400
Western Australia		
Perth	12%	295,800
Fremantle	9%	228,000
Yanchep/Sun City	2%	49,300
Rottnest Island	2%	52,400
Tasmania		
Hobart	2%	61,200
Port Arthur	1%	35,600
Northern Territory		
Darwin	4%	91,000

International tourism has been a major growth industry over the past decade. The average growth rate since 1986 has been around 11% a year. International visitors topped two million for the first time in 1988, and are expected to exceed five million a year by the year 2001.

Domestic tourism trends

During 1991 Australians made 49 million trips as domestic tourists, spending 215 million visitor nights away from home. Excluding business travel, around 147 million visitor nights were spent in coastal areas, 99 million of which were outside of capitals. Outside the major capitals, the 'resort' areas of the Gold Coast and Sunshine Coast were most popular. Growth in domestic tourism has been more modest than that of international tourism. While growth totalled 10% between 1984 and 1989, it declined by 2% (reflecting the downturn in the domestic economy) in 1990-91.

Table 28.2: Australia's top 15 domestic tourist destinations

(1) Sydney (12,978,000 visitor nights);
(2) Brisbane (10,711,000);
(3) Melbourne (9,526,000);
(4) Gold Coast (9,335,000);
(5) Sunshine Coast, Qld (7,325,000);
(6) Adelaide (6,444,000);
(7) Perth (5,719,000);
(8) Illawarra, NSW (5,096,000);
(9) Hunter, NSW (5,052,000);
(10) South Coast, NSW (4,493,000);
(11) Far North Queensland (4,033,000);
(12) Lower North Coast, NSW (4,296,000);
(13) Upper North Coast, NSW (4,152,000);
(14) Outer Sydney (3,950,000);
(15) Fitzroy, Qld (3,735,000).

Coastal and marine attractions and facilities

Attractions for visitors to the coast include both natural areas and wildlife, and synthetic facilities.

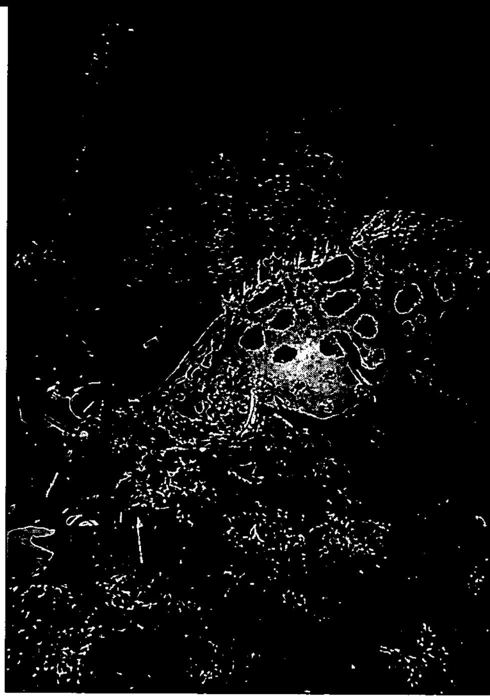
Natural attractions and ecotourism

'Ecotourism', tourism with the natural environment as its primary focus, is one of the fastest-growing sectors of the Australian industry. The well known World Heritage Areas of the Great Barrier Reef, the Wet Tropics, Fraser Island, Lord Howe Island, Shark Bay, and other sites bring increasing numbers of international and domestic tourists. Key attractions such as the Great Barrier Reef may provide the focal point for longer trips to the general area, e.g. the Queensland coast and rainforest of the Wet Tropics.

(Source: J. Lochman, Lochman Transparencies)

a

(Source: GBRMPA)



b

Figure 28.2: Marine ecotourism is a growing industry in Australia. (a) The famous dolphins of Monkey Mia (WA) attract many thousands of visitors each year to this remote area. (b) The giant cod in the Great Barrier Reef's famous Codhole are visited by thousands of scuba divers each year.

While environmental government managers generally provide visitor facilities and interpretive centres, and commercial businesses provide guided tours, there are a growing number of commercial interpretive centres and associated 'theme parks'.

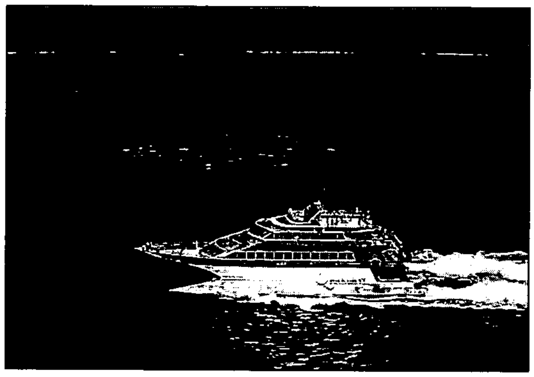
Tourist accommodation

Coastal areas outside the capitals support 38% of the hotels and motels in Australia, 52% of the caravan parks, and 75% of the commercial flats, units and houses, and take around $1 billion per year.

Coastal and island resorts lie on the more 'glamorous' and highly visible end of the accommodation spectrum and provide high quality accommodation, on-site restaurants, shops, pools, golf courses, and various beach and water activities. Major resort complexes have proliferated in Cairns, Port Douglas, the Great Barrier Reef islands, Sunshine Coast, Gold Coast, Coffs Harbour, and Port Macquarie in the east; and Broome and the northern Perth coast in the west. Many coastal towns and cities are heavily dependent on tourism and recreation. Changes to the size and character of towns and cities such as Port Douglas, Cairns and the Gold Coast have been dramatic.

Water transport

A growing fleet of commercial passenger vessels services the marine tourism industry around Australia, and takes tourists to island resorts, sightseeing, fishing, diving, whale watching and on other activities. Queensland has 529 registered passenger vessels; New South Wales 202 (excluding the Sydney Harbour fleet); Victoria 285; South Australia 34; and the Northern Territory 40.



(Source: Quicksilver Cruises)

Figure 28.3: High speed vessels have revolutionised the Great Barrier Reef tourist industry.

The development of large high-speed passenger catamarans and 'wave piercers', in which the Australian shipping industry has been a world leader, revolutionised marine tourism in the 1980s by greatly extending the range, and the comfort, of visitors. Today an international tourist can jet into Cairns in the evening; next morning take a luxury, 300-seat, air conditioned wave piercer from Port Douglas to an outer reef in under two hours; view unspoilt corals and fish by scuba or 'submarine'; and dine at a five star hotel on the same evening.

A growing number of international cruise ships visit Great Barrier Reef destinations such as the Whitsundays and Cairns, and many smaller cruise ships operate four or five day tours.

Marine-based recreation

In general, patterns of recreational use around Australia's coast are affected by proximity to population centres, transport, climate, season, marine hazards (such as sharks, crocodiles and marine stingers), holiday periods, and the natural features of the environment. The mild climate makes south-east Queensland and northern New South Wales popular for year-round marine recreation, while north Queensland is a popular winter destination. Most water activities are concentrated around the sea shore, though some fishing, diving, sailing and cruising occurs further offshore. Recreational fishing, a very popular outdoor activity of Australians, is described in Chapter 33.

Beach recreation and surf life saving

The beach is an icon of Australian life (Chapter 23). Recreational uses include swimming, surfing, walking, beachcombing and fishing. Beaches are the focus of lifesaving carnivals, 'iron man' and surfing competitions, and are the venue for rock concerts, fireworks displays and other functions. With very few exceptions, Australia's beaches are public places, and most beach-side activities are open to people of all age groups and income levels.

As beach bathing may become hazardous at times, regular patrols are undertaken at 300 of Australia's estimated 7,098 beaches by Surf Life Saving Australia, the Royal Life Saving Society of Australia and local councils.

Hundreds of thousands of Australians are to be found on beaches during a summer Sunday. Individual Sydney beaches can draw crowds of 30,000 to 50,000 people, and the beaches of Port Phillip Bay can attract 300,000 people on peak days. A household survey in Adelaide in the mid-1980s found that around 55% of all those interviewed visited the beach at least once each summer,

case study 1

Sydney's ocean beaches

Sydney's magnificent harbour and golden beaches are the focus for the recreational activities for the city's three million inhabitants. The 33 ocean beaches between North Palm Beach and Cronulla, of which Bondi and Manly are world known, are a way of life for Sydneysiders. They are visited by around one third of Australia's overseas visitors each year, and by millions of locals. The 'season' runs 30 weeks from mid-September to April.

Each year the northern beaches from Palm Beach to Freshwater attract over 3 million visitors; Maroubra, Coogee and Clovelly attract 1.8 million; and Bronte 650,000. On a summer weekend day, Bondi Beach can have crowds of 30,000 to 40,000, and Maroubra and Coogee up to 30,000. Surf carnivals may attract up to 50,000 spectators.

Water quality, and particularly bacterial and viral diseases which affect human health, is the major issue for Sydney beach users. The presence of grease, beach litter and discoloured water are also serious concerns. In recent years some beaches have been closed to swimmers as they did not meet human health standards. The major sources of the pollution were discharges from poorly treated sewage from the plants at North Head, Bondi and Malabar but the commissioning in 1991 of deep ocean outfalls which discharge up to 4 km out to sea has reduced the problem.

case study 2

Melbourne's beaches

Around half the Victorian population take their holidays at the seaside. The beaches of Port Phillip Bay near Melbourne are very popular and during hot summer days can attract up to 300,000 people a day. Estimates are that there are 14 million day visits, and 13 million holiday visits to the Bay each year. The 'season' extends from November to April, with peak use over the 10 to 20 hot days of mid-summer. Activities on the Bay include swimming, power boating, sailing, fishing, walking, sunbathing, and picnicking. Sites around the entrance are most popular with scuba divers.

Beaches on the Victorian coast are generally visited for longer holidays. The 'ambience' at many of these places is low key, with caravan parks and camping being popular accommodation. Caravan parks provide 82% of the commercial accommodation along the coast. Some regular (and more affluent) visitors establish holiday homes at the beach. Around 83% of Victorian holiday homes are at the beach, 74% within 150 kilometres of Melbourne.

A survey by Surf Life Saving Australia between Lakes Entrance and Warrnambool found that 66% of those interviewed were from Melbourne; most stayed close to the beach; the mean age range was 14 to 19 years, the average time spent on the beach was 2 hours; and the average respondent spent 31 days at the beach over summer!

case study 3

The Gold Coast

Situated just to the south of Brisbane along 42 kilometres of surfing beaches lies Australia's holiday Mecca. The Gold Coast ranks fourth (after Sydney, Brisbane and Melbourne) in the number of visitor nights spent by domestic tourists (9.7 million), and is visited by over a quarter of all international visitors to Australia.

Visitor surveys show the main attractions are, by order: climate, beaches, tourist attractions, relaxed lifestyle, atmosphere, variety, people, night life, shopping and natural beauty. The Gold Coast has a fast growing permanent population as it becomes a retirement centre. (On census night in 1986 there were 20,000 visitors and 120,000 residents.)

The development has come at a considerable environmental cost. Major environmental issues are the modifications of land and waterways for the construction of canal estates and marinas, the destruction of wetlands, disposal of sewage into the sea, catastrophic beach erosion following the construction of groynes at the mouth of the Tweed River, and the construction of high-rise buildings along the beach.

and nearly half of these beach goers visited the beach once a week in summer.

Environmental issues for beach-goers include water quality (particularly health hazards); conflicts between users (board and body surfers, dog walkers, off-road vehicles etc.); 'development' (alteration of natural surroundings); beach litter (from visitors and from offshore sources); erosion of dunes (by off-road vehicles, access tracks); and urbanisation of shores.

Surfing

The sport of surfing using boards and skis (as opposed to 'body surfing') is very popular in southern Australia. Australia has produced a number of international champions who have become role models for many of our young. Surfing associations claim that 2 million Australians regularly surf using boards.

(Source: L. Zann, GBRMPA)

Figure 28.4: There are around 2 million board surfers in Australia.

The major environmental concern of surfriders is declining water quality. Surfing organisations have become active in opposing ocean sewage discharge, and the Surfrider Foundation has been recently established to protect surfing beaches and act as a pollution watchdog (see Chapter 40). Organisations are increasingly calling for 'surfing reserves' to be declared over Australia's premier surfing sites. Reserves have been established at the well known Bells Beach (Vic) and Margaret River (WA). While direct impacts of surfing are negligible, foreshores may be damaged by access tracks, car parks and associated developments.

Boating and sailing

There are over half a million registered, privately owned motor vessels in Australia. This excludes the hundreds of thousands of unregistered canoes, dinghies and sailing craft. The Australian Yachting Federation (the main body representing sailing clubs) has 81,000 members, owning 25,000 sailing vessels. Research in Queensland indicates that 97% of motor boats are owned by people living in coastal regions, and most are used in marine waters. They are used for 10 to 25 trips each year.

Negative impacts include the disposal of wastes (particularly in crowded sites), construction of marinas (which may be responsible for loss of wetlands), harmful environmental effects of tributyl tin antifouling paints, and overfishing.

Table 28.3: Ownership of private boats with motors, 1992

State	motor boats	sail boats	total
Queensland	na	na	108,287
NSW	na	na	140,691
Victoria	113,863	1,159	115,022
Tasmania	16,052	578	16,630
South Australia	55,876	2,811	58,687
Western Australia	69,453	3,604	73,057

na: not available

(Source: State Government registers)

Diving

Underwater diving using mask and snorkel or scuba enables people to see sea life close up and in natural and exciting situations. It has evolved from an initial focus on spear fishing and wreck plundering from the 1950s and 1960s, to focus more on underwater photography and natural history. Its great popularity around Australia has been a driving force for the creation of marine parks.

Dives may be undertaken through organised clubs, or privately. The dive industry, which characteristically centres around small dive shops and resorts, is a fast-growing one. According to industry estimates, around 700,000 people scuba dive each year in Australia.


(Source: GBRMPA)

Figure 28.5: Each year around 700,000 people scuba dive in Australia.

Around 55,000 new divers are trained each year, compared with 33,000 in 1985. Around half the new divers are tourists, and one third of all new dive certifications are earned in Cairns. The scuba industry is estimated to be worth $350 million per year.

The most popular dive sites are on the Great Barrier Reef. Southern Queensland, northern New South Wales, the Sydney area, Jervis Bay and southern New South Wales are popular for year-round diving. Although the waters are colder around Victoria, Tasmania and South Australia, diving is popular. Reefs near Perth are popular, and Western Australia's northern reefs have great potential.

The major concerns of divers include physical damage to reefs; the effects of chemical pollution (such as algal growth); sedimentation which results in poor water visibility; depletion of fish by fishers; collection of corals and shells; and the depredations of the crown-of-thorns starfish on the Great Barrier Reef.

Impacts of divers are relatively minor but may become significant when diving is concentrated on a few sites. Impacts include damage to corals and other sessile marine life from anchors and fins, litter from vessels, and spearfishing and overcollection of lobsters, abalone and other species. Management of the latter is undertaken through bans on spearfishing and bag limits.

Economics of marine recreation and tourism

Financial value

In 1990/91 inbound tourism contributed 10% to Australia's current account credits, exceeding that earned by coal exports. Expenditure by domestic and international tourists contributed 5.4% of GDP, and directly employed 5.8% of the workforce. It also greatly contributed to decentralisation of economic activity and employment from cities to non-metropolitan areas. Coastal and marine-based tourism directly contributed an estimated 2% of the GDP.

Flow-on effects include the sale of recreational equipment, from swim suits to luxury yachts. For example, the 'beach fashion' industry has a turnover in excess of $1 billion annually.

The use of the marine environment for tourism and recreation involves the use of environmental goods and services that are normally free of charge, and are therefore outside normal market transactions. This tends to underrate the values of the environments in their natural state. Conventional economic analyses has not taken into account the costs of degradation of natural environments due to modification, pollution, overfishing and other impacts.

Non-use values

Economics does recognise a number of types of 'non-use' values arising from environments existing in their natural state, e.g. values to society as havens for biodiversity, contribution to global life support systems, and amenity value. Natural environments also have 'existence values', the values people place on the area remaining as natural; 'bequest values', the values placed on the area being available to future generations; 'option values', the values of having the opportunity to visit the environment in the future; and 'quasi-option values', the values of conserving a natural environment for possible new information which may emerge in the future.

Environmental 'quality'

The issue of environmental 'quality' is particularly important where tourism and recreation are concerned as it is often a particular combination of natural and cultural features which makes an area initially attractive to tourists. This amenity may be changed through modification or 'development'. Loss of environmental quality and attractiveness of tourist destinations is well known around the world (Chapter 29).

'User pays'

While free access to natural environments for recreation purposes has been normal practice in Australia, the costs of managing impacts of use so that sites are not degraded is an issue. The collection of user fees has been controversial.

The Great Barrier Reef Marine Park Authority introduced an Environment Management Charge equivalent to around $1/person/day in 1993 to help offset the rising costs of management. Tourist operators' fears about 'another government tax' were allayed by involving the industry body in the allocation of the proceeds which are used largely for management-related research (Chapter 69).

Status of knowledge and monitoring of tourism

International tourism (numbers of arrivals, economic value) and domestic tourism trends are monitored by the Bureau of Tourism Research. The Australian Bureau of Statistics monitors international passenger arrivals and departures and accommodation facilities. Some States also conduct regular surveys of tourism.

A database on Australian beaches has been developed by the Coastal Studies Unit of the University of Sydney for the Australian Beach Safety and Management Program. This includes 7,098 beaches, approximately 65% of which received some recreational use. It includes information on beach characteristics, facilities, usage and hazards, beach safety equipment, and personnel.

Motor vessel registrations are monitored in all States and Territories. Details of membership are monitored by the respective sports bodies, although most are not routinely reported at a national level.

Summary and conclusions

1. The coast and sea are the major natural recreational resources in Australia. Most of Australia's population lives near the coast and most international visitors stay on the coast.

2. Domestic use of the coastal environment has increased rapidly in recent decades. The non-metropolitan coastal population has doubled since 1970 and has the fastest rate of growth in the nation.

3. The tourist industry, of which most is based on the coast, is economically very important to Australia and contributes over 5% of the GDP. In 1991 there were over 2.3 million overseas visitors and these spent 65 million visitor nights in this country. Australians made 49 million trips as domestic tourists, and spent 215 visitor nights away from home, mostly in coastal areas.

4. Coastal and marine recreation and tourism depends on good environmental quality.

5. Recreational users and their organisations (e.g. sports fishers, surfriders, divers) are increasingly concerned about declining water quality and have been a major influence in marine environmental management.

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Acknowledgments:
The technical paper by S. Driml was reviewed by Professor P. Pearce, School of Tourism, James Cook University, Townsville, Qld; and Dr T. Hundloe, Industry Commission, Canberra, ACT.

Chapter 29. Impacts of tourism on marine and coastal systems[1]

Until the 1980s, the general perception of tourism was that of a 'smokeless' industry, an industry generally considered as a desirable form of land use and without adverse environmental effects. In some cases this view has been justifiable. For example, on the Great Barrier Reef the tourism industry has probably generated more income than oil and mineral production would have, while causing minimal damage to the resource. However, the benign perception of tourism is changing as growing evidence of the undesirable effects becomes evident, and as recognition grows of the cumulative impacts of development on Australia's coastal strip.

Coastal and marine-based tourism is one of Australia's largest and fastest growing industries (Chapter 28). Tourists engage in a wide range of recreational activities in the coastal zone, including boating, swimming, sailing, scuba diving, snorkelling, sunbathing, nature appreciation and fishing. These activities require a range of public facilities such as boat ramps, jetties, marinas, roads, car parks, walk ways, caravan parks, camping grounds, toilets, sewerage, water and electricity and garbage disposal services. Tourists also require accommodation, usually in close proximity to marine and recreational settings, and transport.

(Source: GBRMPA)

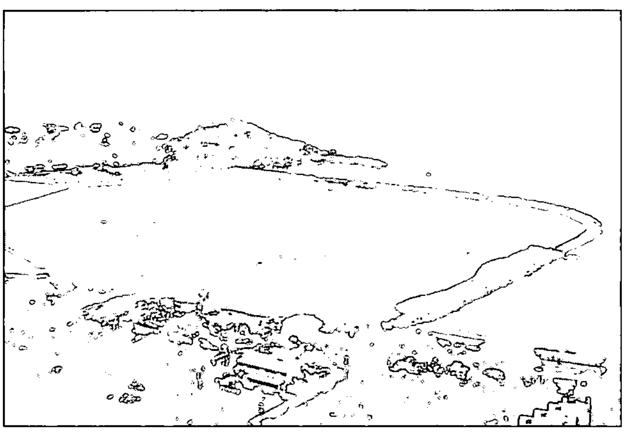
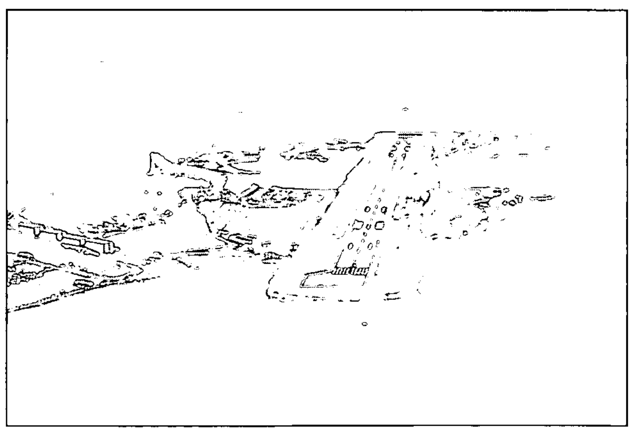


Figure 29.1: Tourist developments may have significant environmental and social impacts. The controversial Magnetic Quays site, Magnetic Island (Qld).

Coastal tourist services and developments often impact upon the environment during construction (for example, by channel dredging and reclamation of wetlands) and during operations (for example by waste disposal, loss of visual amenity and changes in land use). In this chapter the general impacts of tourist and recreation facilities and services development on marine and coastal environments are assessed using a range of examples from around the Australian coastline. The effects of the specific activities in which tourists and recreationists engage, whilst in some cases undoubtedly great, are poorly documented and are omitted from this discussion.

Impacts of coastal and marine tourism

The dynamic nature of the coastal zone often makes it difficult to separate impacts on the marine, coastal and terrestrial environments. Tourist development encompasses a wide and complex range of issues in these areas.



(Source: GBRMPA)

Figure 29.2: Island resorts require airports, marinas and other infrastructure. Hamilton Island (Qld).

Environmental impacts of tourism

Unrestricted or poorly-managed use of natural attractions leads to overuse, environmental damage, congestion and cultural disruption. Over development can destroy the original values of an area which initially attracted visitors, and result in financial losses.

[1] Based on a paper by I. Dutton and K. Luckie, Centre for Coastal Management, Southern Cross University, Lismore, New South Wales.

The emphasis on the gross economic benefits of tourism in Australia has tended to overlook the costs to the environment and society. The range of negative environmental impacts includes coastal erosion, loss of habitat, declines in fauna and flora, declines in water quality, pollution, changes in land formation and land use, and overutilisation of resources. Impacts are greater in sensitive environments, and their extent is influenced by local factors such as soil type, drainage and slope.

Table 29.1: Some impacts of tourism

Aspect	Impacts
Coastal strip	Loss of aesthetic and amenity values; disturbances to shore processes; coastal erosion; groundwater withdrawal; saltwater intrusion into aquifers etc.
Habitats, ecosystems	Reclamations reduce area of habitat; loss or changes in species diversity; increase in nutrients may cause eutrophication; sedimentation reduces photosynthesis, smothers bottom biota and changes channels and currents; introduction of exotic species, weeds etc.
Cultural values	Loss of heritage and historic values; loss of wilderness values
Demography	Unplanned urbanisation; increased traffic congestion, noise and litter; reduced visitor experience and expectations
Access	Restricted access; privatisation of shores; opening of undeveloped areas
Market and financial assessment	Short-term profits which ignore long-term impacts or needs

Social and cultural impacts of tourism

While environmental impacts may be readily apparent, social and cultural impacts are typically more difficult to measure and assess. These may include increased traffic, site-use conflicts, altered quality of life, congestion of buildings, decreased visual amenity, noise, increased theft, vandalism and prostitution, and high rents, rates and prices.

Small, isolated communities, particularly indigenous communities, suffer the most social and cultural disruption from tourism. Tourism is carefully controlled on Lord Howe and Norfolk Islands and

Table 29.2: Positive and negative social and cultural impacts of increased activity and developments associated with tourism

Positive impacts	Negative impacts
• Population growth	• Carrying capacity of area exceeded; land use changes
• Provision of accommodation, transport, entertainment, retailing, and tourist attractions	• Increased pressures on existing infrastructure (e.g. water, electricity, schools, sewage and waste disposal systems, roads); competition for public services funding
• Economic growth; diversification of economic base; increased entrepreneurial opportunities	• Increased cost of living (rising prices, rates, real estate values); uneven distribution of development costs (often borne by disadvantaged groups)
• Regeneration of urban areas	• Unplanned urbanisation; loss of heritage values; competing uses
• Growth in local employment (especially for the unskilled, part-time, and youthful components of the workforce); employment in areas with little other potential for employment growth	• Highly seasonal nature of employment in tourism industry.
• Enhanced visitor appreciation adds to social life of residents	• Altered nature of local community; increase in social problems; community excluded from the decision-making process (especially indigenous communities);
• Improved local services and facilities (e.g. museums, galleries, restaurants, theatres, concerts, sports events)	• Loss of access and amenity

(Source: J. Forbes)

Figure 29.3: Tourism on Lord Howe Island is controlled to avoid adverse environmental and social impacts.

appears not to have had a great socio-cultural impact on these communities. By contrast, proposed tourist proposals for isolated Christmas and Cocos (Keeling) Islands in the Indian Ocean may assist in local employment and education, but at the risk of the culture and lifestyle of the Islanders.

Positive environmental impacts of tourism

On the positive side, real and perceived threats from tourism may provide the catalyst for more comprehensive environmental management, and eventually enhance the conservation of an area. The general attitudes of visitors to the environment may also be altered as a result of their holiday experience. The rapid growth of ecotourism in recent years is evidence of the increasing community interest in the environment.

Tourism development may also result in improved services such as communication and transport, and have beneficial cumulative and 'flow-on' economic effects in the area. For example, the establishment of the Cairns international airport has had a positive effect on the general community, the region and other industries in Far North Queensland.

The dilemmas of tourism

Problems of location

One of the emerging dilemmas facing tourism development is that *'the preferred locations for coastal tourism developments will probably remain those with high amenity (views, proximity to beaches, and relatively unspoilt areas), those where there has already been substantial investment in facilities, and those that can offer a different lifestyle experience'* (RAC 1992).

Another dilemma *'is that the industry depends on finding and exploiting new sites and tourist experiences, leaving old sites in limbo .... Tourists search for new, authentic and untouched destinations. In time visitation rates to established destinations decline' (Craik 1991)*. This has lead to a 'tyranny of small decisions', where localised projects which impact on land use and lifestyle, have produced a string of ribbon developments along the eastern seaboard (HORSCERA 1991). The cumulative impacts of this include a reduction of wetland and mangrove habitats, shore instability and erosion, and a loss of fish breeding grounds and fisheries income.

The 'resort cycle'- the stages of exploration, involvement, development, consolidation, stagnation and rejuvenation - which is a pattern of tourism development, is often ignored in planning and policy formulation. Such ignorance can, as indicated below, lead to both inefficient and ineffective development patterns and large-scale environmental impacts.

Unpredictable growth

Tourism is greatly affected by external, short-term economic and political factors which make strategic planning difficult. The tourist industry in Australia has often failed to grow at the anticipated rates, or grown in ways which were not expected. This has resulted in an oversupply in 'up-market' resorts and facilities in some areas in recent years.

Spill-over effects

Tourism stimulates further development. The economic forces which drive nature-based tourist activities may eventually transform a site or region to provide the facilities of an economic base broader than tourism. Because of the loss of the initial unspoiled natural attractions, more synthetic activities such as theme parks may be developed. Tourism may also result in demographic shifts. For example, in the north coast of New South Wales coastal tourism has resulted in subsequent immigration of retirees to the area.

Case studies from around Australia

Case study 1

The Great Barrier Reef Marine Park

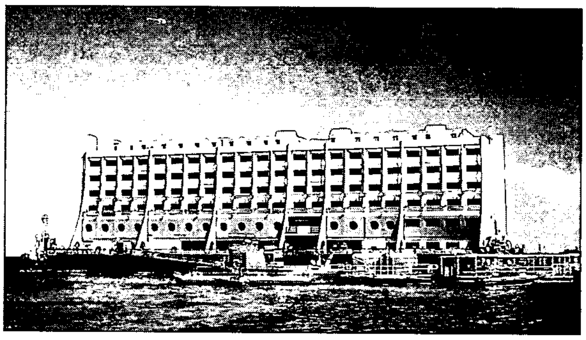
Tourism on the Great Barrier Reef, one of Australia's premier tourist destinations, has significantly increased in the past decade as a result of increased access through international airports, and fast boats (Chapters 28, 69). Fortunately, the boom occurred after the establishment of the Marine Park and a system was in place for its management. However, management of Reef tourism is a major concern, largely because of its geographic concentration and difficulties in coordination.

Case study 1 cont.

Despite the great size of the Great Barrier Reef, opportunities for tourist development, particularly on islands, are unevenly distributed and limited in scope. Tourism has generally been concentrated on the islands and reefs within range of the major mainland access centres, especially Gladstone, Mackay, Townsville and Cairns, often placing pressure on them.

One innovative attempt to overcome this problem was the failed floating hotel on John Brewer Reef off Townsville. This project failed to attract a viable client base suggesting either inadequate market research, poor choice of location, inappropriate facilities, competing attractions, or a combination of these factors. The development raised many administrative and environmental problems such as moorings, waste disposal, bunkering and access, which were resolved through a close working relationship with the lead agency, the Great Barrier Reef Marine Park Authority. The hotel was relocated to Vietnam, leaving minimal disturbance to the environment.

The Great Barrier Reef Marine Park Authority often relies on the support of other regulatory agencies (usually State government), industry and tourism operators to achieve its broad management objectives. This is generally successful on a case-by-case basis but has proven inadequate at the regional level, e.g. during the continuing Cairns tourist boom, and in cases such as the Magnetic Quays project on Magnetic Island off Townsville. In the latter, community concerns and tribunal hearings forced delays in the project, the financiers became bankrupt, and site restoration insurance inadvertently lapsed, leaving the works half completed and dangerous, and compounding environmental impacts and long-term problems of sedimentation and visual pollution (Whitehouse 1993).



(Source: GBRMPA)

Figure 29.4: The floating hotel on the Great Barrier Reef required careful environmental planning. It was not a commercial success and was later removed.

Case study 2

Gold Coast city, Queensland

The attractions of Australia's premier coastal tourism destination include beaches, waterways, a sub-tropical climate and a range of accommodation and synthetic attractions such as theme parks and a casino.

The Gold Coast, one of the most developed coastlines in Australia, is situated on a dynamic, high energy coast and has a continuing problem with beach erosion. The training walls at the Tweed River to the south have blocked the northerly drift of sand which naturally replenishes the beaches. Sand replenishment schemes costing $25 million since 1974, and a system of groynes, offshore bars, boulder sea walls and dune stabilisation schemes have had limited success. Structures to protect coastal property may alter the resilience of natural systems and create artificial systems which are increasingly difficult to maintain.

Key issues include the conservation and management of remaining open space resources, the potential for conflict between residential amenity and tourism development, the desires of residents to maintain their life-styles, traffic congestion and social problems resulting from high unemployment and crime.

(Source: L. Zann)

Figure 29.5: Beach erosion is a major issue on the Gold Coast (Qld).

Case study 3

Monkey Mia, Western Australia

In stark contrast to the large-scale development of the Gold Coast is Monkey Mia on the central coast of Western Australia. Here the major attraction has been the unique daily visits of bottlenose dolphins, and the issue is controlled development. Although growth of tourism has been naturally restricted by its remoteness and poor roads, visitors increased from 38,000 a year in 1985/86, to 114,000 in 1989, necessitating better facilities, roads, car parks, toilets, landscaping and an information centre.

The Monkey Mia Reserve Management Plan limits the possible expansion of infrastructure development. A survey of visitors indicates that this low key development is favoured by 76% of respondents. Monkey Mia is a good example of the increasing demand for nature-based activities and opportunities, and highlights the importance of appropriate visitor education in site management.

Serious concerns have been recently expressed on the effects on the local dolphins. Research indicates that they are now overly dependent on hand feeding and have suffered abnormally high mortality rates, particularly amongst juveniles.

(Source: WA CALM)

Figure 29.6: Tourism expansion at Monkey Mia is controlled and feeding times have been altered to avoid health problems in the dolphins.

Case study 4

Broome, Western Australia

With no physical limits to restrict outward growth in response to tourism, Broome is suffering from unplanned tourism development. While its isolation historically limited tourist development, improved roads have greatly improved access. The seasonal influx of tourists and a lack of tourist accommodation have created overcrowding, illegal camping, shack developments near the coast, and a range of social and environmental problems that are difficult to manage.

Increased levels of human activities on remote beaches and mud flats have reduced their value as wading bird habitats, and pose potential long-term health risks. Local fish, mud crab and shellfish stocks are being depleted, and there has been a loss of amenity, aesthetic and cultural values in the area. Social conflict has resulted between pro- and anti-development groups. The division between rich and poor is widening, and many Aboriginal people feel disadvantaged.

Management of coastal and marine tourism

The primary management goal for tourism development should be to maximise positive effects, and minimise negative effects, whilst protecting the present needs of tourist and hosts, and maintaining opportunities for the future.

Environmental impacts may be minimised if tourism is well planned and managed by industry, government and the local community. Management involves a range of stakeholders and techniques, and requires a high level of intersectoral and inter-regional coordination. Given the complexities in coastal zone management, this has proven to be a difficult task.

One of the few States which has begun to address tourism management needs on an integrated basis is New South Wales. The New South Wales Tourism Commission in 1987 released a State Tourism Development Strategy which established a three-tiered planning system, of regional, local and site tourism management plans. Since then, plans have been developed for various regions such as northern New South Wales, and local areas such as Byron Shire. Site plans have been developed for specific projects, usually as part of the development approval process, e.g. Bonville Resort at Coffs Harbour. While this hierarchically integrated approach to tourism planning is logical and consistent with ESD principles, its practical applications have proven difficult.

Tourism plans should accommodate cumulative impacts and more effectively protect the diversity of attractions within regions. They should also be integrated with the wider statutory planning process, be linked with capital works projects, and be developed around mechanisms for community consultation. Tourism enterprises must be committed to ensuring the maintenance of enjoyable and sustainable experiences. This ideal needs to flow from a national level, to the regional and local perspectives, and to become embodied at the site and operational levels.

Summary and conclusions

1. Although tourism and recreation are generally considered to be 'clean' and renewable industries, they have had significant negative impacts on certain parts of Australia's coastal strip. These have been well documented in recent coastal inquiries by the HORSCERA and Resources Assessment Commission.

2. Typically, tourist and recreational facilities, infrastructure and transport are placed in close proximity to marine and coastal settings, frequently resulting in the loss of those values which were the initial attraction.

3. Negative environmental effects include erosion, loss of habitat, declines in flora and fauna, and loss of water quality. Negative social and economic effects include loss of amenity values, altered quality of life, traffic and congestion, and crime.

4. The dilemmas of coastal and marine tourism are the continuing demand for locations with high amenity value, the spoiling of sites, and unpredictable growth.

5. The primary management goal should be to maximise positive effects, and minimise negative effects, whilst protecting the present needs of tourist and hosts, and maintaining opportunities for the future.

6. An integrated, strategic, and regional approach to tourism planning is required. Environmental impacts may be minimised if tourism is planned and managed by industry, government and the local community. Principles for sustainable tourism include cooperative control systems of planning, development of codes of practice, and raising community and producer awareness.

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Chapter 30. Status of commercial fisheries[1]

Commercial fishing is a major extractive use of Australia's marine environment. It is Australia's fifth largest rural industry and has a gross value of around $1.6 billion per year. Australia's Fishing Zone (AFZ) has an area of 8.94 million square kilometres, and is the third largest in the world. Despite this, Australia's fisheries landings are relatively low (it does not rank in the world's top 50 fishing nations) and a number of Australia's fisheries are fully exploited or overexploited. Commercial fishing occurs, to varying degrees, in almost all of Australia's coastal waters. It is also potentially a major, widespread influence on the marine environment.

Commercial fisheries in Australia exploit around 200 species of fish, 60 species of crustacean, 30 species of molluscs and a few echinoderm species. The total commercial catch is over 200,000 tonnes, and an additional 15,000 tonnes are taken from Australian waters by licenced foreign vessels. The recreational catch is estimated to be around 55,000 tonnes (Chapter 33), bringing the total fisheries production of Australian waters to around 270,000 tonnes. This is only a fraction of that of the major fishing nations. For example, Japan, the former USSR and China each catch between 10-12 million tonnes per year.

Australia's low volume of commercial fisheries is due to the general low productivity of our waters because of limited nutrients from land and absence of large upwellings, and a relatively small continental shelf area (Chapter 2). However, countering the low volume of fisheries production is a high unit value of much of the catch such as rock lobsters, prawns, abalone, pearls and oysters.

The first part of this chapter briefly describes the history of Australia's commercial fisheries, fisheries management and the status of major stocks. The second part briefly discusses effects of commercial fisheries on the environment, and the concerns of commercial fishers about the state of the marine environment.

Development of commercial fisheries and management

Inshore species were commercially fished for local consumption from the times of the first European settlement. Early export fisheries were bêche-de-mer in northern Australian waters, whales and seals in the south, and pearl oysters from Torres Strait and Broome waters.

Inshore species such as oysters, rock lobsters, prawns, crabs and fish were initially targeted by small-scale operations for domestic consumption. After World War I food fish production was prioritised to offset imports, and larger motor vessels with more powerful winches and improved nets appeared. Mullet, barracouta, Australian salmon and school sharks became the major fisheries. New and more effective fishing techniques were again introduced after World War II. Ocean prawn trawling began in New South Wales, southern Queensland and in Shark Bay in Western Australia in the late 1950s, and spread across northern Australia in the 1960s and 70s. In the south, netting for sharks began in Bass Strait in the 1960s, greatly increasing catches.

(Source: GBRMPA)

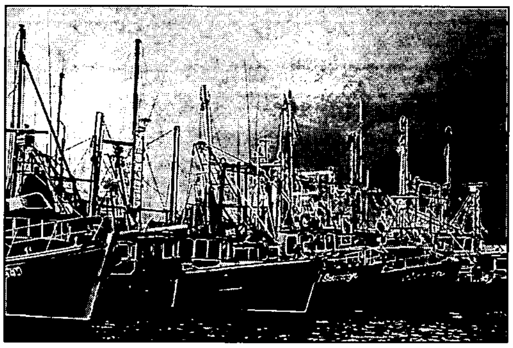


Figure 30.1: Australia's commercial fishing fleet consists of almost 10,000 vessels. Prawn trawlers, Queensland.

Fisheries management

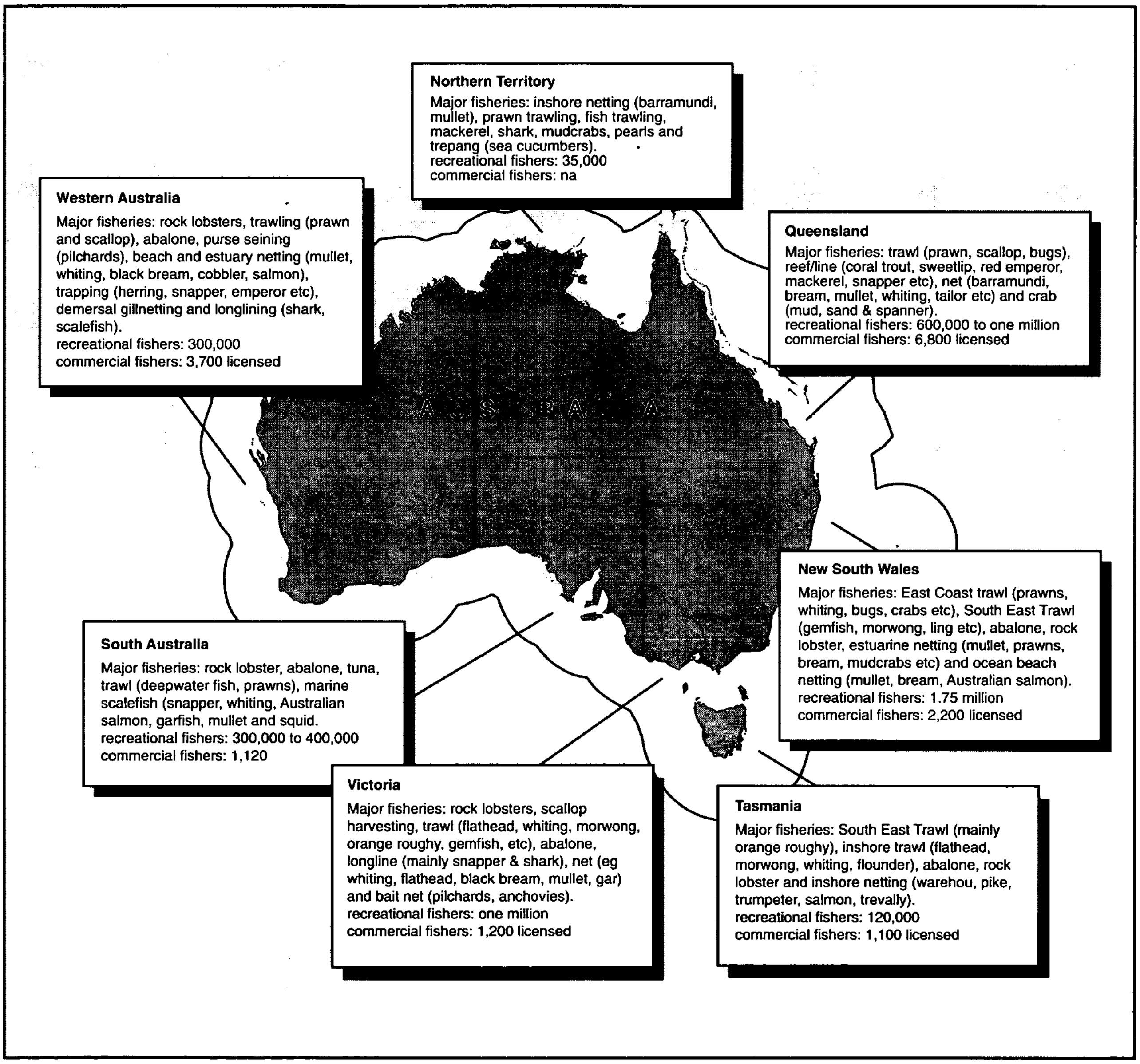
Until the 1960s fisheries were regarded as 'common property'. As most were outside the three nautical mile limit, they were little regulated. Australia was one of the first countries to limit entry to a fishery when, in 1963, Western Australia restricted the rock lobster fishery following an uncontrolled expansion in the 1950s. The need to limit the number and size of vessels to protect other stocks became more acute in the 1970s.

[1]Based on a paper by K. McLoughlin, Bureau of Resource Sciences, Barton, Australian Capital Territory.

The Commonwealth's involvement in fisheries management followed the declaration of the Australian Fishing Zone (AFZ) in 1979. Under this declaration, Australia is responsible for conserving the resources within the zone, but has the obligation to provide for the use of these by foreign nations at sustainable levels if Australians are not able to do so. Prior to this, Japan, the then Soviet Union, Taiwan and Korea had explored and fished these waters, particularly for southern bluefin tuna. Since 1979, foreign vessels have been allowed to operate in the AFZ under licence and payment of access fees, or through joint ventures, so as to gain information on resources. Foreign activity has declined as Australian industry has expanded into offshore waters. Many of the resources of the AFZ are now fully exploited or overexploited, necessitating management.

Management of Australia's fish resources is a complex mix of Commonwealth and State responsibilities. Fisheries jurisdiction was negotiated under the Offshore Constitutional Settlement of 1983 (Chapter 58). The Commonwealth is responsible for highly migratory species such as tunas, and for those offshore from two or more States such as the Northern Prawn Fishery. States are responsible for inshore waters, recreational fishing and aquaculture. The Australian Fisheries Management Authority is responsible for offshore fisheries under the Commonwealth *Fisheries Management Act* 1991. The States have their own legislation for fisheries under their control.

Figure 30.2: Australia's main fisheries, estimated numbers of recreational fishers, and numbers of licenced commercial fishers.



(Source: DPIE and other sources)

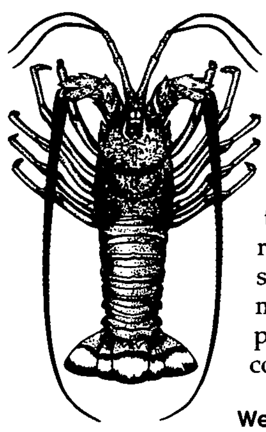
Status of commercial fish stocks

Fisheries stock assessment provides information on how much of a stock is available for harvest. Focusing on species population dynamics (recruitment, growth and natural mortality), it attempts to estimate how much can be taken at a sustainable level. Given often unpredictable variability in time and space, and uncertain interactions with the marine ecosystem, mathematical models and estimates of sustainable yields provide approximations only.

Of 100 main species or groups fished nine are considered underexploited, 23 are fully or heavily exploited to the extent that higher catches would affect stock replenishment, nine are overexploited and require management for populations to rebuild and 59 are of unknown status. A selection of fisheries are described below.

Western Rock Lobster Fishery

The fishery for western rock lobsters *(Panulirus cygnus)* is one of the largest rock lobster fisheries in the world. It is the largest single species fishery in Australia and is a valuable export. Around 10,000 tonnes, worth $250 million, are landed per year. Managed by Western Australia, it is internationally regarded as a well-managed fishery. Monitoring of juveniles settling on shallow reefs enables catches to be predicted four years in advance. The fishery is fully exploited; catch effort is regulated through limited entry, gear restrictions, and closed seasons, and these are closely monitored. Environmental problems include damage of corals by traps.



Western rock lobster

(Source: DPIE 1994)

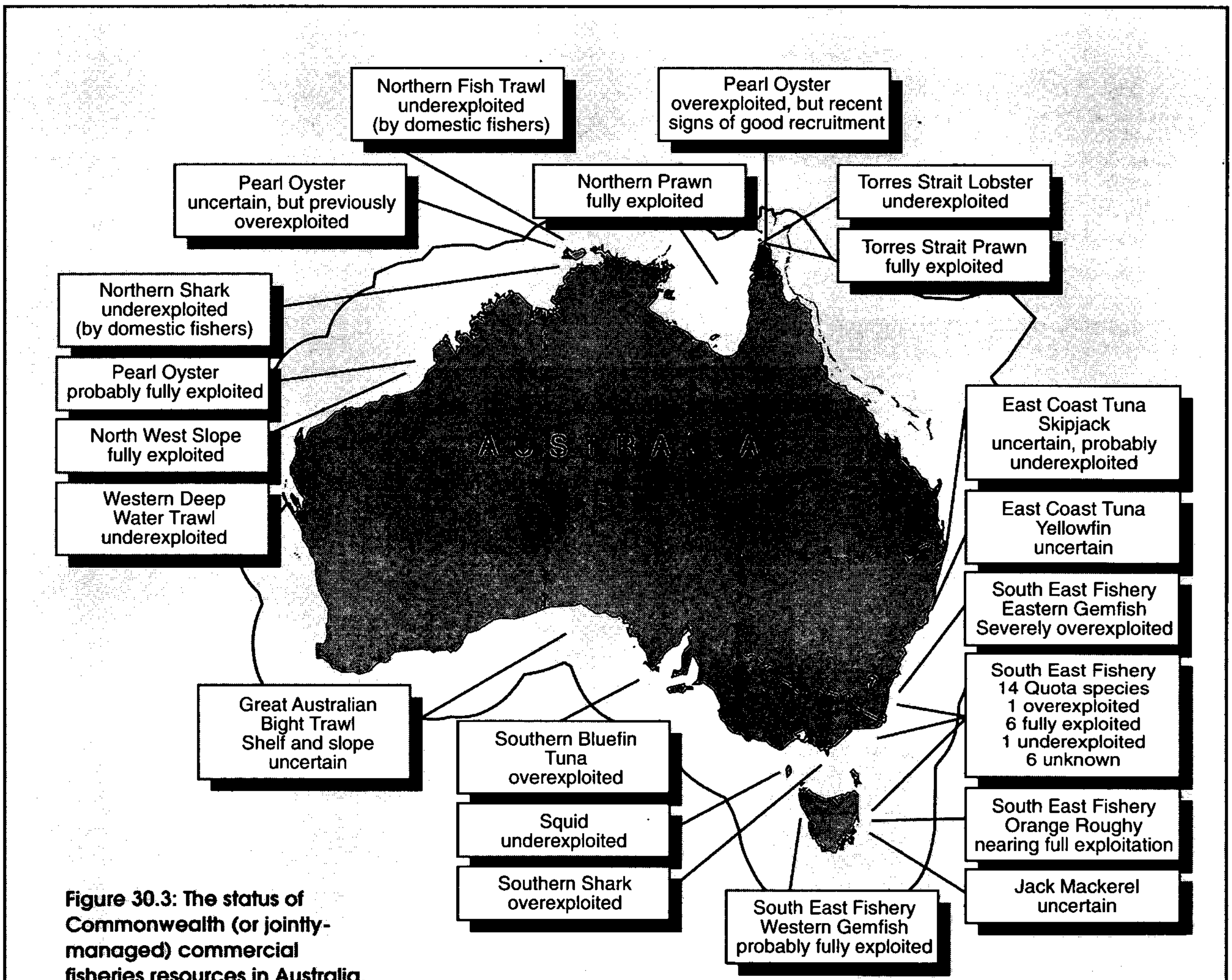


Figure 30.3: The status of Commonwealth (or jointly-managed) commercial fisheries resources in Australia.

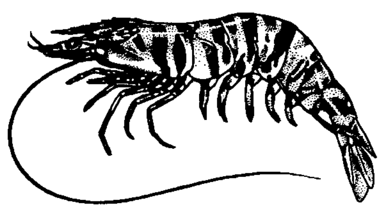
Table 27.1. Status of Commonwealth and jointly managed commercial fisheries resources, 1993

Fishery	Status*	Trend	Catch (tonnes) (TAC** 1994)	Value (A$million)	Method	Management
Northern prawn	fully exploited (3)	variable	7,410	100	trawl	limited entry; gear restrictions; closures
Torres Strait prawn	fully exploited (3)	variable	1,360	20	trawl	limited entry; closures; individual transferable effort
Torres Strait lobster	underexploited	variable	190	4.5	diving	limited entry; minimum size limit
Northern fish trawl	underexploited (2)	confidential	confidential	confidential	trawl	limited entry
Northern shark	underexploited (2)	increasing	600 (1992)	0.6	gillnet	limited entry; gear restrictions
East coast tuna (yellowfin)	uncertain	variable	680 (Australia; 1,100 Japan)	5	longline	limited entry; vessel size and area restrictions; ITQ*** limits on yellowfin catch
East coast tuna (skipjack)	uncertain underexploited?	recent expansion	4,200	4	purse seine; pole-and-line	limited entry; vessel size and area restrictions;
Southern bluefin tuna	overexploited (4)	limited by quotas	13,500 (Aust; Japan; NZ) (TAC: 111,750)	88	longline; pole-and-line	ITQs (domestic only)
Southern shark	overexploited (2)	declining (school shark)	3,500 (1992)	15	gillnet;	limited entry; minimum longline size limit; gear restrictions; closed areas
South east (SE) fishery (14 species)	1 overexploited; 6 fully exploited; 1 underexploited; 6 unknown (1)	limited by quotas	21,500 (TAC: 18,365)	30	trawl; Danish seine	ITQs
SE fishery Eastern gemfish	severely overexploited (4)	limited by quotas	270 (TAC: zero)	0.9	trawl	ITQs
SE fishery western gemfish	probably fully exploited (1)	stable	130 (TAC: 300)	0.3	trawl	ITQs
SE fishery orange roughy	nearing full exploitation (2)	limited by quotas	10,700 (TAC eastern: 1,500; southern 5,000; western 1,500)	30	trawl	ITQs
Great Australian Bight trawl	uncertain	variable	1,100	2	trawl	limited entry
Jack mackerel	uncertain	variable	16,000	1.5	purse seine	TAC
squid	underexploited	stable	1,000 (1992) (TAC: 10,000)	1	jig; trawl	limited entry
Pearl oyster	mostly fully exploited (20	variable	571,000 shells (TAC: 697,000)	130	diving	size restrictions; limited entry; closed seasons; individual quotas
North west slope trawl	fully exploited (2)	variable	scampi 75; prawns 120	2.5	trawl	limited entry
Western deepwater trawl	underexploited (1)	variable	175	0.4	trawl	limited entry

* confidence rating (4: highest) **TAC: total allowable catch **ITQ: individual transferable quotas (Source: DPIE 1994)

Northern Prawn Fishery

Nine species of prawns, mainly banana and tiger prawns, are taken in a large Commonwealth-managed trawl fishery in The Gulf of Carpentaria and Arafura Sea. The prawns grow rapidly and are short-lived, with some individuals maturing at six months, and living one to two years. The fishery is highly seasonal, and the banana prawn fishery lasts only a few weeks in April-May each year after which the boats then turn to tiger prawns. Catches of banana prawns are variable, and depend largely on rainfall and river flow. Although it was widely believed that sufficient prawns always survive to produce young for the next season, there is evidence that declines in tiger prawns result from overharvesting. The fishery is fully exploited and was assessed as economically inefficient as there were too many vessels in the fishery. A major restructuring has recently reduced the number of vessels by 50%. Environmental consequences of bottom trawls may include destruction of benthic communities by nets, capture of many incidental species including turtles, and interference with food chains.



Tiger prawn

South East Fishery

The multi-species south-east trawl fishery targets over 80 species of fish and largely supplies the Sydney and Melbourne markets. Little regulated before 1985, it grew rapidly and some species such as gemfish became overexploited. Eastern gemfish were put under quota in 1988. This was extended into a system of 'Individual Total Quotas' (ITQs)in 1992 to cover 16 other species, under which a total of 31,665 tonnes was allocated for that year.

Australian salmon

Australian salmon (*Arripis* spp, not true salmon), inhabit estuaries, bays and inlets in southern Australia, and school in open coastal waters. Around 3,000 tonnes per year are taken in five States. The commercial catch is sold as fresh fish, canned fish, lobster bait, and pet food. It is also a premier sport fish for recreational anglers. This was considered fully exploited in 1967 and catches have been sustained across most of the range.

Abalone

Abalone (*Haliotis* spp) are found in southern Australia and are most prevalent in cooler waters of Bass Strait to South Australia. Taken by divers, they are a valuable export (e.g. in 1991-92, 5,000

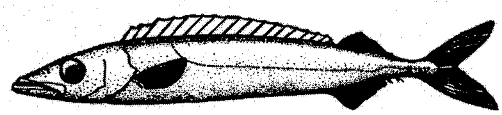
'Boom and bust' fishing

The history of fisheries is characterised by 'boom and bust' fishing, and an 'exploration and mining' mentality, as illustrated by some species in the South-East Trawl Fishery.

Case history 1

Gemfish aggregations

Gemfish *(Rexia solandri)* occur off southern Australia and New Zealand. The eastern Australian stock is fished in deep water during spawning migrations up the New South Wales coast. Catches rose rapidly from 200 tonnes in 1970 to 5,000 tonnes in 1980, but they suddenly fell in 1987. A 'total allowable catch' (TAC) was then set at 3,000 tonnes but only 2,500 tonnes could be caught. The TAC was then reduced to 1,750 tonnes per year in 1990, but only 1,200 tonnes could be caught. Although fishing is not currently allowed, stocks may continue to decline.

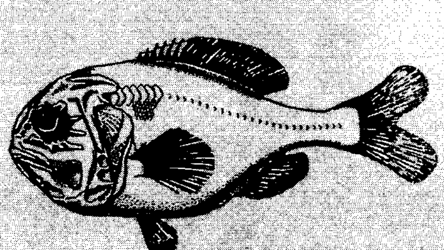


Gemfish

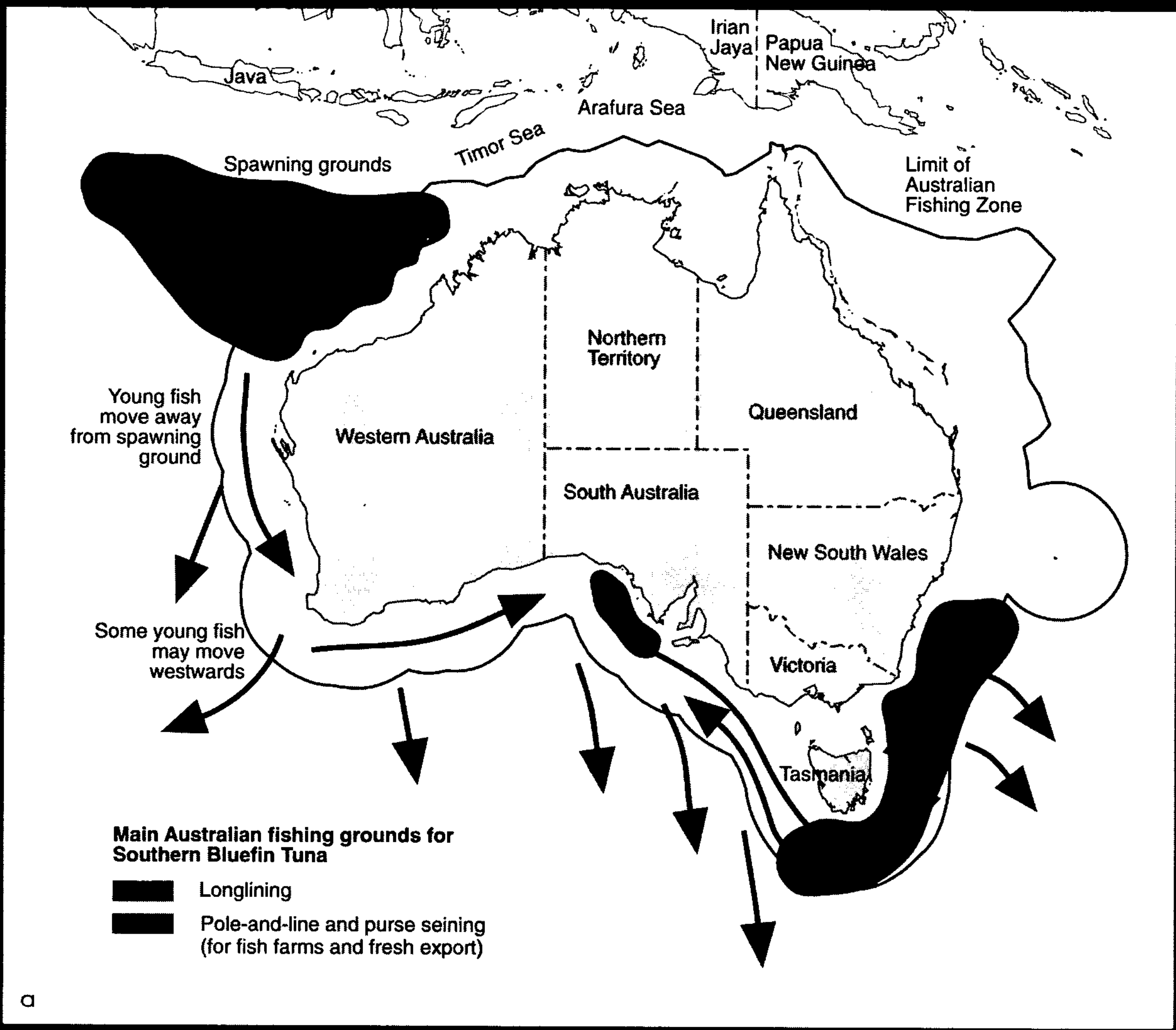
Case history 2

Ancient orange roughy

Orange roughy *(Hoplostethus atlanticus)* is a deep-sea species occurring at depths of 800-1,000 metres. It is long-lived (to 100 years of age) and slow growing, taking 20-25 years to reach maturity. Commercial fishing began in Australian waters in 1982 and were around 400 tonnes per year until 1986, when they rocketed to 4,600 tonnes with the discovery of aggregations off western Tasmania. As more aggregations were located catches climbed exponentially, reaching 41,000 in 1990. However, because of the slow reproduction and growth of the species the sustainable yield may only be in the order of 2,000-3,000 tonnes per year for known stocks.

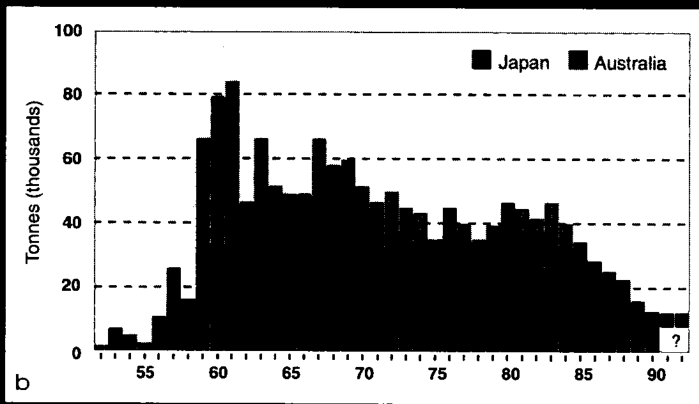


Orange roughy



(Source: DPIE)

Figure 30.4: Southern bluefin tuna have suffered serous declines in recent years and the adult biomass is now below levels considered to be sustainable.
(a) Migration of southern bluefin tuna. Stocks are fished by Australia, New Zealand, Japan, Taiwan and Thailand, making management difficult.
(b) Annual landings of southern bluefin tuna by Australia and Japan. Catches peaked around 1960-61, and have declined since then, despite increasing fishing effort. In 1994 there were signs that the decline may have halted.



(Source: DPIE).

tonnes were worth $90 million). They are fully exploited, and entry into the fishery is strictly controlled in all States with licences being traded for high prices. Bag limits are set on the recreational catch but poaching is a major problem (e.g. in New South Wales the illegal catch is probably twice the commercial catch).

Barramundi

The barramundi *(Lates calcarifer)* is a northern species which migrates between fresh to salt water during its life cycle. It is commercially taken by gillnets. Catches increased from around 200 tonnes per year in the late 1960s, to 1,350 tonnes in 1989-90. Barramundi is a prized sport fish of anglers and the recreational fishery is a valuable one in north Queensland and the Northern Territory. It has been severely depleted on accessible rivers, leading to closures on commercial fishing, and seasons, size limits (both lower and upper), and bag limits for anglers. It is now farmed in aquaculture operations for food and for stocking reservoirs for future fishing.

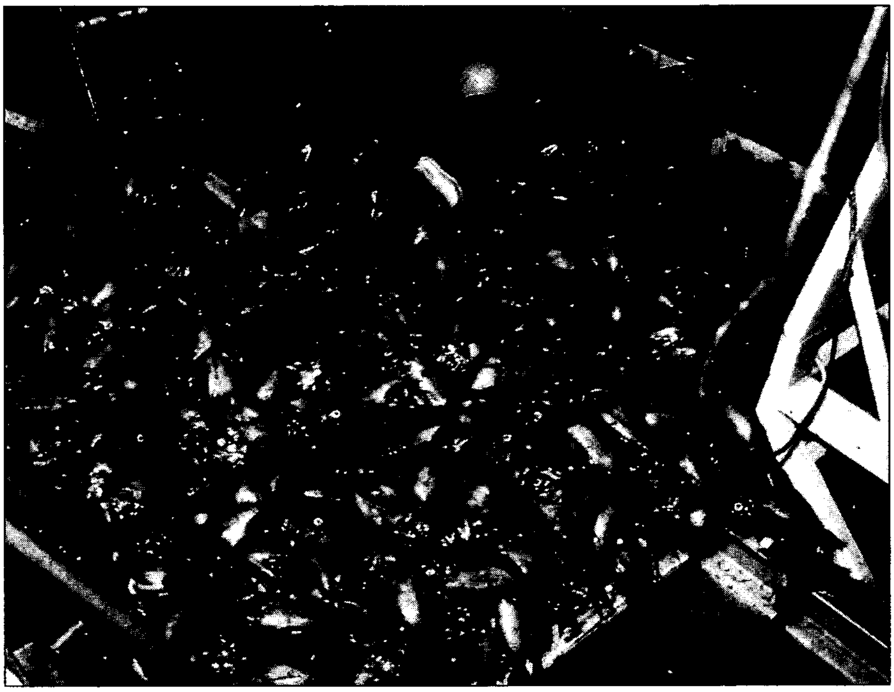


Figure 30.5: Haul of orange roughy, Bass Strait. Concerns exist on the sustainability of the fishery.

Future outlook for commercial fisheries

The catch of Australia's fisheries is not expected to expand much beyond present levels. While the major finds of orange roughy buoyed total production in the late 1980s, declines are occurring as catches are reduced to sustainable levels. However, despite the limited potential for increases in production, Australia can improve the present position of its commercial fisheries as management measures begin to take effect on the overexploited fisheries, and sustainability is achieved.

Increasing value

The value of the catch can also be increased through improved handling and marketing, by using the by-catch, and by diversifying products. Live export of some species to high value markets has been very successful. Live rock lobsters, abalone, reef fish and even tuna are now exported to ensure a top-quality product in the Japanese market. Aquaculture is also greatly increasing in importance. Cage rearing of salmon and trout in Tasmanian waters is highly successful and is being developed for other species.

Increasing competition among users

With growing pressure on resources, the potential for conflict among user groups is increasing. There is already serious competition in some fisheries between the commercial and recreational sectors (Chapter 33), and between fisheries and conservation.

Fisheries versus conservation

The prohibition of commercial fishing within marine protected areas (MPAs) has been a major issue since the establishment of the Great Barrier Reef Marine Park. Prawn trawling is prohibited in 79% of the GBR Marine Park because of its probable effects on inter-reefal benthos, and commercial reef fishing is prohibited on 5.2% of the Marine Park. A widespread belief amongst trawler operators that protected zones have more abundant prawns and fish is testimony to their effectiveness as fisheries refugia. The importance of MPAs as fisheries refugia, and their application for 'rotating crops' has not been widely argued within Australia, although closed areas and seasons have long been important tools of fisheries management in this country.

Environmental concerns of commercial fisheries

Many coastal fisheries are affected by environmental changes.

The Fisheries Pollution Committee, a part of the Commonwealth and State Standing Committee on Fisheries, has identified some of the major environmental issues affecting fisheries. These include:

- impacts of point-source wastes, especially industrial wastes.
- accumulation and effects of mercury, cadmium and other bio-accumulative residues and aquatic wastes in estuaries and coastal waters.
- effects of ballast water, toxic dinoflagellates and phytoplankton blooms on fisheries resources.
- coastal engineering works, ports, canal estates, marinas, dredging, spoil disposal, and their effects on habitats.
- protection and management of seagrass beds.
- contamination and effects of tributyl tin in molluscs.

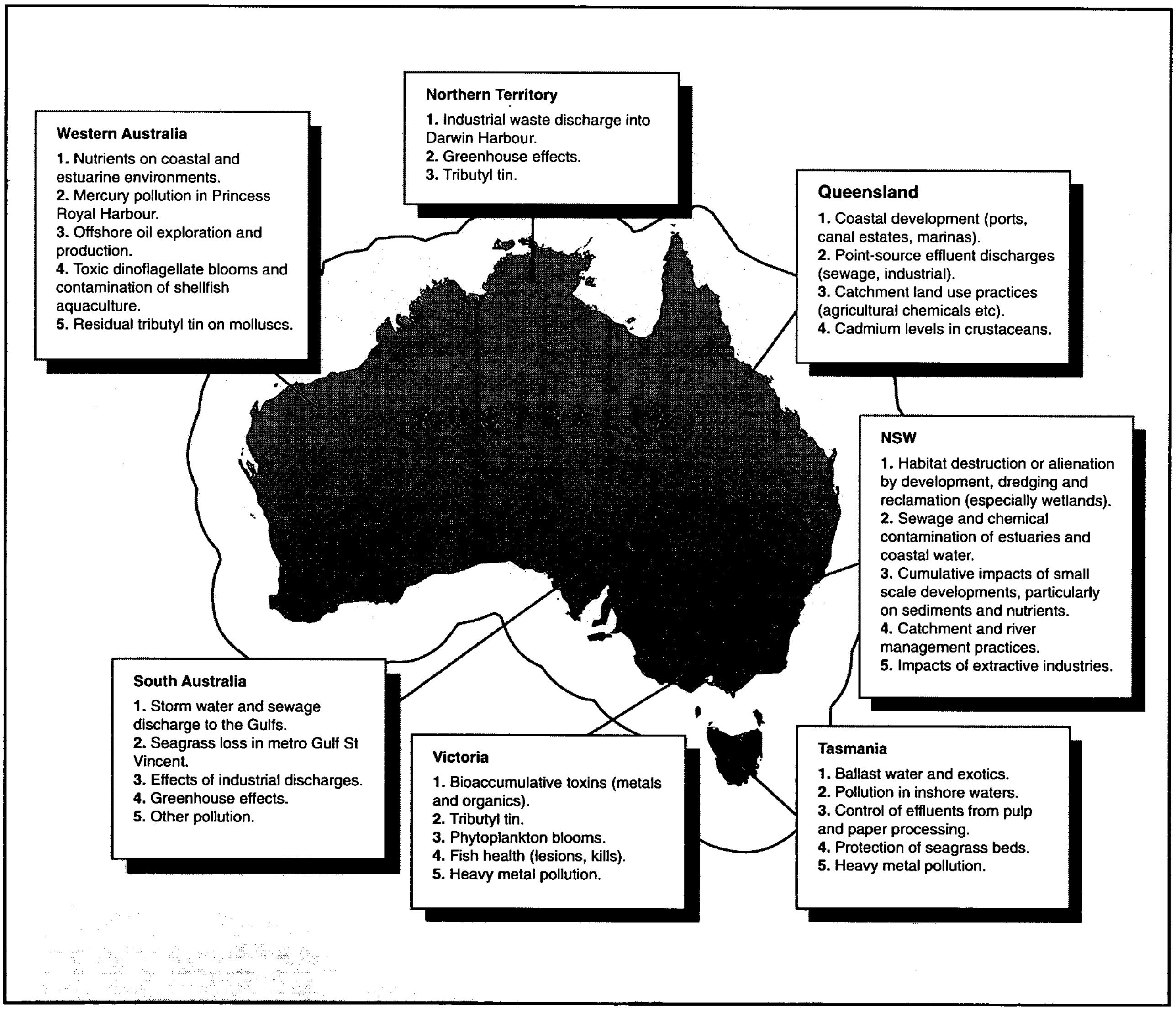
The major issues which concern commercial fishers and managers are catchment use, coastal developments, loss of wetlands and seagrasses, eutrophication, oil pollution, pesticides, heavy metals, ballast water and marine introductions.These are covered in detail in Chapters 40-48.

Effects of commercial fisheries on the environment

Commercial fisheries affect the marine environment and other users of the marine environment in a number of ways. Trawling damages seafloor benthic communities (Chapter 32), commercial fisheries may compete with recreational fisheries (Chapter 33), and fishing is a source of ocean litter (Chapter 46).

Towards ecologically sustainable development

The need to allocate scarce common property resources amongst users, and to justify conservation decisions on closures, greatly increases the demands for scientific knowledge of the resources, their uses and management. Emphasis is being placed on management of aquatic systems as a whole, rather than single species populations. The concept of ecologically sustainable development broadens this approach to management to include the effects of, and on, the environment at the national and global level, and reflects the need to deal with environmental, biological, social and economic issues as a whole. The adoption of an integrated ecosystem-approach to fisheries management is still in the early stages of development in Australia, and its extensive information requirements suggest that it will remain so for some time.



(Source: Fisheries Pollution Committee)

Figure 30.6: Environmental concerns of State and Territory fisheries managers.

Summary and conclusions

1. Australia's domestic commercial fisheries landings are around 200,000 tonnes per year, and are valued at around $1.6 billion per year.

2. The Australian Fishing Zone is 8.94 million square kilometres in area and is the third largest in the world.

3. Despite the large size of the Fishing Zone, Australia ranks only 51st of fishing nations in terms of landings. This is largely because of the low ocean productivity resulting from lack of major upwellings, the relatively low nutrient run-off from land, and the small size of the continental shelf.

4. Of 100 main species or groups fished, nine are considered to be overfished, 23 are fully or heavily fished, nine are underfished, and 59 are of unknown status.

5. Australia has experienced declines in some commercial fisheries, particularly southern bluefin tuna, southern sharks, gemfish and rock lobsters. There are also concerns that the high catches of the long-lived, deep-sea orange roughy cannot be sustained.

6. Reasons for declines in some fisheries include overfishing, use of non-selective fishing gear, loss of habitat, pollution and Australia's marine jurisdictional complexity which hinders management of a fish stock or population.

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Acknowledgments:

The technical paper by K. McCloughlin on which this chapter was based was internally reviewed by the Bureau of Resource Sciences.

Chapter 31. Coastal fisheries: a critical review[1]

'... the universal voice of all professed fishermen is that they never fished in a country where success was so precarious and uncertain.' (Trench 1788)

'The overall conclusion therefore, is that Australian marine waters, must ... be regarded as one of the most nutrient poor regions in the world' (Rochford 1980)

The first comparative assessment of the productivity of Australia's coastal waters was recorded in the journal of Captain Watkin Trench, officer and historian with the First Fleet. The postscript to Captain Trench's observations came two centuries later after extensive surveys by CSIRO regarding the primary production of the waters around Australia.

Australia's coastal fisheries are limited in extent and have not been conservatively managed. This chapter critically reviews the status of Australia's coastal fisheries and their management, as illustrated by the experience of New South Wales.

Coastal fisheries

More than 40 separate methods of fishing - ranging from large-scale commercial trawling and purse seining, to hand gathering - are used in Australia. Trawling, trapping, longlining, mesh netting, trolling and handlining account for the majority of commercial catches. Recreational fishing is almost exclusively by handline, scoop-nets, spear and hand gathering in all States, with cast nets and small bait nets allowed in some States, and mesh netting allowed in Tasmania. Recreational use of coastal fisheries is biased largely towards angling for a broad spectrum of coastal species, but non-consumptive uses such as observation and photography by scuba diving are growing in popularity.

Trends in production

While the gross value of Australia's commercial fisheries production has increased by more than an order of magnitude since the 1970s, the increase in the total volume of landings has been less impressive. More over, much of the increase since 1980 has resulted from the development of the new deepwater trawl fishery, predominantly for orange roughy (Chapter 30). With the decrease in the total allowable catch for this species in the interests of long-term sustainability, total fisheries production has levelled, or even declined in recent years.

The situation is more evident in the coastal fisheries where instances of increased productivity have been more than countered by declines for numerous key species. Fishing now affects the populations of most of the larger key fish and invertebrate species, particularly in waters adjacent to major human population centres such as in New South Wales.

Case history: New South Wales commercial fisheries

Until the early 1980s, fisheries production in New South Wales continued to increase annually, with productivity of most species accommodating ever increasing demands. Exceptions included the abalone *(Haliotis rubra)* and the eastern rock lobster *(Jasus verreauxi)* which had been stable, or in decline, for the previous two or three decades. Catches of mullet *(Mugil cephalis)*, sand whiting *(Sillago ciliata)*, mulloway *(Argyrosomus hololepididotus)* and snapper *(Pagrus auratus)* tended to increase through this period (Figure 31.1).

The late 1980s saw declines in the total commercial catch, and particularly in species such as mulloway and snapper, despite continuous increases in effective effort. Several other species such as dusky flathead *(Platycephalus fuscus)*, tailor *(Pomatomus saltatrix)* and mullet continued to provide relatively stable yields, at least to the end of the 1980s.

The declines in some cases (e.g. abalone, lobsters) almost solely reflect overexploitation of stocks by the commercial fisheries. In some other cases, stocks have been maintained but the share of the growing recreational fisheries have expanded. In others, such as the snapper, it is probable that the combined fishing effort of the commercial and recreational sectors has resulted in real deterioration in the status of stocks.

Unfortunately, the paucity of data on recreational fisheries makes it difficult to quantify the true impacts

[1]Based on a paper by Dr R.E. Kearney, Director, NSW Fisheries Research Institute, Cronulla, New South Wales.

of the fishery on the commercial sector, or the status of the stocks. However, from the case of the bream *(Acanthopaggrus australis)* in which recreational landings in the Richmond River estuary and Sydney Harbour have been estimated to be 15 and 25 times greater (respectively) than the commercial landings, it is evident that recreational fisheries have had major impacts on many species.

Assessment of past management

Although Australia has an international reputation for diversified policies, and even innovation, in fisheries management, our record for managing fisheries conservatively is generally not good.

The Commonwealth and most States lacked fisheries management for many years. All of our commercial fisheries were overcapitalised, and in many cases, resources were overexploited. The decline of the southern bluefin tuna *(Thunnus maccoyii)*, gemfish *(Rexea solandri)*, Australian salmon *(Arripis trutta)*, eastern rock lobsters and snapper in the south, and barramundi *(Lates calcarifer)* in the north, are outstanding examples of lack of conservatism in fisheries management in Australia.

While many factors have contributed to the overexploitation of fisheries resources in Australia, in essence, there has been inadequate priority given to the conservation of the resource as a non-negotiable cornerstone of fisheries policy. The present state of our fish resources demonstrates that the past beliefs that the oceans were limitless and/or that economic forces will prevent serious overfishing, were folly. However, the lack of public understanding of the principles of fisheries conservation and management has meant that, even today, many do not accept that there is any great urgency for action to conserve fish resources. Most individual fishers do not accept that their own activities require control, and even less that they impact on other fisheries. As yet, there is an inadequate commitment from fishing industry bodies to the development of strategies to optimise Australia's fish resources.

Factors contributing to commercial fisheries declines

There is growing recognition, at least in the more populous south-eastern states, that in addition to overfishing by the commercial sector, habitat degradation, effects of other commercial fisheries, pollution, and competition with recreational fishers are serious, albeit unquantified, problems.

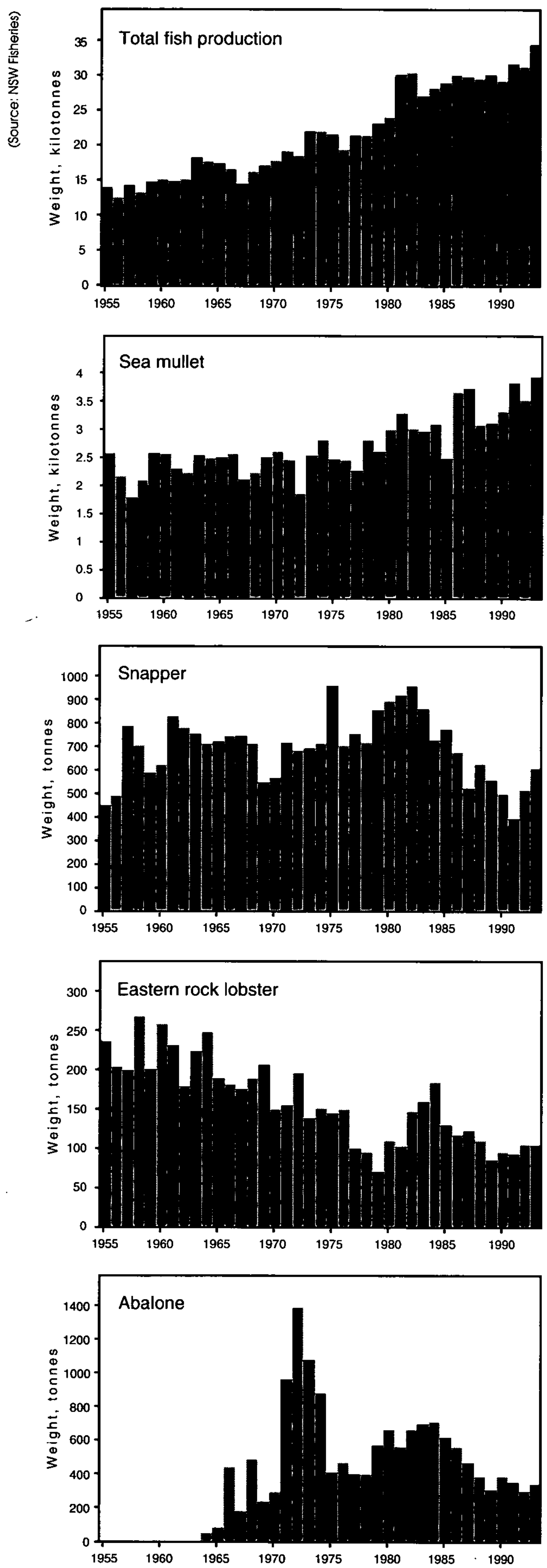

Figure: 31.1. Annual landings of a range of New South Wales fisheries.

Pollution, habitat loss

Two centuries of coastal development in New South Wales has affected key fish habitats such as wetlands and seagrass beds. Over 60% of seagrass has been lost in northern New South Wales since the 1940s. Flood mitigation schemes have significantly damaged fish nurseries in many estuaries. Pollution from industrial and domestic discharges, and negligent disposal of toxic chemicals have caused many fish kills in New South Wales, and no doubt have caused many complex sublethal effects. Eutrophication resulting from agricultural run-off and sewage, and increased water acidity from development of areas with acid soils are increasing problems in estuaries and embayments.

While the conservation movement in Australia has been successful in changing public attitudes towards pollution and habitat degradation, as yet there has been little attempt to redress past damage by restoring water quality and lost habitats.

Use of non-selective fishing gear

The use of non-selective fishing gear has contributed to fisheries declines by taking, as by-catch, the juveniles of the target species, other species, or damaging the habitat. Australia's fisheries managers have historically not given preference to gear which is selective, environmentally friendly, or which produce a higher quality end product. The effects of bottom trawling, the least selective fishing technique, and one of the most commonly used in Australia, are discussed in Chapter 32.

Recreational fisheries

Recent estimates of the size of some of the recreational fisheries - in some cases far exceeding those of the commercial sector - have staggered fisheries managers. Australia's recreational fishery is huge and varied, and about five million people may go fishing each year (Chapter 33).

The recreational fishery encompasses a diverse range of interests including: unlicensed professionals or 'shamateurs' (who fish for monetary gain); subsistence fishers (for food or barter); sportsmen (for the competition for the biggest or most); hunters and enthusiasts (for pleasure of the pursuit and kill, or release); anglers (for challenge of gear and skill); social (for camaraderie and fellowship); underwater enthusiasts (for curiosity of natural history); the outdoors enthusiast (for health); and preservationists (for conservation). A great deal more information on the magnitude of the fishery, species and size composition is required to assess the impacts of this complex and socially important fishery.

Declines in sensitive species

Their life history and behaviour make certain fish species prone to overfishing. Fish of commercial value which aggregate in one place at some stage of their life histories are particularly vulnerable (e.g. Australian salmon, gemfish, bluefin tuna). Those with a rather restricted total distribution throughout which they are exploited are also vulnerable (e.g. eastern rock lobsters and snappers). Those with many and varied spawning and nursery areas, and therefore complex stock structures, have withstood fishing pressure better (e.g. mullet, bream, and flathead). Even the last group are now showing declines in catch per unit of effort.

Towards more effective management of coastal fisheries

(Source: L. Zann GBRMPA)

Figure 31.2: The recreational fishery is large and important in New South Wales.

Better management of the recreational sector

Changes in management strategies are required for the coastal fisheries. Recreational fishers, even more than their commercial counterparts, have trouble accepting their own individually small, but collectively great impacts on stocks. The general freedom of the recreational fishery from economic forces (declining catches do not result in bankruptcy but rather in disappointment) requires re-evaluation of present management strategies.

While management of the freshwater recreational fisheries has been in place for many years, that of coastal fisheries has been slow. The introduction of bag limits in New South Wales was originally justified on the basis of curtailing black marketing, rather than in managing the fishery. Although initially unpopular, public opinion quickly swung towards support for regulations that lead to more equable sharing of the total resource.

The future

Because many coastal fisheries resources are maximally exploited, inevitable increases in fishing effort, particularly by the non-commercial users, will leave no alternative to increasingly stringent management of all activities that affect the resource.

If the coastal fisheries are to prosper and continue to provide high levels of enjoyment and food for future generations, then Australians must adopt the conservation of our resources as a non-negotiable, basic premise for fisheries management. The Commonwealth's 1991 acceptance of the principles of ecologically sustainable development is consistent with this objective.

Public opinion will grow for decision makers to err on the side of conservatism. The Industry Commission's 1992 Report on Cost Recovery in Fisheries clearly places the responsibility for resource conservation in the hands of governments. Responsibility for the management of industry will be progressively devolved to industry through controls on non-selective gear.

Status of monitoring

Most Australian states do not have adequate catch and effort data for their commercial fisheries, while data on their recreational fisheries are almost non-existent. Basic life history information for most key species is alarmingly deficient and few serious attempts have been made to carry out population assessments of key species.

The Commonwealth managed fisheries, most of which are more offshore, are better documented and landings are routinely monitored.

Monitoring of total fisheries production has been a misleading indicator of stocks because increases following the development of new fisheries have effectively masked serious declines in established fisheries. While monitoring of catch per unit effort is a better indicator, it does not account for recent improvements in technology (e.g. fish-finders, position indicators, better gear).

Summary and conclusions

1. Many commercial coastal fisheries around Australia have suffered declines. In New South Wales landings of many species began to decline in the early 1980s.

2. The declines are attributed to overfishing, the increased recreational effort, use of non-selective gear, loss of habitat, pollution and the distributions and life history patterns of certain species.

3. The record of Australian fisheries managers for managing fisheries conservatively is not good.

4. There is inadequate information on catch, effort, life histories and stocks for most fisheries.

5. Fisheries management is being reassessed because of declining landings. Increased regulation of the huge recreational fishery is occurring.

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Chapter 32. The by-catch issue and the effects of trawling[1]

International concern about the effects of oceanic drift nets on cetaceans, turtles, billfish and other pelagic species resulted in widespread banning of the practice. Increasing concerns are now held about the effects of otter-board demersal fish and prawn trawling. The 'by-catch', or that part of the catch which is captured incidentally to the target species, often comprises the bulk of the trawler's catch. In Australia virtually all of the so-called 'trash' is thrown overboard. For example, in 1988 the by-catch from the Northern Trawl Fishery was estimated to be 47,000 tonnes (mostly fish), 97% of which was discarded at sea.

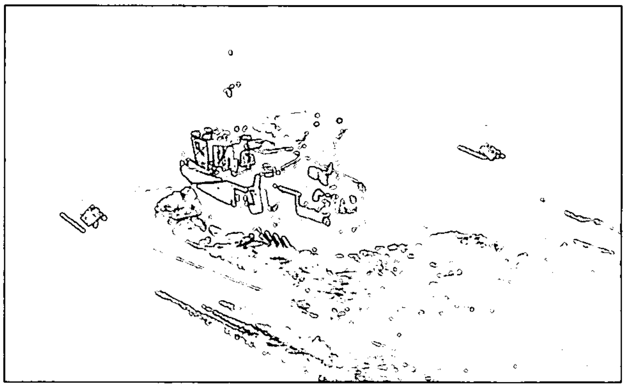
The by-catch issue is not a recent problem in Australia. In 1880 a Royal Commission identified problems of prawn netting in New South Wales, and in 1904 H.C. Dannevig, an early fisheries scientist, investigated the prawn by-catch problem in Sydney Harbour. However, the by-catch from most of our fisheries still remains undescribed, effects on fisheries and the environment are poorly known, and there have been few attempts to address the problem via closures or modified fishing gear.

Although fishing gear such as fish traps, crab pots, longlines, droplines, rods and reels are designed to be selective in what they catch, there is almost always some incidental catch. Gear such as gillnets and otter trawls are less selective, and have the potential of taking a large quantity and wide diversity of other species.

Studies of the effects of trawling

The by-catch of the Northern Prawn Fishery in the Gulf of Carpentaria has been investigated by CSIRO and Northern Territory Fisheries over the past decade to assess its potential commercial usage and the effects of trawling on turtle populations. Around 4,000 turtles were found to be netted each year, of which around 250 died by drowning. While this was not considered a major danger to these populations of turtles by the researchers, others consider it so (Chapter 18).

The by-catch of oceanic and estuarine prawn trawl fisheries has been investigated by New South Wales Fisheries following claims of large-scale mortality of juvenile fish. Hundreds of thousands of juvenile snapper, bream and mulloway were found to be taken each year but impacts on stocks were difficult to assess because mortalities from trawling, natural mortalities, and biomasses of stocks, are not well known. Using the best information available, the by-catch of juvenile snappers in Botany Bay was estimated to be around 350,000 fish per year, representing a possible decline of about 60,000 legal-size fish three years later.



(Source: GBRMPA)

Figure 32.1: There are concerns in many parts of Australia about the effects of trawling on the sea floor.

One of the best attempts to quantify effects of trawling was done by CSIRO in the fish trawl fishery on the North West Shelf. Comparisons were made of surveys done before and after commercial fishing began, and in areas closed and open to fishing. Effects on benthos were also assessed using underwater video. It was found that trawl fishing reduced snapper populations (the target of a trap fishery), increased populations of less valuable species such as threadfin bream and lizard fish, and reduced abundances of benthic organisms.

In the Gulf of Carpentaria, CSIRO compared surveys undertaken prior to the establishment of commercial trawling with those undertaken after 20 years of fishing. Significant decreases were found in 18 taxa, and in the overall diversity of assemblages. Another study in the Gulf found that by-catch of fish in Albatross Bay was less than 10% of the total stock

[1]Based on a paper by Dr S. J. Kennelly, New South Wales Fisheries, Cronulla, New South Wales.

(around 93,000 tonnes). A large number of fish species were found to be affected by prawn beam-trawling in Moreton Bay (Qld) but few significant effects were found in a study of the Hawkesbury River (NSW) prawn fishery.

Effects on food webs

Trawling may have subtle, indirect effects on species assemblages by the removal of large epibenthic organisms and by the alteration of food webs. The death of the by-catch organisms may affect populations of their predators and prey, competitors and other species.

The survival rate of discarded by-catch is quite small. In experiments in Torres Strait and Moreton Bay, around 70% of crustaceans survived a week after capture, but fish survival was very low with only one species recording a survival rate over 30%. Around half the discarded fish floated, while most crustaceans sank. The floating discards were eaten by birds, sharks and dolphins, and sinking discards were eaten by sharks. Dead discards reaching the bottom were eaten by other fish, sharks and crabs. In Moreton Bay the sand crab fishery may benefit from the discarded prawn by-catch, and three major species of seabirds feed primarily on these discards.

Utilisation of by-catch

A major objection by the non-trawl fisheries and the general public is the waste of discards. In many fisheries the by-catch is retained for separate sale or for fish meal. Use of by-catch is minimal in Australia because of limited storage space on trawlers, small market demand, low prices and problems with including toxic species in fish meals. Slipper lobsters, trawl whiting, squids and octopus are by-catch of the Eastern King Prawn Fishery that have a growing domestic market. Specimen shells, sea snakes (for fashion leather) and seahorses and pipefish (for Chinese medicines) are also in demand in Queensland. A study of the by-catch of the Northern Prawn Fishery found that only a few by-catch species such as slipper lobsters, snappers, emperors, large mackerel and cods were retained. Some 43 other species of fish, sharks, crustaceans and molluscs, with an estimated annual landing of 15,300 tonnes, were discarded.

(Source: B. Russell, NT Museum, GBRMPA)

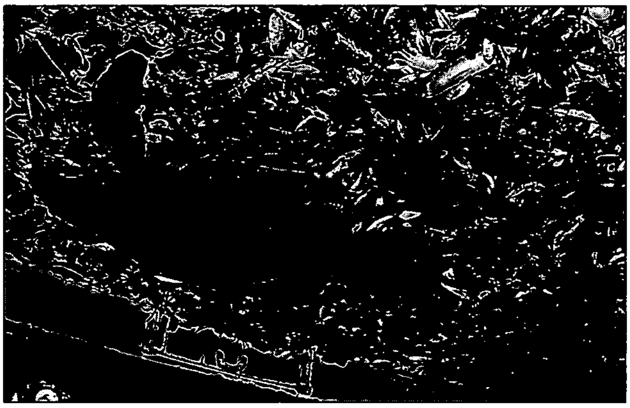
Figure 32.2: Asian trawlers on the North West Shelf (WA) removed large areas of sponges and other benthos.

Management alternatives

While Australians are gaining some awareness of the issues and problems of trawl by-catch, there has been little research on ways of minimising effects.

Trawl closures one alternative

CSIRO research on the North West Shelf demonstrated the effectiveness of closures. Extensive areas of the Great Barrier Reef Marine Park are closed to trawling (all zones except General Use 'A'), including a large cross-shelf transect in the Far Northern Section. Closures are unpopular with fishers where valuable fisheries exist, and violations have been frequent. Fisheries managers are concerned that increasing fishing effort is redirected toward areas open to trawling, causing increased damage. Considerable research will be necessary to identify if, where and when closures can be implemented without affecting the economic viability of the fishery.



(Source: GBRMPA)

Figure 32.3: By-catch from the Northern Prawn Fishery. There are some concerns about turtle mortalities.

More selective gear another alternative

Research on the development and implementation of more selective gear and fishing practices to minimise the by-catch and mortality of unwanted organisms is in its infancy in Australia compared to other countries. For example, 'Turtle Excluder Devices' (TEDs) and other by-catch excluders are commonly used in the United States.

A modified semi-demersal fish trawl (the 'Julie Anne'), trialled in the Northern Prawn fishery took 43% of the by-catch and 3% of the epibenthos of a conventional trawl. An American net (the 'Morrison soft TED') trialled in the New South Wales King Prawn Fishery significantly reduced by-catch by excluding all organisms from the cod end (the collection sock at the end of the net) larger than the mesh size of the TED panel. Modifications involving square-mesh panels have been developed in New South Wales and these allow swimming juvenile fish to escape before reaching the cod end .

A variety of modifications of fish and prawn trawls were described in the 1992 International Conference on By-Catch in the Shrimp Industry and at the American Fisheries Society's meeting in 1993. Many are demonstrated to be effective but require modification to suit local fisheries and conditions. The close involvement of the Australian fishing industry in such gear development is considered essential.

Summary and conclusions

1. The by-catch resulting from trawl fisheries is one of the central issues in fisheries and marine environmental management in Australia.

2. Insufficient information is known of the by-catch of most Australian fisheries.

3. Possible effects include reduction in juveniles of targeted and other species, adult fish and invertebrates; removal of epibenthos; and changes to food webs, including increase in populations of scavengers such as seabirds, fish, and crabs.

4. Management options include development of by-catch products and markets, development of more selective fishing gear, and spatial and temporal closures to trawling.

5. The involvement of the industry in all aspects of the research and management of this issue is essential.

6. Despite some studies of impacts of trawling, Australia has lagged in by-catch utilisation and particularly in the development of more selective gear.

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Chapter 33. Recreational fisheries and the catch-sharing issue[1,2]

Recreational fishing is one of the major outdoor activities of Australians, and a major use of the marine environment. Around five million people go fishing at least once a year, spending around three billion dollars on fishing and related activities. Surprisingly, the great size, economic and social importance of the recreational fishing sector, and its major share of the coastal catch, has only recently been appreciated by Australia's fisheries managers.

(Source: L. Zann, GBRMPA)

Figure 33.1: Recreational fishing is an important pastime for Australians. Beach fishers, New South Wales.

Both recreational and commercial fishers are becoming increasingly concerned about declining fish catches, and loss of fisheries habitat and effects of pollution. Recreational fishers attribute much of the decline in catches to the far more efficient commercial sector. The already heavily managed commercial fishers blame the vast, rapidly growing and little-managed recreational sector, and fear for their livelihood. The reality is that they are both competing for the same, often dwindling resource.

As recreational fishers are numerically by far the most important extractive users of Australia's marine environment, the values, importance and issues in recreational fisheries around Australia are a major consideration in the development of a national marine conservation strategy.

The first part of this chapter describes the importance of the recreational fishery in Australia, particularly its size and economic value, and assesses the status of its management. The second part focuses on the issue of catch-sharing, a source of continuing conflict between recreational and commercial fishers around the nation.

Importance and value of recreational sector[1]

Recreational fishing is a major activity of Australians. A study commissioned in 1984 by the Australian Recreational and Sport Fishing Confederation estimated that over 4.5 million Australians went fishing at least once a year and over 800,000 people went fishing more than 20 days a year. The total number of fishing trips was around 48 million per year.

Total spending on fishing and related activities was estimated to be around $2.2 billion, or $489 per fisher per year. Later surveys suggest that the economic value is even larger, around $736 per fisher per year in Queensland in a 1987 study, and $710 per fisher in Western Australia in a 1990 study.

Based on the 1984 survey and Australia's population growth, it is estimated that the number of recreational fishers is now over five million and that between 34,500 and 76,500 people are directly employed servicing the recreational fisheries. Fishing is also an important attraction for international tourists. Over 90,000 of the 2.2 million international tourists in 1988 indicated that fishing was one reason for visiting Australia. These tourists spent around $153 million and generated around 1,767 jobs. An additional $764 million is derived each year for the Commonwealth's consolidated revenue from duties and taxes on tackle, boats, caravans, off-road vehicles and fuel associated with recreational fishing.

Table 33.1: Breakdown of expenditure by recreational fishers 1984

Item	%	$ million
Tackle	9.1	287
Boats and assoc. equipment	26.5	837
Vans, camping equipment	15.2	480
Motor vehicles	9.4	297
Motor fuel	32.9	1 038
Other (bait, insurance etc)	6.8	215

[1]Based on a technical paper by G. Coleman, Australian Recreational and Sport Fishing Confederation, Canberra, Australian Capital Territory.
[2]Based on a technical paper by B. Shorthouse, fisheries consultant, Townsville, Queensland.

What is the recreational catch?

There are no accurate estimates of the recreational catch in Australia. A figure of around 54,000 tonnes has been tentatively suggested (Kearney 1994). This compares with the total commercial catch of around 200,000 tonnes.

This figure was based on the estimated 48 million trips a year (above); an assumption that 25% of fishing is in fresh water, 40% in estuaries and 35% in the ocean; and an average catch of 1.13 kilograms per fishing trip (from NSW data).

Coordination and management of the recreational fishery

The recreational fisheries in Australia are not adequately documented, coordinated or managed. Most of the day-to-day administration of recreational fishing is delivered by State fisheries services. There is no specific Commonwealth body charged with monitoring and liaising with the recreational industry, although at least 15 separate Commonwealth agencies and 32 different State and Territory bodies are relevant to the recreational fisheries.

Since 1984 recreational fishing clubs and associations have been able to become members of the Australian Recreational and Sport Fishing Confederation, which now represents 220,000 fishing club members around the nation. The Confederation (by default) has been given a charter by the Commonwealth government to deliver a range of Commonwealth initiatives in relation to recreational fishing, including sports development, water safety, conservation and tourist promotion, as well as to contribute to fisheries management issues. The non-associated recreational fishers (the vast majority) are not adequately represented.

The recreational fishing industry is likewise very fragmented. The only industry body is the Australian Fishing Tackle Association. Individual charter boat operators, tour companies, guides, lodge owners, tackle shops and other businesses must promote their interests individually.

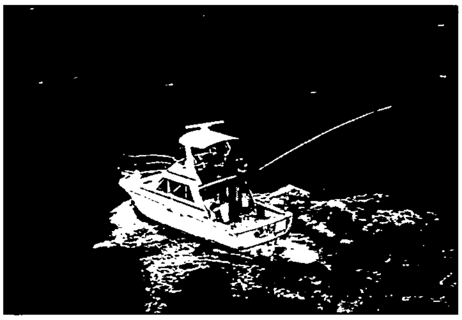

Figure 33.2: Big game fishing is a major industry in Cairns and other ports.

(Source: GBRMPA)

Developing a policy on management

In 1991 the Standing Committee on Fisheries, which comprises all State and Commonwealth heads of departments responsible for fisheries, found that a national policy on recreational fisheries was needed in order to place their management into context with other natural resource management issues. A national working group on recreational fishing, with members from Australia's fisheries management agencies and the Confederation, developed a draft policy which is now available for public comment.

The draft goals of management were identified as: (1) to ensure quality fishing, and maintain or enhance fish stocks and their habitats, for present and future generations as part of the environmental endowment of all Australians; (2) to develop partnerships between governments, the recreational fishing community, and associated industries to conserve, restore and enhance the values of recreational fisheries throughout Australia; (3) to allocate a fair and reasonable share of Australian fish resources to recreational fishers, taking into account the needs of other user groups; (4) to establish an information base at national and regional levels to meet the needs of recreational fisheries management; and (5) to establish a funding base at Commonwealth and State/Territory levels to effectively manage the nation's recreational fisheries.

(Source: D. Shultz).

Figure 33.3: Recreational and commercial fishers may compete for some coastal species.

The Confederation believes that a national recreational fisheries policy should acknowledge the importance of these fisheries in terms of national health and welfare, and the economy. The New Zealand, Canada and United States of America models are considered appropriate. These define the roles of national and local governments and voluntary organisations; they emphasise the cooperative nature of fisheries management; they ensure that funds are collected from the economic beneficiaries; and they disburse these funds to organisations responsible for promotion and management.

Key principles developed by the National Working Group on Recreational Fishing:

1. Recreational fisheries should be managed as part of the total fisheries resources to ensure quality fishing, and maintain fish stocks and habitats, for present and future generations of recreational and commercial fishers and other users.
2. The economic, educational, health and other social benefits of recreational fishing should be widely recognised and promoted.
3. Our fisheries resources and habitats are national assets which require protection by the general community as part of the environmental endowment of all Australians.
4. Governments are entrusted with stewardship responsibilities to conserve, restore and enhance recreational fisheries and their habitats.
5. Recreational fishers should participate in the protection and management of the resource.
6. Recreational fishers should develop their own codes of practice which support a strong conservation ethic.
7. Recreational fishers are entitled to a fair and reasonable share of the resource.
8. Recreational fishing opportunities should be encouraged.
9. Recreational fisheries management should accommodate conservation and non-exploitative uses.
10. Preference should be given to selective fishing methods.
11. Reasonable physical access to fishing areas should be provided throughout Australia.
12. Community consultation at all levels of government should be a key component of recreational fisheries management.
13. A strong fishing conservation ethic should be developed and reinforced through community awareness, education and enforcement for positive change in attitudes and values.
14. The catching of fish for sale or profit by recreational fishers is unacceptable.
15. Management decisions should be based on sound information covering fisheries biology, fishing activity, catches, and economic and social values.
16. Adequate funding and support should be provided at Federal and State/Territory levels to manage the fishery as part of integrated resource and environmental management strategies.
17. Recreational fishers should contribute to the cost on a user-pays principle.

Major concerns

The major concern of the Confederation is the management of recreational fishing. However, environmental issues, catch-sharing, diminishing fish stocks, and growing fishing pressure are increasingly dominating public debate on fisheries issues.

The Confederation recognises that a healthy environment in which fish stocks can flourish is essential for both fishing sectors. Uncontrolled coastal development is seen as a serious problem as over 70% of fisheries are directly dependent on coastal wetlands for some part of their life cycle. Loss of water quality is also considered a major problem. The Confederation believes that all sewage discharged into aquatic environments should be tertiary treated, that is, all solids and dissolved materials removed. It is particularly opposed to the discharge of wastes containing dioxins and other organochlorides from paper pulp mills.

Catch-sharing and conflicts: differing perspectives of recreational and commercial fishers[2]

Catch-sharing and competition between the recreational and commercial sectors is one of the major fisheries issues around Australia. Recreational fishers take fish for their enjoyment, and own consumption. Commercial fishers harvest seafood for sale to those people who do not catch their own. The recreational fishers now number over five million and spend over $2.2 billion a year on fishing activities (above). The commercial sector numbers around 16,000 and landings are worth over $1.3 billion per year (Chapter 30).

Around Australia the recreational and commercial sectors are in increasing competition for a shared resource. The issues vary from place to place, as do the perspectives of the two fisheries sectors, and the fisheries managers. The subject is often controversial, and it is necessary to consider the perceptions of all stakeholders.

The issue of catch-sharing is not well documented nationally. The following summary of issues is based on interviews with many fishers and fisheries managers around Australia.

Overview of catch-sharing concerns[2]

Catch-sharing is a controversial and complex issue around Australia. Generally the major concerns of recreational fishers centre on netting in inshore areas which they think are responsible for diminishing fish stocks; the effects of trawling; growing fishing pressure; and perceived inequitable regulations which they think favour the commercial sector.

Catch-sharing issues around Australia[2]

Queensland

Recreational perspectives ...
There are 600,000 to one million anglers in Queensland, of which 30% fish more than 10 times a year. Particular concerns include: (1) commercial netting near populated areas, e.g. for barramundi in central and northern rivers, for lesser mackerels around headlands, and for tailer in the south; (2) the use of haul and tunnel nets which are perceived to take whole schools; and (3) effects of trawling (on juveniles of recreational species, alteration of the bottom ecology, and modification of food chains).

Commercial perspectives ...
There are 6,800 licensed fishers in Queensland. Their association, the Queensland Commercial Fishermen's Organisation's (QCFO) concerns on catch-sharing include: (1) inequitable controls (tight management of the commercial sector and minimal management of the recreational sector); (2) the substantial impact of the recreational catch on many stocks and a lack of awareness amongst anglers of their accumulative effects; and (3) illegal selling or 'black marketing' by some amateurs.

Management's perspectives ...
Queensland's fisheries are managed by both State and Commonwealth agencies. Their concerns are: (1) there are more perceived conflicts than real ones, that public perceptions tend to be negative, and that the commercial sector is necessary as it supplies fish to the majority of people; (2) since 1984 improved technology, effort transfer and under-used licences being sold and more fully utilised has bought some growth in real commercial effort; (3) loss of fisheries habitat and degradation of water quality has led in some estuarine/inshore areas to diminished fish stocks; (4) the increasing recreational effort must be assessed; (5) effects of trawling must be assessed through long-term research; and (6) communication between the sectors should be improved.

A special Government inquiry on declining recreational fisheries in 1993 identified the many problems associated with resource sharing. This has led to a review on current arrangements which will be completed in 1994, introducing some new restrictions on commercial effort in some areas and more efficient recreational fisheries management.

The future...
The formation of Management Advisory Committees (MACs), technical working groups and community-based Regional Advisory Committees with a broad spectrum of marine user groups should reduce friction.

New South Wales

Recreational perspectives ...
NSW has the largest recreational fishery with around 1.75 million (30% of the population) but little information is available on effort. The concerns of the major representative organisation, NSW Recreational Fishing Advisory Council, include: (1) effects of trawling, reducing recreational fish takes and by-catch (particularly in estuarine areas like Clarence, Hunter, Hawkesbury Rivers, Sydney Harbour, Botany Bay); (2) netting (such as beach, gill and mesh netting for mullet, bream, and jew, particularly in spawning seasons, in river mouths); and (3) trapping (taking of fish targeted by recreational fishers).

Commercial perspectives ...
There are approximately 2,200 licensed fishers represented by the NSW Commercial Fishing Advisory Council and Oceanwatch. Their major concerns include: (1) the great increase in recreational fishing; (2) a lack of information on recreational catch, including questionable economic valuation; and (3) 'black marketing' by amateurs.

Management perspectives ...
According to NSW fisheries management: (1) 'black marketing' of snappers, rock lobsters, mulloway, kingfish, and poaching of abalone is a problem and may in cases exceed the commercial catch; (2) effects of trawling are being investigated; (3) there are concerns about sustainability and equitable access to the diversity of fish stocks; and (4) joint representation on Management Advisory Committees should reduce conflicts.

The future...
Links between commercial and recreational fishers have been formed in some areas on Regional Advisory Committees and Management Advisory Committees. However, many fishers feel that this is not sufficient to resolve problems.

Victoria

Recreational perspectives ...
There are around one million recreational fishers in Victoria (28% of population) of which around 10% go fishing more than 10 times a year. Around 50% of trips are to the coast, and 22% are within Port Phillip Bay. Major concerns are: (1) commercial netting in inshore areas should be more restricted; (2) scallop dredging is damaging Port Phillip Bay; and (3) there is limited stock assessment on key species (such as snapper, whiting and bream), and lack of information on the effects of habitat/environmental changes.

Commercial perspectives ...
The State's 1,200 licensed fishers are represented by the Victorian Fishing Industry Federation. Major concerns include: (1) catch-sharing in bays, inlets and coastal inshore areas, particularly Port Phillip Bay; (2) 'black marketing' of fish and poaching of abalone; and (3) declining fish catches being blamed on commercial activity rather than increasing recreational effort.

Management perspectives ...
(1) Difficulties arise from lack of information on the recreational sector, and on stocks and habitats; (2) conflicts are generally restricted to bays, inlet and coastal lakes, with snapper, whiting and bream the major problems; (3) recreational fishing effort is rapidly increasing, but is not adequately controlled; (4) declines in stocks of rock lobster are considered serious; (5) both sectors support environment and habitat issues; and (6) a peak recreational representative body is to be established in 1994.

The future...
(1) Monitoring and research programs such as those currently underway in Port Phillip Bay will assist in developing management practices that ensure equitable sharing of fish stocks; (2) the majority of recreational anglers would support licences/fees but would want the monies raised to be spent appropriately; and (3) consideration is being given to establishing more fisheries advisory bodies such as that at Corner Inlet.

Tasmania

Recreational perspectives ...
There are around 120,000 recreational fishers in Tasmania (25% of population), fishing an estimated 600,000 days a year. Unlike most other States, certain gillnets are allowed, and the taking of rock lobster, abalone and scallop is permitted through licences. Major issues are: (1) competition with commercial sector for rock lobsters; (2) non-selective purse seining and trawling with jack mackerel, barracouta, and trevally as by-catch; (3) decline in recreational tuna catches perceived because of offshore longline fishery; (4) competition with the commercial ring netting (off beach) fishery for Australian salmon; and (5) effects of scallop dredging and inshore trawling on the environment.

Commercial perspectives ...
The 1,100 commercial fishers are represented by the Tasmanian Fishing Industry Council. They considered that there are relatively

few conflicts with the recreational sector and issues are resolved through consultation. Concerns include 'black marketing' of fish and poaching of abalone.

Management perspectives ...
(1) Resource allocation is a problem, requiring information on the biology and stock dynamics, economics, social amenity, catch and effort of the fisheries; (2) rock lobsters are adequately known and are being managed to reduce total effort; and (3) all sectors are concerned about environmental issues, particularly the introduction of the destructive Japanese starfish from ballast water.

The future...
Although some resource sharing and other issues will never be completely resolved, Tasmania is improving the level of communication between the sectors.

South Australia
Recreational perspectives ...
There are about 300,000 to 400,000 recreational fishers in South Australia but little is known of their effort. Licences are required for rock lobster and nets. While communications are improving between sectors, the major concerns are: (1) competition for inshore stocks of Australian salmon, a major sport fish (recreation bag limits exist but no limits exist for commercial, bait and pet food fisheries); (2) netting (limited controls on commercial effort, nurseries threatened by powerhaul netting); (3) longlining (for example, concerns on snapper stocks in Gulf St Vincent); (4) purse seining - stock assessment needed (for example, for pilchards, salmon, mulloway, snapper, tunas); (5) concerns over damage by trawlers to habitat and effect on foodchains; and (5) aquaculture in small inlets displaces recreational fisheries.

Commercial perspectives ...
The 1,120 commercial fishers are represented by the SA Fishing Industry Council. Major concerns are: (1) 'black marketing' and abalone and rock lobster poaching; and (2) inadequate enforcement and education.

Management perspectives ...
(1) Commercial fisheries are necessary to supply fish to non-fishers; (2) the recreational sector claims to be worth more, but flow-on effects from commercial sector are not included; and (3) generally, conflict levels are not high.

Both sectors have been involved in consultative processes and Integrated Management Committees have been established. These differ from Management Advisory Committees as in other States in that they are decision makers, rather than advisers, to the Minister.

The future...
Research programs are underway on (1) resource allocation in marine scalefish; and (2) impacts of commercial netting and recreational line fishing on King George whiting. Conflict levels are not high and should continue to diminish due to ongoing communication between the sectors.

Western Australia
Recreational perspectives ...
Following a two year study ('The Future for Recreational Fishing' 1991) the sector is better known than in other States. There are around 300,000 recreational fishers (27% of population) of which around 15% go fishing more than 26 times a year. The value of the fisheries is estimated to be around $200 million to $415 million a year, making it worth about two-thirds of the landed catch value of the commercial sector. Management includes licences for some species (rock lobster, netting). Principal angling species are Australian herring, Australian salmon, tailer, whiting and a variety of reef fish. The peak representative body is the WA Recreational and Sportfishing Council. Major concerns include: (1) beach seining Australian salmon, (used for bait and pet food, competes with sportfishery); (2) mulloway (major recreational, minor commercial fishery); (3) demersal gillnetting for shark, snapper and jewfish; and (4) effects of trawling (damage to seafloor, capture of targets of recreational sector).

Commercial perspectives ...
The 3,700 commercial fishers are represented by the WA Fishing Industry Council. Major concerns are: (1) recreational fishers do not appreciate their cumulative effect or the variability in recruitment and they blame commercial fishers for natural declines; (2) 'black marketing', e.g. for jewfish and snapper.

Management perspectives ...
(1) A better knowledge of recreational effort and stocks is required; (2) the Commonwealth has the responsibility of managing the recreational sector but has not adequately appreciated its importance and impact;
(3) consultation and negotiation is essential in catch-sharing; and
(4) finfish licence 'buy-backs' are reducing commercial effort and conflict with the recreational sector.

The future...
Most informants believe that the majority of issues can be resolved over the next few years through the Recreational Fisheries Advisory Council, Regional Advisory Committees and other appropriate consultative structures.

Northern Territory
Recreational perspective ...
There are around 35,000 anglers in the NT (35% of the population). Each year 8,000 visitors come specifically to fish, and another 12,000 fished on their visit. Sport fishing is popular and some sources believe around 60% of the barramundi are taken by recreational anglers. Permits are required for some declared Aboriginal areas. Major concerns are: (1) competition over barramundi, mudcrabs;
(2) commercial effort on flats and beaches should be reduced;
(3) recreational access to Aboriginal land is controlled, but commercial access is not.

Commercial perspectives ...
The commercial fishers are represented by the NT Fishing Industry Council (NTFIC) and other bodies. Concerns include: (1) the lobbying power of anglers has resulted in closure of net fishing in rivers and some trawling grounds; (2) there is inadequate consultation between sectors, and management; (3) recreational bag limits are high; (4) improved roads have increased recreational pressure on stocks. Conflicts are declining, and both sectors are concerned for environmental protection. The NTFIC Code of Practice avoids where possible contact with recreational fishers, e.g. through weekend closures.

Management perspectives ...
(1) The recreational fisheries are recognised as an important part of the NT economy; (2) recreational effort is being monitored; (2) licence 'buy-back' in the barramundi fishery has given anglers exclusive access in the Roper, Mary and Daly Rivers; (3) many recreational anglers are willing to pay towards management but would want funding to go into research; and
(4) the commercial sector is often unjustly blamed for declines.

The future...
Most feel conflicts are declining as the level of consultation between the sectors improves with both grassroots contact and the more formal forums of the various Management Advisory Committees. Some say conflict resolution would be aided if there was better consultation between the NT Conservation Commission and the user groups on the issues of Marine Parks.

(Source: J. Robertson, GBRMPA)

Case history

Catch-sharing in the Great Barrier Reef Region

The Great Barrier Reef supports an extensive reef line fishery involving both commercial and recreational sectors. The 200-300 commercial operators, who fish largely for coral trout (75-85% of catch) and other large species, catch around 4,000 tonnes per year. Restrictions are placed on gear used and size limits of major species. The recreational sector consists of around 260 charter boats and some 24,000 private speed boats, catching between 3,500-4,000 tonnes per year. The fishery is restricted by minimum size limits and bag limits.

(Source: GBRMPA)

Figure 33.4: Surveying coral trout on the Great Barrier Reef.

There are growing concerns on the sustainability of the fishery as the commercial catch has remained stable for the past few years despite an increase in fishing effort (number of fishers). Despite an increase of 25% in the recreational fishery there has been a 30% decline in mean fish size, and a 50% decline in catch per unit effort (the weight of fish caught in a given time).

Because of concerns that line fishing may be altering the trophic structures of reefs, the Great Barrier Reef Marine Park Authority has monitored coral trout populations on fished and protected reefs. Some studies show densities of larger and older coral trout are higher on protected reefs. Densities of red throat sweetlip (10-15% of catch) are much more abundant on protected reefs. A large-scale manipulative experiment involving many fished and protected reefs is currently underway.

Conversely, major concerns of the commercial fishers centre on the strict regulation of their own sector but limited regulation of the expanding recreational sector; the individually small but cumulatively large effects of the recreational anglers; and, in particular, widespread 'black marketing' and poaching. While all States and the Northern Territory recognise the necessity for better management of the recreational fishery and resolution of catch-sharing issues, they lack the resources for research, monitoring, extension and enforcement.

The future: will there ever be accord?

One of the problems common to both professional and recreational groups is the quality of the marine environment. Increasing awareness of habitat degradation has created a common bond.

Strategies which have been suggested to reduce catch-sharing issues include integrated management of shared fisheries; better monitoring and management of the recreational fisheries; education programs to promote the positive benefits of the fishing industry; and greater contact between the two sectors at all levels.

(Source: GBRMPA)

Figure 33.5: Coral trout are the major target of Great Barrier Reef commercial line fisheries, charter boats and recreational fishers.

Summary and conclusions

1. Australia's recreational fishery is of great economic and social importance, and has a significant impact on some coastal fish stocks.

2. The recreational fisheries are very poorly documented (e.g. catch and effort data is almost entirely lacking).

3. The recreational fisheries, in most cases, are not adequately managed.

4. Major environmental concerns (shared by both commercial and recreational sectors) are loss of fisheries habitat through uncontrolled coastal development, and loss of water quality.

5. The aspirations of recreational fishers, as the most numerous extractive users of Australia's marine environment, must be a major consideration in the development of marine environmental management programs.

6. The major concerns of recreational fishers are netting in inshore areas (which they think are responsible for diminishing fish stocks); the effects of trawling; growing fishing pressure and perceived inequitable regulations which they think favour the commercial sector.

7. Conversely, the major concerns of the commercial fishers centre on the strict regulation of their own sector but limited regulation of the expanding recreational sector; the individually small but cumulatively large effects of the recreational anglers; and, in particular, widespread 'black marketing' and poaching.

8. Strategies which are being used to reduce catch-sharing issues include integrated management of shared fisheries; better monitoring and management of the recreational fisheries; education programs to promote the positive benefits of the fishing industry; and greater contact between the two sectors at all levels.

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Chapter 34. Shoreline harvesting[1]

In Australia most recreational fishing and harvesting is conducted from the shore. Because of the highly urbanised nature of our population and the concentration of cities around estuaries and embayments, there is an increasing pressure on local shores.

Australia's shores were traditionally very important for the subsistence of Aboriginal peoples, as evident by the many middens around the coast (Chapter 19). The Gunnai people of Gippsland, for example, harvested at least 70 species of invertebrates such as spiny lobsters, crabs, shrimps, snails, and bivalves from rocky and sandy ocean shores, and from estuaries and inlets. Today, shoreline fishing and gleaning remains important for many southern and northern Aboriginal communities and particularly, for Torres Strait Islanders (Chapters 20-22).

Around metropolitan and holiday areas, the shore is intensively used for recreational purposes. Passive activities such as swimming and sunbathing may have no direct effects on the shore, but angling, collection of food, bait and specimens for display, off-road vehicles and heavy foot traffic may have significant impacts on shore biota.

Patterns of use

There have been few investigations of the patterns of human activities on Australian shores. Studies in several areas of Victoria and New South Wales showed that visitations and activities varied throughout the year. They were highest in summer, particularly on sunny days, during school holidays, and on weekends outside holidays. Activities varied from place to place. Collecting was most common during summer, and angling was common year-round.

While most visitors engage in passive activities, the proportion undertaking exploitative activities may be high, for example, between 16% and 53% of visitors to rocky shores monitored near Melbourne. Numbers may also be high; for example up to 25 people were recorded in each two kilometre section of rocky shores monitored near Sydney. Because of aggregation at favourite fishing spots, local exploitation rates were much greater in some areas.

(Source: L. Zann GBRMPA)

Figure 34.1: Shores around urban and recreational areas are under increasing pressure from trampling and harvesting for food or bait.

Humans as predators on New South Wales rocky reefs

(Source: Kingsford et al 1991)

Humans have a major impact on some temperate intertidal reefs in New South Wales. A detailed study on rocky shore fishing and harvesting between 1986 and 1989 found that:

- 37 types of fish (representing species, genera, families) were taken (major types were luderick, bream, snapper, mullet, tailor, trevally, whiting, drummer, sea carp, rock cod, mado, and wrasses);
- a large proportion of fishers collected bait from the shore (19-80% of fishers);
- green algae was taken by 11-46% of fishers;
- 17 different types of invertebrates were collected (major types were snails (turbans, whelks, limpets, abalone, periwinkles), bivalves (mussels), echinoderms (urchins), crustaceans (grapsid crabs, spiny lobsters, shrimps), and ascidians (cunjevoi)); and
- ascidians, crabs and snails were most heavily exploited.

In a survey of four sites along 1,000 km of coast (near Kempsey, Boomerang Beach, Bateman's Bay and Merimbula) it was found that:

- there were no significant differences in numbers of people amongst sites, but there were large differences between summer and winter;
- 25 types of fish were taken (major types were luderick, bream, tailer, horse mackerel, blue mackerel, whiting, sweep, kelpfish); and
- 5 different types of invertebrates were taken (major types were limpets, grapsid crabs, cunjevoi, octopus, errant polychaetes).

[1]Based on a paper by Dr G.P. Quinn, Dept of Ecology and Evolutionary Biology, Monash University, Victoria; Dr P.G. Fairweather, Graduate School of the Environment, Macquarie University, New South Wales; and Dr M.J. Keough, Dept of Zoology, University of Melbourne, Victoria.

The shore organisms were collected for food, fish bait and display purposes. In the Sydney area, 17 rocky shore invertebrate species were taken by collectors, the majority for bait. Some sea urchins and snails were taken as food. While there is anecdotal evidence of some ethnic groups being primarily responsible for taking intertidal organisms for food, details are not documented.

A variety of methods are used by shore collectors. Knives and scrapers remove attached organisms. Crowbars are used to break open rock crevices to extract organisms. Pumps and shovels are used to extract bait species from mud. Some of these methods may cause significant damage to habitats.

Effects on shore biota

There have been a number of studies, primarily from overseas, on the effects of harvesting on plants and animal populations on rocky shores, but few have been taken on soft shores. Two major approaches have been used to assess human impacts: spatial comparisons of protected and unprotected areas, or of accessible and inaccessible areas; and temporal comparisons of an area before and after protection. The adequacy of the statistical analyses of these vary widely.

Table 34.1: Shore organisms collected in Australia, with the main purposes, methods of collection and their commercial interest

Organism	Method	Purpose	Commercial	Comments
Commonly taken				
Brown algae	H, KS	F, O	yes	gardens, stock food
Green algae	H, KS	B	no	gardens
Polychaetes	BP, D, H	B	some	sandy/muddy shores
Abalone	KS, S	F, S	yes	mainly subtidal, commercial
Limpets	KS	F, B, S	no	also for stock food
Snails (non-whelks)	H	F, S	potential	turbans etc
Mussels	KS, H	F, B	yes	mainly subtidal
Oysters	KS	F	yes	
Cockles, pipis	H, D	F, B	potential	sandy/muddy shores
Crabs	H, SP	F, B	potential	rocky, sandy/muddy shores
Spiny lobsters	H, SP	F	yes	subtidal, commercial
'Shrimps'	BP, D, N	B, D	no	sandy/muddy shores
Sea urchins	KS, SP	F	potential	small local fisheries
Ascidians	KS	B	no	mainly cunjevoi (*Pyura*)
Rarely taken				
Anemones	H	D	no	
Sponges	H	D	no	
Medusae	H, N	F		
Corals	H	D	no	
Chitons	KS, S	B	no	overturning boulders
Nudibranchs	H, N	D	no	rarely intertidal
Barnacles	S	D	no	incidental epibionts
Pycnogonids	H	D	no	
Sea stars	H	D		
Sea cucumbers	H	F		mainly in tropics

Keys:
Methods: KS - knife or scraper; H - hand collection; BP - bait pump; N - net; D - digging; S - smashing rock; SP - spearing. Purpose: B - bait; F - food; S - shell collecting; D - live or dead display; O - other.

Direct effects

Studies show that the abundance and/or size of the target species generally decrease in response to harvesting. Near Melbourne there has been a significant reduction in size and/or abundance of three common species of gastropod in exploited areas. Near Perth the size and abundance of abalone has declined. Community structure (species diversity etc) may also be altered. There have been few studies of recovery rates once shores are protected, but one in South Africa found that surf fish recovered quite rapidly.

Indirect effects

In addition to the depletion of the target species, there are a variety of other, more subtle effects of fishing and collecting, including the destruction of habitats from the harvesting activities, and from ancillary activities such as trampling, and flow-on ecosystem effects.

Destruction of habitats may dramatically alter shore biota. Crow bars used to smash sea urchins from crevices effectively remove the crevices and associated biota together with the urchins. Collection of worms from mussel beds and tubeworm masses also destroys the associated sessile invertebrates. Collection of mussels, oysters and cunjevoi and other habitat-forming organisms affects the associated plants and animals by providing space which may be colonised by other sessile species within the assemblage. Alterations to communities may be complex and variable.

Management

Commercial bait collection is controlled through licences. For example, in Victoria there are 29 commercial licences for sandworms, bass yabbies, crabs, shrimps, prawns, pipis, mussels and mud cockles. The number of bait licences have been frozen pending a review of the fishery.

However, as the great majority of shore fisheries are recreational rather than commercial in nature, they are poorly documented and inadequately managed.

Marine protected areas and other methods

Sanctuaries on shores can provide refuges for the preservation of breeding populations and facilitate increased harvests in adjacent areas. They may also provide a means for rotational cropping.

Only a small proportion of Australia's coastline is included in marine protected areas. Within most protected areas collecting is generally prohibited, but angling is permitted. Outside protected areas, management of shoreline biota varies from State/Territory to State/Territory.

In Victoria the 'Shellfish Protection Zone' legislation of 1983 prohibits the harvesting of any plants or animals except cephalopods, crabs, and ghost shrimp, and spiny lobsters and abalone (the last two are subject to size and bag limits). Enforcement is limited mainly to the Melbourne area, and to the peak holiday season. Particular species or communities may also be protected under the 'Flora and Fauna Guarantee' legislation.

In 1993 New South Wales Fisheries introduced a management plan for shore harvesting which included the prohibition of the use of destructive implements, reduced bag limits and the establishment of a network of Intertidal Protected Areas (IPAs) to act as breeding reservoirs for invertebrates (Chapter 10).

Tasmania, South Australia and Western Australia have size and bag limits on commercial species such as abalone and spiny lobsters. While there are no special controls on shore harvesting in Queensland, extensive areas of the mainland coastline and many of the islands are marine protected areas.

(Source: L. Zann, GBRMPA)

Figure 34.2: Soft shore habitats may be damaged by fishers digging and pumping for bait.

Summary and conclusions

1. Australia's shore fisheries are mainly recreational in nature. They are neither well documented nor well managed.

2. Direct effects of human harvesting on shores are reduced densities and altered size structure of target species populations, particularly molluscs, ascidians and fish.

3. Indirect effects on other species and ecological mechanisms include loss of habitat and release from competition or predation.

4. Impacts appear most severe around metropolitan and holiday areas.

5. Research is required to determine the patterns of human activities (including socioeconomic aspects) along Australian coastlines; to assess human impacts by comparing directly or incidentally protected areas and exploited areas; to establish effects of harvesting on target and other species; and to establish the indirect effects of harvesting such as competitive or predatory release on other species.

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Chapter 35. Aquaculture and its potential environmental impacts[1]

Aquaculture, the farming of freshwater and marine species, is an important and logical development from the capture fisheries, just as farming on land was a monumental step from hunting and gathering. Aquaculture is a young and rapidly growing industry in Australia and while it has many positive economic benefits, conflicts in coastal usage, introductions of exotic species and diseases, genetic modifications, and water pollution are potential problems.

Aquaculture involves the breeding or collection, rearing and cultivation for sale of fish, molluscs, crustaceans and aquatic plants. While demand for seafoods increases and landings of the wild stocks are falling worldwide because of overfishing, aquaculture production is increasing at around 9% a year, and is expected to triple over the next decade. Growth in Australia in recent years has been even more rapid at around 20 to 25% per year.

Australia's growing aquaculture industry

A major boom in aquaculture began in Australia around the mid 1980s. While production was then valued at less than $50 million per year, by 1990-91 it had soared to around $237.5 million, and totalled 14,300 tonnes. There are now around 4,400 mariculture farms in Australia, the majority of which (90%) are in New South Wales.

(Source: I. Dutton)

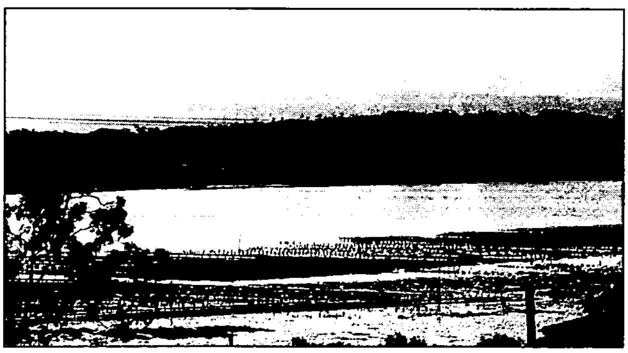


Figure 35.1: Oysters have been extensively cultivated in the south-east for many years.

Although rock oysters and pearl oysters have been raised for many years in this country, the recent growth in aquaculture has been largely due to the production of Pacific oysters, salmon, trout and prawns. Around 60 species of organisms from algae and aquarium fish, to crocodiles and freshwater crayfish, are cultured in Australia. Australia's aquaculture is based largely on small volumes of relatively high value products for local and overseas markets. Elsewhere in the world, and particularly in Asia which accounts for 85% of the total world production, it is based on low cost, large volume production to meet domestic food requirements.

Environmental issues

Aquaculture is a regenerative rather than exploitative use of the coastal environment, and is therefore amenable, and indeed dependent on effective environmental management. Positive environmental consequences of aquaculture include the production of juveniles of overexploited species for restocking purposes; reduced fishing pressure on wild stocks; and an increased scientific understanding of the species and better management of wild stock.

Aquaculture developments also have potential for negative effects on the environment and key environmental issues raised by aquaculture development in Australia have been recently addressed by the Working Group on Aquaculture (1992). These are summarised below.

(Source: GBRMPA)

Figure 35.2: Aquaculture has grown rapidly in Australia in recent years.
A prawn farm, north Queensland.

Coastal zone water and land use planning

As aquaculture requires an unpolluted environment and

[1]Based on a paper by Dr P. Rothlisberg, CSIRO Marine Laboratories, Cleveland, Queensland; and J. Gillespie and C. Barlow, Department of Primary Industries, Brisbane, Queensland.

often considerable quantities of coastal land and water (fresh, brackish or salt water, depending on the organisms), suitable sites are often restricted in their availability and there may be competition with other users for them.

Wastes from intensive cultivation may elevate phosphorus and nitrogen loads in the surrounding waters, inducing eutrophication. Concerns have been expressed on potential effects of wastes from barramundi floating cages in the vicinity of coral reefs on the Great Barrier Reef.

Clearing or alteration of foreshores, mangroves and saltmarshes may have a harmful effect on coastal habitats. In South-East Asia there has been a serious loss of valuable mangrove wetlands for fish pond construction. In north Queensland conservationists have been concerned about the clearing of swamp communities for prawn ponds.

Findings of Resource Assessment Commission's Coastal Zone Inquiry

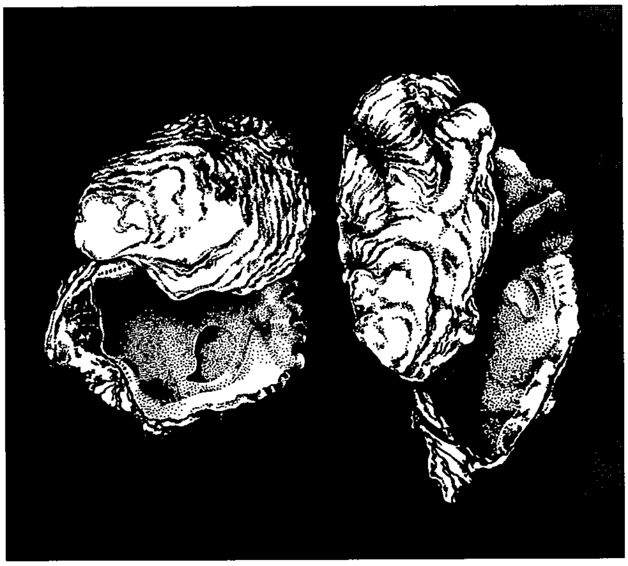
Resource requirements:
The RAC Inquiry considered the demands of Australia's fast growing mariculture industry in the coastal zone for: sites in bays, estuaries and other sheltered waters; high water quality; ease of access and transport networks; and proximity to processing plants and markets.

Competition:
RAC noted that the mariculture industry is particularly susceptible to pollution from industrial, urban, marine-based and agricultural run-off and discharges. It also considered that mariculture operations generate significant impacts on the environment and other users of the coastal zone, including increase of nutrient loadings; visual and noise impacts; risks of disease and escaped exotic species; and limitations of public use, particularly on recreation, tourism and fishing.

Recommendations:
RAC recommended the establishment of a national, strategic approach to coastal zone management, the National Coastal Action Program. The objectives of this would include the fair and equitable public and commercial use of the coastal zone, and the maintenance (or restoration) of the ecology, biodiversity and water quality of coastal ecosystems. The outcomes would include a sounder base for the development of fish and shellfish farming.

Aquaculture ponds, rafts, racks, cages and other equipment may be unsightly, reducing the aesthetic value of a waterway, as in the case of some oyster farms in New South Wales. Native species of fish, shore and wading birds, seals and others animals which naturally prey on the cultured species may become pests, and require controls. The use of chemicals to control diseases may pose problems to farmers, to consumers and possibly to the environment, through waste water discharges. There is currently no Australian register of chemicals for use in aquaculture.

The Working Group on Aquaculture recommended that these problems could be addressed through government and industry licensing conditions which ensure the industry operates within acceptable social and environmental standards; development by industry of codes of practice to ensure high levels of compliance; research into reducing nutrient outputs; guidelines for monitoring of discharges; standards for therapeutic chemicals; and a register of these chemicals.



(Source: BRS)

Figure 35.3: The Pacific oyster, *Crassostrea gigas* (right) which was introduced into South Australia for aquaculture has become feral. It has spread along the south-eastern coast to southern Queensland, displacing native *C. commercialis* (left) in many areas.

Quarantine and movements

Australia is free of most of the diseases which affect aquafarms in other countries and the accidental importation of infectious diseases could jeopardise the future growth of the industry (Chapter 48). The Working Group on Aquaculture recommended that all schedules of the *Wildlife Protection (Imports and Exports) Act* be reviewed; appropriate risk assessment protocols for importation and intra and interstate movement of organisms be implemented; and industry and public awareness of these risks be raised.

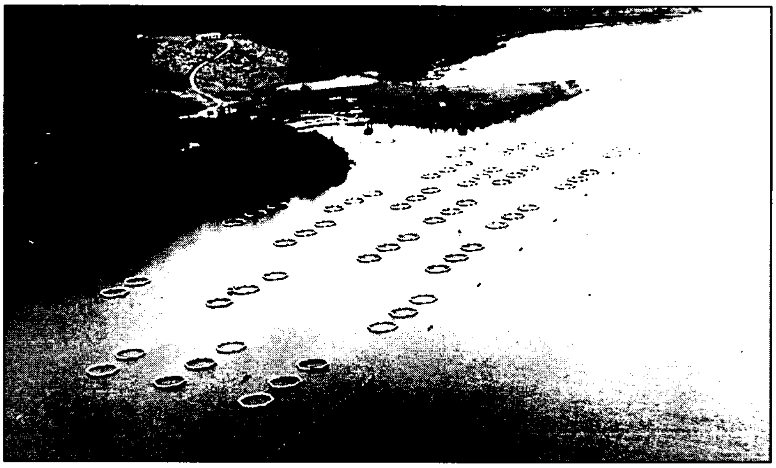
Genetically modified stocks

At present Australian aquaculture is based largely on the farming of wild animals but significant productivity gains are possible through selective breeding or genetic manipulations. The possibility of the escape of modified organisms raises issues on the protection of the genetic integrity of ecosystems. The Great Barrier Reef Marine Park Authority has been concerned about the restocking of reefs with cultured giant clam species, and has suspended research on the use of biological controls for crown-of-thorns starfish because of possible adverse environmental effects.

The Working Group on Aquaculture recommended that industry and public awareness on the potential benefits and hazards of selective breeding and genetic manipulation be enhanced, and that the guidelines set by the Genetic Manipulation Advisory Council be adhered to.

Relationships with capture fisheries

Aquaculture and wild fisheries in Australia currently regard themselves as competitors for resources and markets. To ensure cooperation in research, the Working Group on Aquaculture recommended that the potential of aquaculture to benefit fisheries through stock enhancement be explored; that management plans for common-property fisheries resources should encompass the needs of both sectors; that consultation between government and commercial sectors to resolve issues; and that management plans should include risk assessments on the potential impacts of cultured animals on the health and integrity of wild fish stocks.



(Source: DPIE Tasmania)

Figure 35.4: Salmon farming, south-east Tasmania.

Summary and conclusions

1. Positive environmental consequences of aquaculture include the production of juveniles of overexploited species for restocking purposes; reduced fishing pressure on wild stocks; an increased scientific understanding of the species; and better management of wild stock.

2. Negative environmental consequences include demand for coastal foreshores, mangroves and saltmarshes for aquafarms; production of wastes from intensive cultivation which induce eutrophication; unsightly rafts, cages and other equipment which reduce aesthetic values; culling of native predators; use of chemicals to control diseases; and the possibility of escape of introduced or genetically altered species. Recommendations have been made by the Working Group on Aquaculture to address negative impacts.

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Acknowledgments:
The technical paper by Dr P. Rothlisberg, J. Gillespie and C. Barlow was reviewed by D.J. Staples, Fisheries Resource Branch, Bureau of Resource Science, Canberra, and Professor A. Gilmour, Centre for Environmental studies, Macquarie University, NSW.

Chapter 36. Shipping and ports[1]

Because Australia is an isolated island continent with a long coastline, shipping and ports constitute a major use of its coastal waters. The marine transport industry is probably worth more in economic terms than any other use, including fishing and tourism. Each year there are around 12,000 overseas shipping calls to Australian ports, and around 350 million tonnes of freight is carried. In terms of tonnage carried and distance travelled, Australia ranks as the fifth-largest user of shipping in the world.

Shipping and port operations present significant potential for environmental impacts to the marine environment. For example, over 2,000 large ships transit the sensitive Inner Route of the Great Barrier Reef each year, and around 1,800 use Torres Strait. Shipping generates several sources of 'operational' pollution, including potentially contaminated ballast water, sewage, garbage and waste oil, and presents the potential for accidental spillage of fuel oil and hazardous cargoes such as oil and other chemicals. In addition effects such as propellor-wash suspension of bottom sediments may cause deleterious environmental impacts.

Ports are amongst the most polluted areas in Australia. The impacts of port operations include disturbance and transport of marine sediments from dredging and dredge-spoil disposal operations, physical alteration of the coastal environment from port expansion and generation of chemical pollution.

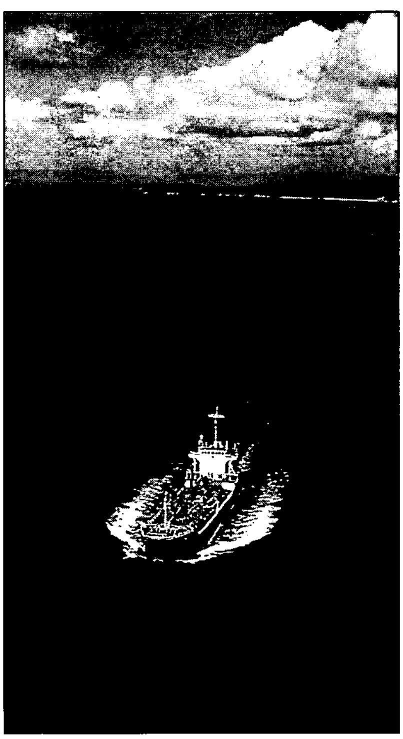

(Source: GBRMPA)

Figure 36.1: Australia is the fifth-largest user of shipping in the world. Bulk carrier at sea.

In this chapter the general importance of shipping and ports in Australia, and some of their effects on, and threats to, the marine environment are described. Because of the international nature of much of the shipping in Australian waters, and the difficulties this creates in its management, the international conventions for the management of pollution from shipping are described. Details of the various environmental impacts of ports (such as oil pollution, tributyl tin pollution and loss of habitat) are discussed in later chapters.

Shipping and effects on the marine environment

Under the 1982 Convention on the Law of the Sea, ships have the right of 'innocent passage' (i.e. not prejudicial to the peace, good order or security of the coastal state) across territorial and international waters. International conventions have been established to ensure these ships do not pollute the international or territorial waters.

Shipping lanes run around the entire coastline of Australia but the greatest shipping concentration occurs in the south-east, between Brisbane and Adelaide (Figure 36.2).

Australian registered ships

In 1990 the Australian trading fleet comprised 94 vessels in excess of 150 gross tonnes and around 6,550 smaller ships.

Table 36.1: Ships registered in Australia, 1990

	commercial	govt.	fishing	pleasure	total
Qld	284	28	628	944	1,889
NSW	239	3	272	1,357	1,877
Vic	104	5	177	453	743
Tas	56	4	214	170	444
SA	40	3	262	210	515
WA	126	3	382	427	943
NT	18	1	56	159	236
total	867	47	1,991	3,720	6,553

[1]Based on a paper by S. Raaymakers, Great Barrier Reef Marine Park Authority, Townsville, Queensland and Dr L. Zann, SOMER Coordinator.

(Source: DTC and NATPLAN)

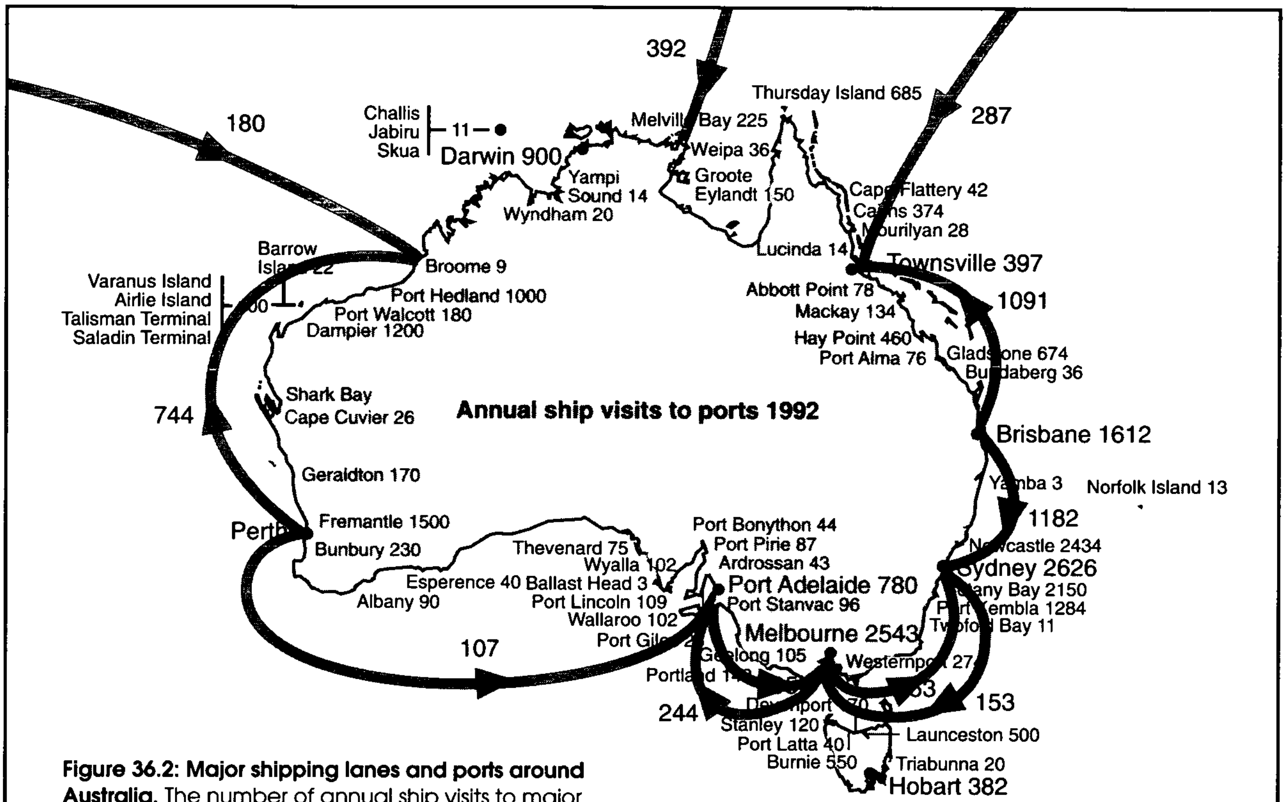


Figure 36.2: Major shipping lanes and ports around Australia. The number of annual ship visits to major ports are indicated (1992). Arrows show petroleum tanker movements to each region (1988).

Overseas shipping

Each year around 12,000 overseas ships arrive in Australia. These vessels are registered in around 25 different countries, the major ones being Panama, Japan, Philippines and Liberia.

The main types of inward shipping are tanker (13 million tonnes), bulk carrier (10 million tonnes) and general cargo (9 million tonnes). The main types of outward shipping are bulk carrier (2.5 million tonnes), general cargo (14 million tonnes) and oil tanker (8 million tonnes).

Overseas cargoes

A great variety of cargo is carried in Australian waters. Raw materials make up the bulk of outward cargoes. Major cargoes are agricultural products such as textiles (worth $6 billion), cereals ($3 billion) and meat ($2 billion); and minerals such as coal ($3.5 billion), non-ferrous metal ($4 billion), metal ores ($3 billion) and petroleum products ($4 billion).

Manufactured products make up the bulk of inward cargoes. Major cargoes include vehicles ($5 billion), industrial machinery ($2 billion), petroleum products ($2 billion), textiles and clothing ($2 billion), and electrical goods ($1 billion). Organic chemicals ($850 million), inorganic chemicals ($360 million) and chemical materials and products ($500 million) are also imported by sea.

Ship-sourced pollution

Operational discharges from ships and spills of oil and hazardous chemicals from accidents at sea are significant threats to the marine environment.

Ballast water

The introduction of exotic organisms in ships' ballast water is a serious quarantine problem in Australia. Several species already introduced in southern States have serious economic and ecological impacts, and the potential for human health impacts. The potential impacts of ballast water introductions may be far more serious than the impacts of other forms of ship-sourced pollution such as oil spills, as they are usually permanent and irreversible (Chapter 48). The Australian Quarantine and Inspection Service (AQIS) is conducting periodic sampling of ships for toxic dinoflagellates at major ports (Chapters 14 and 48).

Oil spills

Oil spills from operational discharges and accidental loss during bunkering and from groundings and collisions are a serious hazard adjacent to major shipping lanes and near ports, particularly in the busy and dangerous channels of Torres Strait, the Inner Route of the Great Barrier Reef and Bass Strait. The frequency and volume of shipping through the Inner Route and its highest rate of collisions and groundings per unit shipping in Australia poses a very real risk of

Safety at sea: 'Ships of Shame'

The loss in close succession of six bulk carriers off the Western Australian coast over 18 months of 1990-91 resulted in an inquiry by the House of Representatives Standing Committee on Transport, Communications and Infrastructure on ship safety in 1992. Its findings were alarming from both a safety and environmental perspective. The world's bulk carrier fleet is aging and many vessels have been transferred from the major shipping nations to 'flags of convenience' registries in nations with less rigorous operational and safety standards. Vessels in a weakened condition due to age and wear and tear were literally falling to pieces on the high seas. Worldwide, 47 dry bulk carriers had sunk between 1988 and 1991 with the loss of 149 lives and 2.6 million tonnes of cargo. Crews were often poorly trained and abused by officers; classification societies were providing false papers; the safety equipment was substandard; and there were many other problems. The Inquiry made wide-ranging recommendations to the International Maritime Organisation and the Australian Maritime Safety Authority, many of which have already been implemented.

a major oil spill on the Great Barrier Reef (Chapters 39 and 69).

Current measures for preventing oil spills rely heavily on traditional navigation technologies where human error is a weak link in the system. Current arrangements for responding to oil spills are reliant on essentially primitive and ineffectual technologies, with chemical dispersants forming the main response tool.

Hazardous chemicals
A variety of hazardous chemicals are carried in Australian waters, with the potential for accidents resulting in spills. Little is documented on the types, quantities and routes of chemicals carried in Australian waters, and of the likely impacts or appropriate response options should a hazardous chemical spill occur.

Garbage
Despite legislation regulating the disposal of garbage from ships at sea, including a total ban on disposal of plastics, much of the Australian coastline and even offshore coral cays are littered with ship-sourced garbage including plastics (Chapter 46).

Sewage
Ships generally discharge raw sewage directly into the sea. The quantity of sewage generated by ships at sea in relation to the volume of water does not represent a significant environmental impact. However, sewage discharge around ports and other destinations may present significant local environmental and health issues.

Anti-fouling paints
Tributyl tin (TBT) used in anti-fouling paints is environmentally hazardous. TBT is now banned on vessels less than 25 metres in size in most places but may still be used on ships greater than 25 metres as they are not considered to remain in port long enough for significant leaching to occur, and because the economics of switching to a new system are still not considered favourable (Chapter 44).

(Source: G. Abraham)

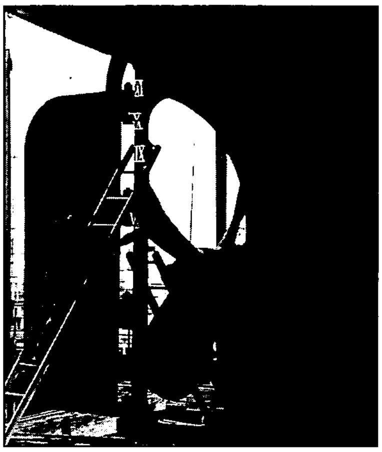


Figure 36.3: Antifouling paints release toxic substances to keep ships' hulls free of attached organisms.

Prop-wash suspension
The shallow nature of some coastal waters (generally <40 metres) means that large ships often suspend bottom sediments, with clearly visible suspended sediment plumes being left in their wake. This has the potential for a number of impacts, including disturbance of the benthic flora and fauna in the sediment being suspended, temporary light attenuation over adjacent benthic communities, settlement of the suspended sediment onto adjacent benthic communities, a general increase in the mobility of sediments and their susceptibility to resuspension.

Environmental effects of ports

There are 68 main ports around Australia handling around 380 million tonnes of cargo each year. The largest ports, in terms of cargo loaded, are Port

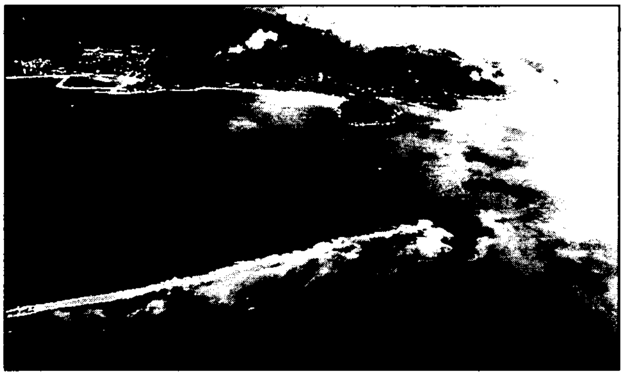
Hedland and Dampier (WA), and Hay Point (Qld). In 1992 the largest ports, in terms of ship visits, were Sydney (2,626), Port Melbourne (2,543), Newcastle (2,434) and Fremantle (1,500).

Australian ports are managed by independent corporations, statutory port authorities or State/Territory maritime authorities. Port activities with the potential for impacts on the environment often require approvals and permits under various State/Territory and Commonwealth legislation, and research and monitoring studies are often required.

Table 36.2: Overseas ship and cargo movements in Australian ports 1990/91

	arrivals		departures	
	no. ships	cargo ('000t)	no. ships	cargo ('000t)
Queensland				
Brisbane	1,195	2,262	1,178	6,160
Cairns	106	91	103	540
Townsville	344	533	336	1,703
other	1,290	660	1,206	64,322
total	2,935	3,546	2,877	72,725
NSW				
Sydney	1,115	6,363	1,060	4,258
Botany Bay	572	50	550	270
Port Kembla	280	1,028	279	9,725
Newcastle	713	1,631	719	30,846
other	95	1,903	95	1,019
total	2,775	10,975	2,703	46,118
Victoria				
Melbourne	1,388	5,049	1,431	3,653
Geelong	254	2,308	258	1,753
other	231	485	222	3,415
total	1,873	7,842	1,911	8,821
Tasmania				
Hobart	131	121	135	238
Launceston	160	110	150	2,835
Burnie	136	95	136	371
other	94	54	85	2,839
total	521	380	506	6,283
South Australia				
Port Adelaide	421	742	410	1,449
Port Pirie	45	28	51	636
other	243	1,719	237	3,192
total	709	2,489	698	5,275
Western Australia				
Fremantle	1,123	1,258	1,122	8,360
Port Hedland	367	135	357	32,514
other	1,184	5,358	1,210	80,569
total	2,674	6,751	2,689	121,443
Northern Territory				
Darwin	173	296	171	1,475
other	171	875	172	5,142
total	344	1,171	343	6,617
Total Australia	11,831	33,155	11,727	267,284

(Source: ABS 1991)



(Source: Townsville Port Authority)

Figure 36.4: Spoil from channel dredging may increase turbidity and smother benthic communities. The effects of dredge silt from Townsville's shipping channel on coral reefs of Magnetic Island (background) are being monitored.

Pollution from ports

In general, the most highly polluted marine areas around Australia are adjacent to ports and major urban areas. Ports can be significant sources of pollution as they are often located in enclosed harbours, bays, estuaries or river mouths and adjacent to large urban areas. Port sediments are often contaminated with a variety of chemicals from urban run-off, industrial discharges, sewage outlets, spillages during ship loading and unloading operations, run-off from slipways, sandblasting and painting facilities, and leaching of antifouling from vessels.

Ports are often chronically polluted by hydrocarbons. Globally, it has been estimated that 83% of all accidental oil spills from ships occur during fuelling and loading or unloading operations in port.

Dredging and sea dumping of dredge spoil can disturb and release contaminants contained in port sediments. The sediments themselves can act as pollutants, increasing turbidity and causing physical impacts on benthic communities from smothering.

Sea dumping of wastes

A common method of disposing of a variety of wastes generated by industry and other activities of modern society is to dump them at sea. Such wastes include radioactive materials, chemical wastes from factories and industrial plants, garbage from cities, sewage sludge from cities, dredge spoil and old ships and aircraft.

In response to increasing concerns about the environmental effects of such sea dumping, in 1972 the British Government sponsored a United Nations Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter. This resulted in 1975 in the London Dumping Convention which

provided an international regulatory regime for the control of sea dumping.
The London Dumping Convention specifies three lists (Annexes) of substances:

- Annex I - substances that are prohibited from dumping at sea.
- Annex II - substances that can only be dumped subject to special conditions.
- Annex III - substances that can be dumped subject to routine assessment and permission.

The London Dumping Convention, recently simplified to the London Convention, also provides guidelines for the assessment of sea dumping proposals and the issue of permits to control sea dumping. It is implemented in Australia by the *Environment Protection (Sea Dumping) Act* 1981. This Act is administered Australia-wide by the Commonwealth Environment Protection Agency (CEPA), and in the Great Barrier Reef Marine Park by the Great Barrier Reef Marine Park Authority.

The Act generally requires all possible alternatives to sea dumping to be considered and adopted, if feasible, before sea dumping permits will be issued. Since 1984, when the Environment Protection (Sea Dumping) Act came into force, 135 sea dumping permits have been issued in Australia. These include 79 for dredge spoil, 15 for industrial waste (including jarosite from metallurgical process, process liquor from paper making and spent caustic soda), 14 for old or wrecked vessels, 6 for burials at sea and 21 for solid wastes such as car bodies, demolition materials and rubber tyres, often used for development of artificial reefs.

The dumping of industrial wastes can cause serious environmental impacts through chemical pollution of the oceans, sea dumping of dredge spoil can cause impacts on marine organisms and habitats and amenity of an area, through release of any contaminants that might be contained in the spoil, and through increasing turbidity and sedimentation.

Sea dumping of industrial waste will be prohibited by the London Convention by 1995, and new guidelines are being developed for the dumping of dredge spoil.

Environmental management of shipping and ports

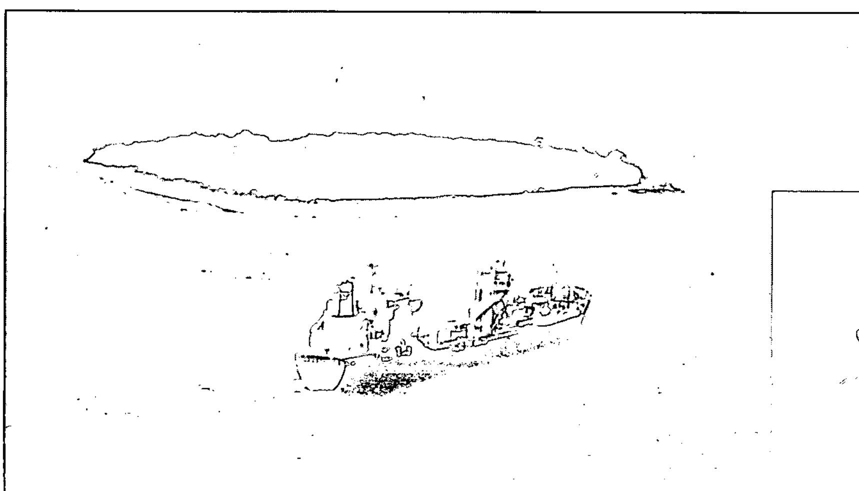
National responsibility for the management and regulation of ship-sourced pollution in Australia rests with the Australian Maritime Safety Authority (AMSA), a Commonwealth government business enterprise formed from elements of the Department of Transport and Communications in 1991. The overall role of AMSA is to deliver safety in navigation and related services to the Australian maritime industry, in an efficient and cost-effective manner. AMSA includes a Marine Environment Protection unit, which has responsibility for implementating, administering and enforcing of Australian legislation, implementing international marine pollution conventions such as MARPOL, and managing Australia's National Plan to Combat Pollution of the Sea by Oil.

Because of difficulties in managing shipping in territorial waters, Australia has adopted a number of international conventions covering marine pollution.

Monitoring and environmental reporting

Despite the high economic value of shipping and ports, and the high actual and potential environmental impacts, marine transport receives relatively little attention from environmental management agencies in

(Source: Gladstone Observer, GBRMPA)



a

(Source: L. Zann GBRMPA)

b

Figure 36.5: Bulk ore carrier *TNT Alltrans* stranded on the Great Barrier Reef, 1985 (a). The cause was human error. Reef-edge corals were severely damaged (b).

International conventions related to marine pollution

MARPOL 73/78
This convention defines pollutants and specifies when, where and how a substance can or cannot be discharged into the sea. MARPOL 73/78 contains five annexes:
Annex I: Oil (oil mixtures, distillates, gasoline etc)
Annex II. Noxious liquid substances (mainly chemicals, including acids, alcohols, castor oil, hydrogen peroxide, pentanol etc)
Annex III. Harmful substances carried in packaged forms (freight containers, portable tanks etc)
Annex IV. Sewage (wastes from any form of toilets, drainage from medical premises, drainage from spaces containing live animals etc)
Annex V. Garbage (plastic bags, synthetic ropes, food wastes, paper products, glass, metal, crockery, packaging material, synthetic fishing nets etc)

Under Annexes I, II and IV, most vessels are subject to regular surveys to ensure compliance. Under Annex V the disposal of plastics at sea is totally prohibited.

MARPOL regulations also specify arrangements for the disposal of marine pollutants, criteria for design, construction, equipment and operation of ships (including double hulls), and recording and reporting procedures.

MARPOL generally prohibits the discharge of any substance within 12 nautical miles of the nearest land, and oil tankers are prohibited from discharging within 50 nautical miles of land. There is a total ban on discharges within the Great Barrier Reef Region.

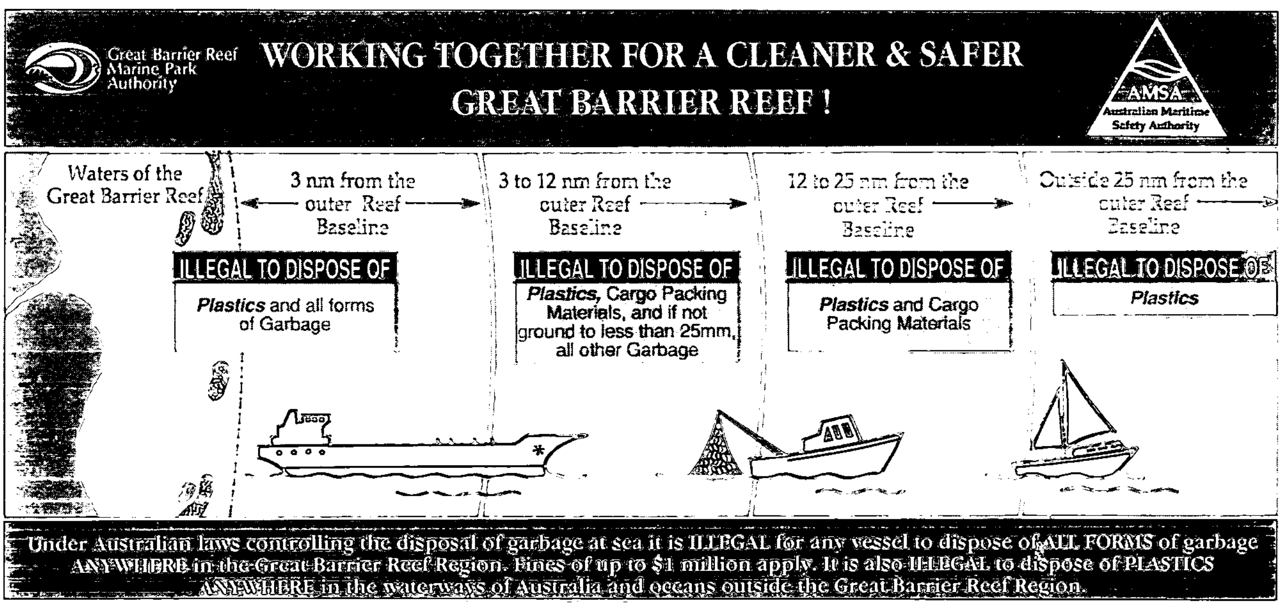
Australian legislation under MARPOL *The Protection of the Sea (Prevention of Pollution from Ships) Act* 1983, the *Navigation (Protection of the Sea) Amendment Act* 1983) provides for penalties up to $200,000 for an individual and $1 million for companies failing to comply with the regulations.

CLC (International Convention on Civil Liability for Oil Pollution Damage) is designed to ensure adequate compensation is available to persons suffering damage from oil pollution. Ships carrying over 2,000 tonnes must maintain adequate insurance cover, with liability being placed on the ship's owners. The 1992 Protocol to the Convention raised the limit of compensation to around $120 million. In Australia the convention is given effect by the *Protection of the Sea (Civil Liability) Act* 1981.

INTERVENTION (Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties) and its amending protocol relating to other pollutants, authorises governments to take measures on the high seas to protect their coastline and related interests such as fisheries, tourism and the environment. Measures include moving, removing the cargo, sinking or destroying the ship. The *Protection of the Sea (Powers of Intervention) Act* 1981 gives effect to the convention.

OPRC (International Convention on Oil Pollution Preparedness, Response and Cooperation) makes provision for international cooperation in combating oil spills. It largely resulted from the major disasters of *Exxon Valdez* and *Kharg 5* which overwhelmed the local response capability, and it was also applied in the Arabian Gulf during the Gulf War.

FUND was established as a regime for compensating victims of an oil spill (fishers, resorts etc), and covering the costs of clean-ups at sea and on beaches when the compensation by CLC is inadequate. It is financed by levies on major importers of oil. Compensation available under FUND is around $120 million. The *Protection of the Sea (Shipping Levy) Act* 1991 and the *Protection of the Sea (Shipping Levy Collection) Act* 1981 apply.



(Source: GBRMPA)

Figure 36.6: Regulations on disposal of rubbish at sea. A GBRMPA/AMSA sticker for boats in Queensland.

Australia in terms of research, monitoring and management effort. This is perhaps because other government agencies such as the Australian Maritime Safety Authority (AMSA) are perceived as being responsible for the management of shipping.

Because the activities of agencies such as State transport authorities and AMSA are primarily concerned with provision of transport infrastructure and safety of navigation, rather than protection of the environment, and because both shipping and ports have a significant and ever increasing potential to cause impacts on the environment, it is necessary that management agencies conduct coordinated research and monitoring of shipping and port activities in order to assist in their ecologically sustainable development.

Information on shipping (e.g. vessel movements, weights, cargoes, values, ports) is maintained by port authorities and is reported annually by Australian Bureau of Statistics. AMSA maintains a database, called OILSPILL, on all marine oil spills from all sources in Australia.

Summary and conclusions

1. As an island nation, Australia is very dependent on shipping for the conduct of trade. Around 350 million tonnes of freight are handled each year.

2. Shipping generates a number of actual and potential environmental impacts including operational pollution from sewage discharges, transport of organisms in ballast water, disposal of garbage and discharge of waste oil, and the accidental spillage of oil and hazardous cargoes.

3. The introduction of foreign organisms in ships' ballast waters may constitute a very serious threat to Australia's marine environment at this time.

4. The risk of major marine oil spills from shipping accidents remains a major threat to vulnerable areas such as the Great Barrier Reef and Torres Strait.

5. The international nature of the shipping industry, the significance of economics to the industry and the continuous nature of the marine environment pose a number of difficulties for the management of the environmental impacts of shipping.

6. The impacts of port operations include disturbance and transport of sediment from dredging and dredge spoil disposal, physical alteration of the coastal environment and habitat destruction from port expansion and generation of chemical pollution.

7. Technological, engineering and management solutions exist to prevent, minimise or mitigate these impacts, as long as there is commitment of adequate resources and management effort.

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Acknowledgments:
This chapter was reviewed by the Australian Maritime Safety Authority, Canberra.

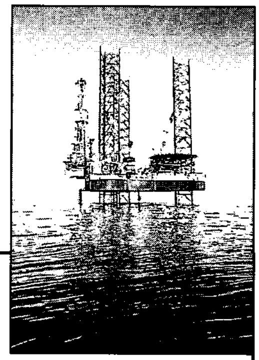
Chapter 37. Offshore petroleum exploration and production[1]

Offshore petroleum is a major industry in Australia. During the past 30 years more than 1,100 wells have been drilled offshore and 2,800 million barrels of oil, worth around $120 billion in current values, have been extracted. In 1992/93 exports of petroleum products were worth $4.5 billion, or equivalent to those of gold or meat, and around 10,000 people were directly employed in the industry. Australia is 82% self-sufficient in liquid fuels, of which 88% is provided by offshore fields.

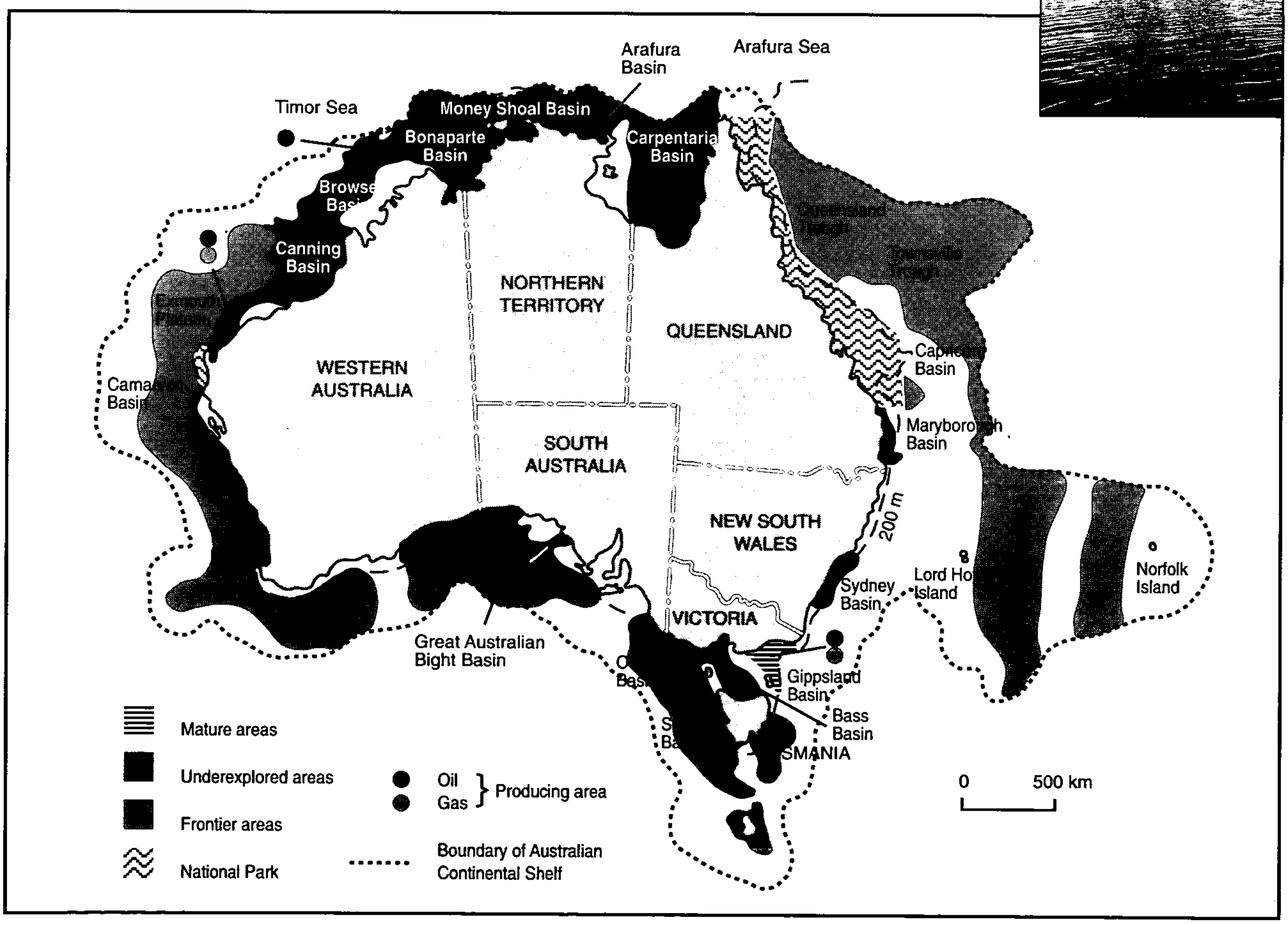
Offshore oil exploration is conducted using mobile drilling rigs. These exploration wells are often plugged and abandoned even after a discovery has been made. Offshore oil production usually occurs from platforms which are fixed in place and convey the oil from the developed wells to storage.

While offshore oil exploration, production and transport each pose potential environmental problems, the Australian offshore oil industry has an excellent safety and environmental record. Since the beginning of offshore exploration, a total of only around 800 barrels of crude oil have been spilt into the marine environment. But despite this, many conservationists still perceive offshore petroleum

Figure 37.1: Australia's offshore petroleum exploration status. Note: Not all offshore Territories or the Australian-Indonesia Zone of Cooperation are shown (Redrawn from DPIE 1990). (Inset): Offshore rig, Western Australia.



(Source: Lochman Transparencies)



(Source: DPIE)

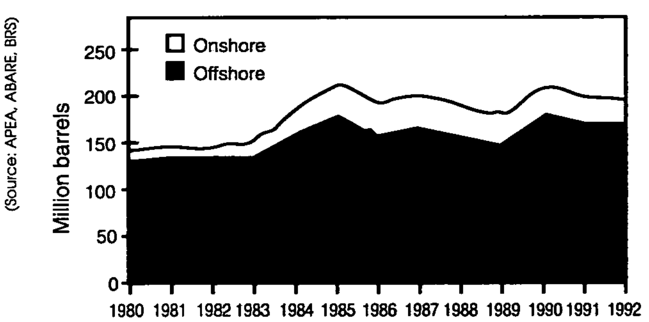
[1]Based on a paper by J. Beck, Australian Petroleum Exploration Association, Sydney, New South Wales; and other sources.

exploration and production as a major threat to Australia's marine environment (Chapter 38).

Because of conservationists' concerns on offshore petroleum, in 1992-93 the Australian Petroleum Exploration Association (APEA) co-funded with the Energy Research Development Corporation an Independent Scientific Review Committee (ISRC) to assess the environmental effects of the offshore industry. This chapter briefly describes the offshore oil industry in Australia and presents the major findings of the scientific review.

Australia's offshore oil industry

Australia's remaining oil and gas reserves, both economic and uneconomic, are estimated to be around three billion barrels of crude oil and condensate and 72 trillion cubic feet of natural gas. Over 90% of both the oil and the gas reserve lie below the seabed of our continental shelf. Over 2.8 billion barrels of oil have been extracted to date. The gap between demand and supply for liquid fuels has been relatively constant over recent years.



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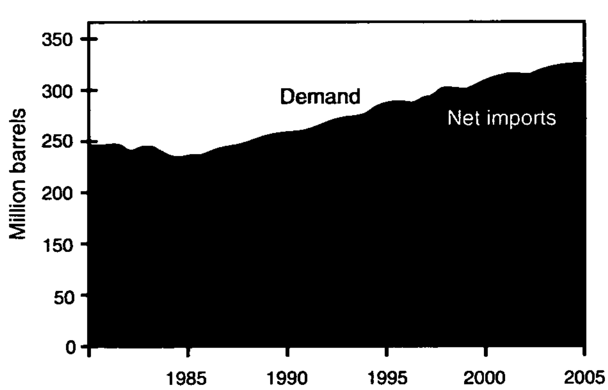

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Figure 37.2: (a) Oil/condensate production in Australia. (b) Past and projected future trends in supply and demand for crude oil in Australia. The gap between supply and demand is increasing and net crude imports are expected to increase at a rate of 7% pa. New developments, particularly from fields which have been discovered offshore north-west Australia are expected to be the main source of increased production in the future. This assumes that new discoveries are made and developed.

Offshore fields

A comparatively small area of Australia's shelf has been explored in detail. Much of the exploration effort has been concentrated in Bass Strait, the offshore Carnarvon Basin off Western Australia and the offshore Bonaparte Basin off Western Australia and the Northern Territory.

Bass Strait

Petroleum production in Bass Strait is from a shallow, rectangular basin around 400 kilometres east-west, by 200 kilometres north-south, off the Gippsland coast of Victoria. In 1992 the area yielded 107 million barrels of oil/condensate, and 195 billion cubic feet of natural gas.

This area is a biologically diverse, temperate shelf. The adjacent coastline is sandy with a high wave energy, backed by an extensive dune and lake system.

Offshore Bonaparte Basin

Situated between north-western Australia and Timor Island, the Bonaparte Basin is around 0.26 million square kilometres in area, with exploration in water depths up to 1,000 metres. In 1992 the offshore area yielded 24.7 million barrels of oil/condensate.

This area contains a complex series of offshore reefal shoals and islets. The adjacent Western Australian coastline includes the Buccaneer and Bonaparte Archipelagoes, and the Kimberley and Joseph Bonaparte Gulfs.

Offshore Carnarvon Basin

The offshore Carnarvon Basin extends over 1,400 kilometres of the Western Australian coastline, and covers an area of 0.54 million square kilometres. A submarine shelf extends out at depths of over 1,000 metres to the Exmouth Plateau. There are several small platforms producing oil and gas in the field, and the large North Rankin platform which produces gas and condensate for domestic use and for export.

With a capital cost of $12 billion, the North-West Shelf natural gas project is the largest single development program ever undertaken in Australia. It will include two platforms, a 134 kilometre submarine pipe line, an onshore gas plant, and liquid natural gas (LNG) tankers to supply gas to the power utilities in Japan. Production in 1992 was 39.2 million barrels of oil/condensate, 118 billion cubic feet of natural gas, and 187 billion cubic feet of liquefied natural gas.

This area contains a number of reefs and islands. The adjacent coast includes narrow sandy beaches backed by dunes or tidal flats.

Potential environmental impacts

Offshore petroleum industry operations involve seismic surveys, drilling activity, development, production and transport, all of which potentially involve some environmental risks.

(Source: APEA)

Table 37.1: Extent of offshore petroleum exploration and development in Australia, 1977-1991

Activity	1977-81	1982-86	1987-91
Length of seismic records (km)	166,596	154,550	338,936
Exploration & development wells	85	200	203
Production wells	48	116	93

Seismic activity

Seismic surveys use reflected noise pulses to determine the stratigraphy of rock beneath the sea floor. A seismic cable trailed behind a vessel emits intense noise pulses generated by compressed air. Eggs, larvae and adult fish and crustaceans in close proximity, less than a few metres, may be physically damaged but effects outside around five metres are negligible. Communications and behaviour of marine mammals in the vicinity may be disturbed.

Most companies consult with fisheries and environmental authorities and other groups before conducting seismic surveys. Other measures that companies may adopt include conducting surveys outside whale migratory routes, and actively avoiding whales during operations. Regulations or directions may also impose restrictions on seismic activity, for example during crayfish season in Western Australia, and in whale calving areas.

Development

Erection of platforms and laying of pipes cause localised damage to the benthos. Once positioned, they serve as substrates for encrusting species, and shelter for mobile species, eventually becoming artificial reefs. Near Bass Strait platforms seals often rest on supply boat mooring buoys, and the surrounding areas of some North West Shelf platforms are said to be popular fishing spots.

Pipelines may be laid along the seafloor or buried in trenches. Issues in laying and retrieving pipelines include cost, safety, fishing interests and the environmental impacts. In trawling grounds, pipes may be buried to prevent net snags.

Production

'Produced water', which is present with the oil and gas, is separated at the surface and discharged back into the sea, carrying with it traces of hydrocarbons, and chemicals used as biocides, corrosion inhibitors and oxygen scavengers. Low levels of contamination are found in sediments in the vicinity of discharge points. Where oil-based drilling fluids have been used, they may be detected up to 1,000 metres away. Environmental impacts are reduced through oil separation equipment, and discharge pipes are placed to maximise dispersal in the sea, and to avoid sensitive sites.

Mixtures of fluids which are oil - or water-based are used in the drill pipes to cool and lubricate the drill 'bit', to maintain head pressure to prevent a back flow of petroleum, and to carry drill cuttings to the surface. APEA surveys indicate that nearly all of drill fluids used in Australia are water-based and are environmentally less harmful than oil-based fluids. These are controlled under the Commonwealth *Petroleum (Submerged Lands) Act* 1967. Typical drilling fluids may contain barite sulphate (63% by volume, non-toxic), bentonite clay (24%, non-toxic), ligno-sulphonates (2%, moderately toxic), lignite coal (1.5%, non-toxic), sodium hydroxide (1%, toxic but rapidly dispersed in sea water), and various additives (8%, ranging from non-toxic to toxic).

Monitoring of drill fluid dilution rates in Exmouth Gulf (WA) indicates that discharges reach background suspended solid levels within 560 metres of the discharge point. A fluid dispersal simulation conducted by Esso in Bass Strait found concentrations below acceptable acute toxicity levels within 20 metres of the discharge point and rapid returns to normal levels upon cessation of discharges. Cuttings of rock are discharged overboard and settle to the seafloor forming mounds. Monitoring in the North West Shelf indicates that the mounds cover a limited area (average 70 metres x 30 metres), and that impacts are direct burial and increased turbidity. Overseas studies indicate that physical effects on corals are restricted to a 500 metre radius of the platform.

Service vessels

The vessels regularly servicing platforms have the potential to damage the environment through anchor damage, groundings, litter, sewage and hydrocarbon pollution. In the North West Shelf there are bans on anchoring near coral reefs and fishing from service vessels. In all situations the disposal of wastes from vessels and platforms is banned under MARPOL (Chapters 36 and 39).

Decommissioning

No platforms have yet been decommissioned in Australia. Under International Maritime Organisation (IMO) guidelines for decommissioning oil platforms, adopted in Australia's Petroleum (Submerged Lands) Act, offshore facilities are to be completely removed, except in certain circumstances where partial removal is permitted. Wells are to be plugged with cement below the seabed, and obsolete pipes are to be flushed, sealed and either removed, left in place, or buried.

Policy: Commonwealth Offshore Exploration Strategy

The Commonwealth's Offshore Strategy for promoting petroleum exploration was released in 1990 (DPIE 1990). Its goal is to 'maximise the contribution the petroleum industry makes to the wellbeing of all Australians', through the release of offshore exploration areas to companies, by providing geological and geophysical data, and by offering title and taxation incentives. Titles for exploration permits, retention leases and production licences give exclusive rights for hydrocarbon production over the title area.

There are twice yearly releases of areas for bids to undertake petroleum exploration in offshore areas of Australia. An information package including guidance notes on environmental arrangements is released at the same time and widely circulated. Where an exploration permit holder makes a commercial discovery, there is a right to a production licence over the discovery but production can only proceed subject to prior approval of development plans. Applications for approval are considered in accordance with the principles of ecologically sustainable development.

Offshore petroleum exploration and production activities are undertaken subject to the provisions of Commonwealth legislation which provides for the protection of the environment (see Offshore petroleum legislation, below). The Minister for Resources may require that special environmental protection operating conditions are applied to an exploration permit area. These conditions can be tailored to suit the unique environment of an area or the multiple marine uses within the area. Occasionally offshore areas may be released where the Minister for Resources indicates that the *Environment Protection (Impact of Proposals) Act* 1974 is likely to be invoked prior to approval to drill the first well in the permit area.

(Contributed by Petroleum Division, Commonwealth Department of Primary Industries and Energy)

Major findings of the ISRC Report

The review by the Australian Independent Scientific Review Committee (ISRC) on 'Environmental Implications of Offshore Oil and Gas Development in Australia' investigated effects of underwater seismic surveys on biological communities; drilling wells and especially the disposal of drilling fluids and cuttings; production of oil and gas, especially disposal of 'produced water'; construction and operation of coastal support facilities; and oil spills associated with the above, especially likely short and long-term effects on biota. The review excluded oil and gas transport.

The major findings presented at the meeting held at the Australian Academy of Science in August 1993 were:

- there is minimal oil spill threat caused by Australian explorers;
- there is no evidence of harm caused to marine animals by seismic survey activity;
- Australian oil producers are world leaders in produced water treatment standards and technology;
- coastal facilities associated with offshore activities cause minimal marine impacts; and
- offshore drilling has few toxic effects on the marine environment.

Main conclusions of the ISRC report

Oil spills: 'Oil spills from Australian offshore production are relatively insignificant in comparison with chronic sources, particularly the amounts of petroleum hydrocarbons entering the Australian coastal environment from urban run-off and industrial sources.'

Amounts of oil entering from land sources each year (estimated at 16,000 tonnes) are about 200 times greater than the total from 25 years of offshore production. The estimate by the Commonwealth Bureau of Transport and Communication Economics of a 67% risk of a major spill over 20 years is overly pessimistic given Australia's good safety record.

Seismic surveys: 'It is generally accepted that air guns (and related devices) do not pose any significant hazard to marine life - at least in the offshore environment.' Experiments indicate lethal effects only on plankton close to the guns. There is no documented evidence of effects on populations of marine animals.

Drilling activities: 'Acute toxic effects of drilling fluids on marine organisms are found only at very high concentrations, typically observed less than 150 metres from the discharge point, and only for short periods after a discharge.' Physical smothering or burial of benthos and alteration of substrate characteristics are usually the main observable effects of drilling discharges. Impacts are insignificant because of the small number of wells drilled (50 to 100 per year). Potentially toxic chromium lignosulphate is rarely used in Australia.

Production activities: 'Because concentrations of toxic chemicals usually are low in produced formation water

(PFW) and can be diluted rapidly following discharge to the ocean, the risks to plants and animals living in the water column are minor and localised close to the discharge ... '

Australia is a world leader in the treatment of produced water using innovative technology such as hydrocyclones and air stripping. Australian standards for produced water are the highest in the world. No major impacts of production activities have been identified.

Coastal facilities: 'at present there are unlikely to be significant environmental consequences arising from coastal facilities associated with offshore production activities.' Discharges are subject to normal State EPA controls. Impacts are mainly from construction (dredging, sedimentation) and are of short duration. Effects on sensitive habitats can be minimised.

Offshore petroleum legislation

The cooperative arrangements between States/Territories and Commonwealth with respect to offshore petroleum are specifically established under the Commonwealth *Petroleum (Submerged Lands) Act* 1967. The environmental impact assessment for each petroleum exploration and development proposal may be considered under the requirements of the *Environment Protection (Impact of Proposals) Act* 1974, or equivalent State/Territory legislation. Offshore operators are also required to operate under a number of Commonwealth Acts which fulfil the terms of international agreements, e.g. the *Environmental Protection (Sea Dumping) Act* 1981, the *Protection of the Sea (Prevention of Pollution from Ships) Act* 1983, and the *Whale Protection Act* 1980.

Exploration and production oil spills, and management strategies

Accidental oil spills

Oil spills occur during exploration and production as a result of mechanical and human error. Between 1965 and 1991 there were 29 spills greater than 80 litres recorded from Australian offshore operations. These totalled 440 barrels in Commonwealth waters, and around 160 barrels in State/Territory waters. Only one spill resulted in minor beach pollution. The environmental impacts from these incidents are considered to be minor and short-lived.

Characteristics of Australian crude oils

Most Australian crude oils are light (API gravities greater than 40), low-sulphur, and paraffinic. When spilled into the ocean, oils of this type evaporate readily and are easily dispersed with chemicals. While they often contain higher proportions of the more toxic benzene compounds than heavier oils, these are also the most readily evaporated or degraded and any effects would be for a short time period. Heavier crudes weather more slowly and can emulsify or leave residues in the form of tar balls.

Management strategies

While management strategies emphasise mechanisms for the prevention of spills (such as use of automatic shut-down valves), each company is required to have an appropriate oil spill contingency plan which includes equipment for containing and dispersing oil, projections on the spread of oil, and identified sensitive environmental sites. Oil spill response strategies are described in detail in Chapter 39.

Status of knowledge and monitoring

The 1993 ISRC review indicated that while there is a considerable body of knowledge on the effects of various aspects of the offshore petroleum industry, there are also major information gaps. For example, there are few detailed studies on long-term effects of seismic surveys on marine mammals, and particularly on their behaviour; the sound intensities required to produce pathological effects are largely unknown; little is known of chronic effects of drilling fluids and other discharges; and little toxicological work in this area has been carried out in Australia.

The ISRC observed that there had been very little involvement by government and university research groups in environmental aspects of the industry, and emphasised the need for coordinated research. It also found that environmental inventories, in geographic information system (GIS) form, were required to identify the scale of ecological sensitivity for Australia's marine habitats, to map distributions of habitats, and assess risks. Major activities in the production of these inventories include development of appropriate remote sensing techniques, development of a coastal GIS, and development of integrated models of environmental risk.

Monitoring

Petroleum companies are required to monitor and report to State/Territory or Commonwealth regulatory authorities all safety incidents including oil spill incidents. Further conditions may also be imposed which require companies to report marine biological monitoring results; effluent characterisation and/or monitoring results, and pre and post-drilling site surveys.

The ISRC emphasised the need for readily available information on wastes associated with commercial activity. This includes information on chemical composition, toxicity, dilution, distribution, deposition and biodegradation of waste discharges and oil. An appropriate public database could identify physico-chemical compositions and behaviour of dispersed oils from Australian reserves; the toxicity of dispersants; chemical composition of produced waters from various sources; natural weathering rates and environmental fates of Australian crude oils; development of appropriate methodologies for baseline analyses; and development of fluid dynamics models. The ISRC also emphasised the importance of databases for public information and education.

Summary and conclusions

1. Offshore petroleum has great economic and strategic importance for Australia.

2. The Australian offshore petroleum industry has an excellent environmental record. Spills since production commenced 25 years ago have been insignificant (ca 800 barrels).

3. An independent review on the environmental implications of the industry has found that environmental effects of offshore exploration and production have been minimal.

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Chapter 38. Offshore petroleum and marine conservation issues[1]

Despite the negligible amounts of oil spilled in offshore oil exploration and production in Australia, offshore oil drilling has been a major concern of conservationists since the proposal to drill for oil on the Great Barrier Reef in the 1960s. Australian conservationists point to overseas disasters such as the *Ixtoc 1* drilling rig blow out, the largest single spill in history, which released 475,000 tonnes of oil in the Gulf of Mexico. There is also some risk that a major spill could occur from a platform: a risk analysis by the Commonwealth Bureau of Transport and Communications Economics estimated that the probability of a major spill from offshore petroleum platforms and pipelines in Australia over any five year period is 39%, although this estimate is strongly argued by the industry as overly pessimistic.

The previous chapter described the offshore petroleum industry and its environmental impacts on the marine environment. This chapter describes the risk analysis study and presents, without judgement, the differing viewpoints of the petroleum industry, conservationists and marine protected area managers on offshore petroleum exploration and production in marine protected areas (MPAs). The subject was a very controversial one and drafts of the chapter were widely reviewed for objectivity (see Acknowledgments).

Estimated levels of risk of oil spills from offshore platforms

The Bureau of Transport and Communications Economics (BTCE) (1991) estimated that the probability of a major spill (greater than 1,000 tonnes) from offshore petroleum rigs and pipelines in Australian waters was 39% in any 5 year period, 61% in any 10 year period, and 83% in any 20 year period. The risk for platform spills for these periods was estimated to be 26%, 44% and 67% respectively, and for pipeline spills was 17%, 30% and 49% respectively.

The report on 'Environmental Implications of Offshore Oil and Gas Development in Australia' considered that these estimates were overly pessimistic (Swan et al. 1993). The major criticisms were that the study was based on overseas data, and that practices had greatly improved during the 25 years from which the data was taken.

The Bureau of Transport and Communications Economics (BTCE) report did concede that ...'there is evidence that improvements in technology and procedures have led to reduced risk. This has not been quantified and hence contributes to the pessimistic bias in the results.' (BTCE 1991)

Commonwealth policy on mining in Marine Protected Areas

The Commonwealth Government has no defined policy on oil drilling in marine protected areas other than the Great Barrier Reef Marine Park and Ningaloo Reef Marine Park. The following was compiled for SOMER by the Protected Areas Development Unit of the Australian Nature Conservation Agency (ANCA).

With the exception of the Great Barrier Reef (in which oil drilling is specifically prohibited under the *Great Barrier Reef Marine Park Act* 1975) and waters of the Territory of Heard and the McDonald Islands, marine protected areas for which the Commonwealth Government has responsibility are managed in accordance with the provisions of the *National Parks and Wildlife Conservation Act* 1975. This Act specifically prohibits mining activity, including exploration, in Kakadu National Park. The Act also states that:

No operations for the recovery of minerals shall be carried on in a park or reserve (not being Kakadu National Park) other than operations that are carried on, with the approval of the Governor-General, in accordance with the plan of management relating to that park or reserve.

To date, no proposals for mining in parks or reserves declared under the Act have been submitted to the Governor-General for approval.

Plans of Management currently in effect for the National Nature Reserves proclaimed under the Act provide for a 50 kilometre buffer zone around each of

[1]By Dr L. Zann, SOMER Coordinator, from the sources indicated.

the Reserves. ANCA considers that it is undesirable for drilling for petroleum to be conducted in these buffer zones, and considers that any exploration or production permits issued in these zones should be subject to special environment protection conditions.

In accordance with procedures announced in the former Prime Minister's *One Nation* Statement of February 1992, an assessment must be made on the economic potential of an area proposed for reservation as a park or reserve prior to proclamation under the above Act. This process enables areas which may have petroleum or mineral potential to be identified before a decision is made on the reservation of an area for nature conservation purposes. Conversely, there is currently no requirement for an assessment of the nature conservation values of areas proposed for release for exploration or mining activity. However, the Department of Primary Industries and Energy routinely circulates proposals for exploration release areas to relevant State/Territory and Commonwealth agencies for comment in relation to environmental issues.

The debate on oil drilling, threats to the marine environment and marine protected areas

This section presents some of the differing viewpoints of industry, conservationists and environmental managers on the issue of oil drilling in marine protected areas.

Some industry concerns on MPAs

In 1992 the Australian Petroleum Exploration Association (APEA) released a position paper outlining the industry's perspectives on marine protected areas (Wells 1992). The following summarises the major concerns.

APEA stated that it has a demonstrated commitment to the marine environment. Since 1978 it has developed a Code of Environmental Practice to maintain and promulgate desirable environmental standards in the industry. It also recently co-funded the Independent Scientific Review Committee to assess the environmental effects of the offshore industry (Chapter 37).

APEA acknowledged that MPAs may be necessary to protect specific identified values, but considered that their establishment should be based on: clear, scientifically supported objectives for the definition, selection and management of MPAs based within the framework of ecologically sustainable development (ESD); objective assessment of both predictable impacts and unplanned events; and management which is integrated and coordinated at the Commonwealth and State/Territory levels, and adequately funded, monitored and periodically audited.

APEA emphasised that the United Nations Convention on the Environment Agenda 21 (1992) stated that *the nature and extent of environmental impacts from offshore oil exploration and production activities generally account for a very small proportion of marine pollution.* It also pointed to the conclusions of GESAMP (1993) that the environmental impacts of operational discharges from oil and gas exploration and production activities are circumscribed, and smaller than those from other marine activities such as fishing, dredging, and offshore disposal of wastes.

The industry's major concern on the establishment of marine protected areas is that they may preclude oil exploration and production. It regards the exclusion of petroleum exploration and production in the Great Barrier Reef Marine Park as an 'unobjective' decision, and consider that impacts of oil exploration and production are likely to be small compared with permitted uses for shipping and tourism.

In its review of this chapter, APEA submitted: *Industry would rather see the development of a system whereby the sensitivity of particular ecotypes (coral, seagrass, mangroves) is assessed in respect of potential industry activities (seismic, drilling, production). Where activity is proposed within an area where a sensitive ecotype could be impacted, then the responsibility would fall to the operator to institute appropriate mitigating measures, in line with established management objectives. The onus would be placed on the proponent to convince the administering authorities that the risks of impact were adequately addressed. The review of such applications should be conducted on the basis of the available evidence and in a scientific manner, free of preconceived notions as to the outcome.*

Such a system allows industry the freedom to use innovative concepts or new technology to access potential resources without presenting a threat to the aspirations of marine conservation. It would permit the designation of larger areas as marine protected areas without industry objection. It also permits industry the opportunity to assess whether it wishes to meet the financial costs of accessing areas where the presence of significant ecotypes would demand sophisticated measures. (J. Beck pers. comm.).

Some concerns by conservationists on offshore petroleum

Many conservationists view the offshore petroleum industry as an environmental threat. For example, at the Fourth Fenner Conference on the Environment, Olson (1993, p. 17) considered that: *in Australia, offshore oil presents by far the greatest direct threat to the marine environment* but did not elaborate on the reasons for this statement.

At the same conference, Greenpeace Australia also claimed that offshore oil exploration and extraction was a major threat to the marine environment. Greenpeace was particularly concerned with the opening up of *vast areas of the Australian outer* *continental shelf for oil exploration, allowing little consultation with the people who will be affected by this development* (Crew and Fry 1993, p. 61). Greenpeace was highly critical of Australia's offshore petroleum policy and the lack of environmental impact assessments prior to the granting of permits for exploration wells (Crew and Fry 1993).

In a submission to SOMER on issues in the marine environment, the Australian Conservation Foundation also regarded marine oil production as of 'particular concern':

Marine oil production can create special problems for the protection of biodiversity. Pollution from mining operations in the marine environment can occur throughout the life cycle of petroleum products - namely, exploratory drilling, full-scale production; disposal of by-products; transportation and end use of products. The combination of all these inputs can result in considerable direct impacts, but also in sub-lethal and cumulative effects on marine life. (ACF 1994, p. 2).

Perspectives of MPA managers

The former Chairman of the Great Barrier Reef Marine Park Authority, Professor G. Kelleher, contributed the following perspectives from the viewpoint of environmental management:

Marine environmental managers are faced with the difficult task of managing the environment to maintain biodiversity and achieve ecologically sustainable development, while balancing conflicting uses and aspirations. While the economic and strategic value of the Australian offshore petroleum industry is obviously great, and the environmental record of the industry has been excellent to date, the risk of oil spills cannot be considered to be insignificant. Catastrophic blowouts have occurred from offshore drilling rigs in other countries; no major spill has ever been successfully contained before significant damage has occurred; and operational discharges from platforms do cause at least localised impacts.

The environmental value of an area, the local, regional and global importance of its biodiversity, and social and

Submission to SOMER on offshore petroleum

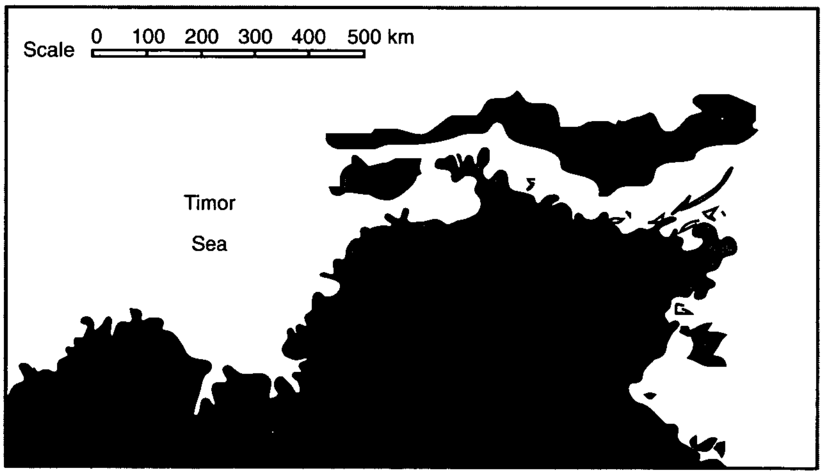
The following concerns were raised in a submission to SOMER by R. Whitling from the Northern Territory. These were responded to in a review of this chapter by APEA and by the Petroleum Division of the Department of Primary Industries and Energy.

(1) The Commonwealth's 1991 'Offshore Exploration Strategy' permits exploration in extensive offshore areas, in which an oil discovery would guarantee development irrespective of the marine environment. It is seen as potentially affecting the establishment of the network of marine protected areas in the Ocean Rescue 2000 program. *(The response of DPIE is that no guarantee of development is given).*

(2) The risk of a major platform spill is understated by industry, given the Bureau of Transport and Communications Economics' estimate of risk. *(The response by APEA and DPIE is that the degree of risk has been overestimated).*

(3) There are inconsistencies in Environmental Impact Assessments among States/Territories, a lack of opportunity for public comment in Preliminary Environment Reports, and a lack of formal Environmental Impact Statements or Public Environmental Reports for exploration permits.

(4) Related activities and impacts requiring assessment are increased shipping and air traffic, construction of infrastructure such as refineries, loss of public amenity, noise, introduction of exotic species, increased major hazards of explosions and toxic chemical spills. *(The response by APEA and DPIE was that many of the activities occur away from the site, and that local production of oil would reduce the risks involved in shipping).*



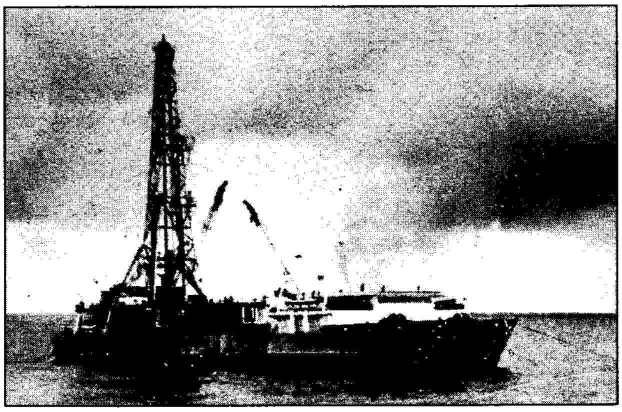
(Source: R. Whiting)

Figure 38.1: An oil spill the size of that of the *Exxon Valdez* spill would have a catastrophic effect on the Northern Territory.

cultural values, and commercially important uses such as fisheries, tourism and oil must all be important considerations in marine environmental management decisions.

For example, the Great Barrier Reef is ranked amongst the most highly valued parts of the World Heritage, and the Great Barrier Reef Marine Park was established largely because of the concerns by Australians about the perceived threat from offshore oil drilling. Drilling is therefore specifically prohibited under the Great Barrier Reef Marine Park Act *1975. With respect to the inconsistencies in the prohibition of oil and the allowance of potentially more dangerous shipping, oil pollution from ships is recognised as a major threat to the Marine Park and a variety of management responses are being implemented* (Chapters 39 and 69).

Marine environmental managers might not see hydrocarbon exploration and production as being fundamentally incompatible with large, multiple-use marine protected areas in which some areas are completely protected. The issue is one of assessment of risk. In some circumstances the risks of an oil spill and its environmental consequences might be acceptably small.



(Source: GBRMPA)

Figure 38.2: Proposals to drill in the Great Barrier Reef for oil aroused widespread community concern which eventually resulted in the declaration of the Great Barrier Reef Marine Park. Test drilling in the Swains Reefs around 1965.

Summary and conclusions

1. The Commonwealth Bureau of Transport and Communications Economics estimates that the probability of a major spill from offshore exploration and extraction over a five year period is 39%. While the industry considers this to be very pessimistic, some degree of risk must be considered to exist.

2. The Commonwealth Government has no defined policy on oil drilling in marine protected areas. The *'One Nation'* Statement in 1992 stated that an assessment must be made on the economic potential of an area proposed for reservation as a park or reserve prior to proclamation. This process enables areas which may have petroleum or mineral potential to be identified before a decision is made on the reservation of an area for nature conservation purposes.

3. The offshore petroleum industry argues that the environmental impacts of operational discharges from oil and gas exploration and production activities are circumscribed, and smaller than those from other marine activities such as fishing, dredging, offshore disposal of wastes. It also argues that decisions to preclude oil drilling from marine protected areas are often 'unobjective'.

4. Conversely, the major conservation groups in Australia perceive offshore petroleum as a major threat to the marine environment.

5. Marine environmental managers are faced with the difficult task of managing the environment to maintain biodiversity and achieve ecologically sustainable development, while balancing conflicting uses and aspirations. While the economic and strategic value of the Australian offshore petroleum industry is obviously great, and the environmental record of the industry has been excellent to date, the risk of oil spills cannot be considered to be insignificant.

6. It is possible that offshore exploration licences may affect the establishment of some marine protected areas in the Ocean Rescue 2000 program, or that MPAs will have to accommodate industry activities. The degree of risk varies with the site. In some circumstances oil exploration and production may not be incompatible with large, multiple-use marine protected areas.

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Acknowledgments:
The material in this chapter was widely reviewed because of some reviewers' concerns on biases in earlier drafts. The material in Chapters 37 and 38 was therefore critically reviewed by all members of the SOMER Advisory Committee; S. Woodley, GBRMPA, Townsville Qld; and Professor G. Kelleher, Chairman GBRMPA, Canberra, ACT. Comments were also provided by J. Beck and others at the Australian Petroleum Exploration Association Limited, Sydney, NSW; D. Wright and P.E. Williamson, Petroleum Resources Branch, Bureau of Resource Sciences, Canberra, ACT; and J. Tysoe and P. Smith, Petroleum Division, Commonwealth Department of Primary Industries and Energy, Canberra, ACT.

Chapter 39. Oil spills, prevention and control[1]

The general effects of oil spills on the marine environment have become well known over the past 25 years through the growing list of ecodisasters such as the *Exxon Valdez* in Alaska, the Gulf war and the *Ixtoc I* oil rig blowout in the Gulf of Mexico. So far Australia has been lucky: only two large ship spills have occurred and these fortunately resulted in little environmental damage. However, the chances of a major spill from ships are high. A risk analysis places the chances of a major ship spill in Australian waters in a five year period as high as 49%.

While the large spills are headline catching, it should be emphasised that far more oil actually enters Australia's marine environment from industrial, sewage and stormwater discharges from the land, and these have a more insidious and long-term impact on coastal marine life (Chapters 37 and 43).

This chapter examines the major sources of oil pollution in Australian waters, particularly from ships. Oil spill prevention through the improvement of navigation of ships and Australia's oil spill response plans are also discussed.

Major sources of marine oil pollution

The sources of oil pollution around Australia are not well known. The Australian Petroleum Exploration Association (APEA) has estimated that around 20 million litres (16,000 tonnes) of oil enters the Australian marine environment each year from urban and industrial areas, compared with around 800 barrels (95,000 litres) which has been released from offshore platforms since production began in Australia 25 years ago (Chapter 38).

Global estimates of sources of oil pollution in the sea

Terrestrial sources:
Around 37% by volume of global marine oil pollution comes from land-based industrial discharges and urban run-off. It is the major cause of chronic oil pollution.

Operational spills from shipping:
Illegal discharge of waste oil from ships' engines, fuel and cargo tanks and bilge waters accounts for around 33% by volume of marine oil pollution.

Groundings, collisions and structural failure:
Oil spills from shipping mishaps account for around 20% of the total number of spills. They may involve large amounts of oil and cause intense damage to marine communities.

Bunkering and cargo loading/unloading:
Around 80% of accidental spills occur in ports when ships take on fuel oil and tankers load and unload petroleum. Although the vast majority are less than 10 tonnes and may be mitigated by authorities, port spills can result in long-term degradation of seagrass and mangroves in the vicinity.

Offshore oil exploration and production:
Spills from offshore blowouts and discharges contribute about 1.5% by volume of global marine oil pollution. In Australia it is less than 0.5% of the terrestrial sources (Chapter 37).

Oil spills from shipping

Oil pollution from shipping comes from routine discharges (waste oil from engines, cleaning of fuel and cargo tanks, and discharges of bilge waters) and from accidental oil spills.

Operational spills from shipping

Under the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) discharge of waste oil is prohibited within 12 nautical miles of the territorial sea baseline by ships other than tankers, and within 50 nautical

[1]Based on a paper by S. Raaymakers, Great Barrier Reef Marine Park Authority, Townsville, Queensland.

miles by tankers. Operational discharge rates outside these limits must not exceed 60 litres per nautical mile, or a concentration of 100 parts per million. The Australian Maritime Safety Authority (AMSA), who have national oil spill responsibilities, receives around four reports of illegal oil discharges per week. In addition, under MARPOL, all discharges of oil are prohibited within the general area of the Great Barrier Reef Marine Park and Torres Strait.

Oil spill risks and incidents in Australia

Although Australia's population is insufficient and its size too great to have generated serious sea lane congestion, natural shipping hazards and congestion in ports create localised high levels of shipping accident risks. The Bureau of Transport and Communications Economics (BTCE) in 1991 estimated that the probability of one or more major spills (i.e. over 1,370 tonnes) from oil tankers over five years was 49%, and that over 20 years was 84%. It found the highest risk areas were Bass Strait, and between Brisbane and the South Australian Gulfs. The highest accident rates per unit of shipping were on the Inner Route of the Great Barrier Reef.

The two major spills (*Oceanic Grandeur* in Torres Strait and *Kirki* off Western Australia) apparently did not result in any major long-term environmental effects although there is anecdotal information that dispersants used in the former may have caused a long-term decline in pearl oyster beds.

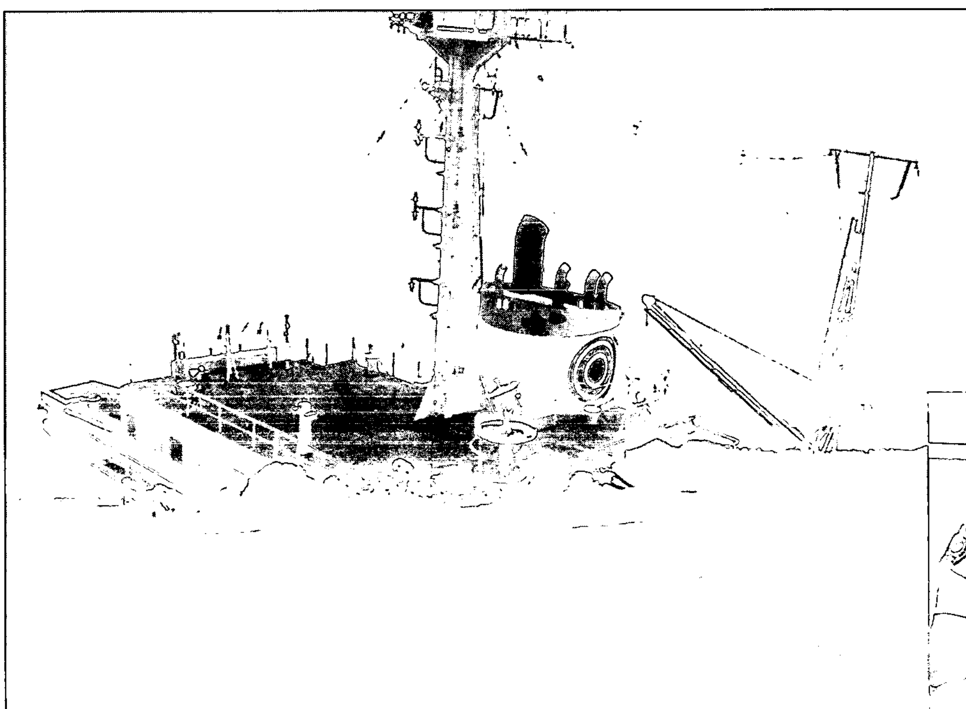
Table 39.1: Major oil spills in Australian waters

Ship	Place/date	Size (tonnes)
Oceanic Grandeur	Torres Strait (1970)	1,067
Kirki	off WA (1991)	18,000
Sanko Harvest	Esperance (WA) (1991)	570
Arthur Phillip	Cape Otway (Vic) (1990)	na
Era	Spencer Gulf (SA) (1992)	296

Several smaller spills have caused substantial damage. The *Sanko Harvest* spill off Esperance in 1991 affected over 100 kilometres of almost pristine national park and oiled 200 fur seals (13 died). The *Arthur Phillip* spill off Cape Otway resulted in the oiling of 338 little penguins (273 died). The *Era* spill in the Spencer Gulf in 1992 resulted in over 200 oiled birds, most of which died, and damaged around 100 hectares of mangroves.

Small spills occur regularly but relatively few are reported. Reports from Coastwatch and other sources are collated by AMSA.

(Source: N. Holmes)



a

b

(Source: (b) and (c) The West Australian)

c

Figure 39.1: The *Sanko Harvest* (a) sank off Esperance (WA) in 1991, spilling 570 tonnes of oil, 30,000 tonnes of di-ammonium phosphate and 300 tonnes of superphosphate fertiliser. Around 100 kilometres of coast was oiled, affecting fur seals (b) and seabirds (c).

(Source: AMSA)

Table 39.2: Oil spill reports, by State and Territory 1989-92

	1989	1990	1991	1992
Qld*	84	62	85	92
NSW	32	26	13	41
Vic	37	28	38	24
Tas	3	3	0	3
SA	6	6	4	3
WA*	14	29	35	26
NT*	4	9	10	9

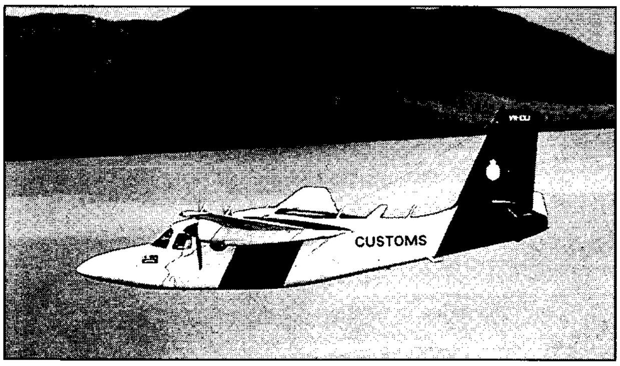
*Note: Because Coastwatch operates here, the number of spills reported will be higher than other States

(Source: AMSA)

Table 39.3: Oil spill reports by origin, 1989-92

Source	number
bulk carrier	68
chemical tanker	6
fishing vessel	88
general cargo vessel	42
naval vessel	5
oil tanker	60
offshore oil rig	10
other vessels, barges etc	61
unknown vessel	42
unknown source	355

Apart from monitoring of discharges from oil platforms and some ports and estuaries, little is known of chronic oil pollution or its effects in Australia. Studies of the distribution of hydrocarbon-degrading bacteria in Great Barrier Reef waters show higher concentrations in areas of greatest shipping activity, possibly indicating that background levels are already elevated.



(Source: Coastwatch)

Figure 39.2: Coastwatch flights report on oil spills from shipping in northern Australia.

Oil spill prevention

The prevention of spills through the safe operations and navigation of ships is the primary objective of management.

Improving vessel safety

Safe vessel operations are a significant component of oil spill prevention. The 1992 Inquiry into Ship Safety by the House of Representatives Standing Committee on Transport, Communications and Infrastructure, entitled 'Ships of Shame', found very serious deficiencies in vessel safety and operations (Chapter 36). The Australian Maritime Safety Authority (AMSA) implements MARPOL regulations and currently carries out a 'port state' inspection on about 25% of ships visiting Australian ports. AMSA use Coastwatch aerial patrols for surveillance and detection of pollution infringements.

Major Commonwealth oil pollution legislation

A range of Commonwealth legislation relates to the control of oil pollution. All states and the Northern Territory have legislation complementing the *Petroleum (Submerged Lands) Act* 1967. New South Wales, South Australia and Tasmania have legislation implementing MARPOL regulations covering oil. Queensland and Western Australia are drafting appropriate legislation.

Major Commonwealth oil pollution legislation includes:
Protection of the Sea (Civil Liability) Act 1981 (this makes pollution insurance mandatory for vessels carrying over 2000 tonnes of bulk oil);
Protection of the Sea (Powers of Intervention) Act 1981 (this permits the Federal Minister to intervene in an actual or threatened pollution incident at sea);
Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (this implements the International Convention on the Prevention of Pollution from Ships (MARPOL 73/78, described above));
Navigation Act (this implements aspects of MARPOL 73/78 dealing with ship construction to reduce pollution);
Australian Maritime Safety Authority Act 1990 (sets out the powers and functions of AMSA, including oil pollution combat; administering Commonwealth marine pollution legislation, including MARPOL; and administration of the National Plan to Combat Pollution of the Sea by Oil);
Petroleum (Submerged Lands) Act 1967 (regulates oil exploration and production (discussed in detail below));
Great Barrier Reef Marine Park Act 1975 (includes the prohibition of oil exploration and production).

Although the chances of capture and successful prosecution of an offending vessel at sea are not great, the MARPOL Convention has had a strong deterrent effect. The US National Research Council Marine Board estimates that global oil pollution has been reduced by 60% since the Convention took effect.

Improving navigation

United States statistics indicate that 90% of ship groundings are due to navigation error. Lights, markers and beacons necessary for safe navigation, and essential to the prevention of oil spills, are provided nationally by AMSA and are funded by a levy on shipping calling at Australian ports, and by State/Territory maritime authorities.

The production and updating of charts is undertaken by the RAN Hydrographic Service. Many charts based on surveys conducted last century are being updated through an ongoing hydrographic survey program, including Laser Airborne Depth Sounding.

Modern electronics has improved ship navigation. The Electronic Chart Display and Information System (ECDIS) uses the Global Position System, Electronic Chart Database, and Computer Graphics to provide the mariner with continuous, real-time, high-accuracy position superimposed on an electronic chart display with audible warnings of impending danger. The United States study suggests that 70% of groundings could be prevented by ECDIS.

Compulsory pilotage on the Great Barrier Reef

As around 2,000 ships, 200 of which are tankers, use the hazardous inner route of the Great Barrier Reef each year, voluntary pilotage was recommended by the International Maritime Organisation (IMO) in 1987. While compliance was estimated at around 90%, the risks were considered sufficient (a non-piloted ship is estimated to be 31 times more likely to suffer a grounding than a piloted ship) that compulsory pilotage was recommended. After a successful international campaign by the Australian Government to gain consensus, the IMO agreed in 1990 to designate the Great Barrier Reef a 'Particularly Sensitive Area'. This was the first such designation in the world. All ships over 70 metres in length and all loaded tankers require a pilot in the most hazardous northern Great Barrier Reef to Cairns route, and Hydrographers Passage off Mackay.

Double hull precaution

As an added safety factor in the case of a grounding, under MARPOL all tankers built after July 1993 are required to be of double hull or equivalent design.

Oil spill response plans

While prevention remains the priority, it is accepted that accidents are inevitable. After the near disaster of the *Oceanic Grandeur* grounding in Torres Strait in 1970, the Commonwealth established the National Plan to Combat Pollution of the Sea by Oil (NATPLAN). This is operated by AMSA, funded by a levy on ships, and implemented by multiagency National Plan State Committees.

NATPLAN: Australia's national oil spill plan

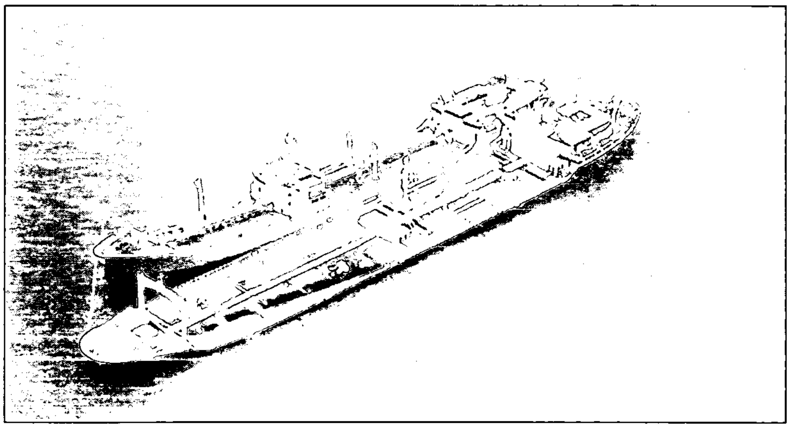
NATPLAN maintains stockpiles of oil spill response equipment on loan to State/Territory Authorities at strategic ports around Australia. This equipment is supplemented by that of the States/Territory and the industry-funded Australian Marine Oil Spill Centre in Geelong (Vic), from which equipment can be flown to anywhere in the nation within 24 hours.

NATPLAN is based on a tiered response philosophy

Tier One (spills of <10 tonnes, handled using local equipment from industry and/or State/Territory authorities);
Tier Two (spills 10-1,000 tonnes, handled with local, State/Territory and national equipment);
and Tier Three (>1,000 tonnes, as above, and including international equipment from major industry stockpiles in Singapore, United Kingdom and elsewhere).

In the event of a vessel grounding the priorities are, firstly, saving lives, salvage operations, plugging leaks, transferring oil into intact tanks or another vessel and secondly, prevention of oil spreading through the use of booms and chemical dispersants.

NATPLAN prioritises, by order, the protection of natural habitats, rare and endangered species, commercial, cultural and amenity resources. Should



(Source: QDPI)

Figure 39.3: The *Oceanic Grandeur* stranded in Torres Strait, 1970.

sensitive sites be endangered, chemicals may be used to disperse the slick while it is still in open water.

Problems in the use of chemicals include their inability to disperse many oil types, logistical problems in accessing equipment and stockpiles, and their toxic nature which may cause greater damage than the oil itself. Booms may also be deployed to deflect oil. Response operations include shoreline clean-up, wildlife rescue operations, and post-spill rehabilitation of affected wildlife.

In reality, large-scale oil spills are not manageable and responses have had limited success around the world. In Australia the problems are greatly compounded by the vast size of our coastline. Recognising this, a review of NATPLAN was undertaken in 1992. Included in its recommendations were greater coordination between industry and government, upgrading to a 10,000 tonne response capability, increasing response capability in high risk areas such as the Great Barrier Reef, increasing the scope of NATPLAN to include other pollution incidents, and developing a wider awareness of the limitations of response capabilities.

(Source: GBRMPA)

Figure 39.4: REEFPLAN oil booms in practice deployment.

'REEFPLAN': protecting the Great Barrier Reef

In recognition of the sensitivity of the Great Barrier Reef a subset of NATPLAN was developed. REEFPLAN, lead by the Queensland Department of Transport and supported by AMSA, includes a first-strike capability centred in Townsville, and a tiered response philosophy allowing the use of NATPLAN and other national and international stockpiles. The Great Barrier Reef Marine Park Authority provides environmental and scientific advisers.

Summary and conclusions

1. Oil pollution in Australia is largely localised in urban, port and industrial inshore waters. Other areas are under varying degrees of threat from oil spills from ships.

2. The greatest sources of marine oil pollution in Australia are terrestrial sources, and operational discharges from shipping.

3. The greatest number of spills come from accidents during bunkering and loading/unloading in ports.

4. While Australia has not experienced any environmentally serious oil spills, the risk of a spill remains high. Particular concerns exist regarding the poor standards of international shipping.

5. Oil spill management prioritises good practice to prevent spills. Management of large spills is rarely effective.

6. A national, coordinated oil spill contingency plan (NATPLAN) is operational in Australia. Logistical problems limit its effectiveness.

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Acknowledgments:
The technical paper by S. Raaymakers was reviewed by the Australian Maritime Safety Authority, Canberra, ACT.

Part 5

General issues in the coastal and marine environments

While overfishing, tourism and oil pollution (outlined in Part 4) may have major, localised effects on the marine environment, many of the factors affecting the marine environment come from other, and more remote sources. Sea level and climate may ultimately be affected by Greenhouse gas emissions from countries half a world away. Poor land-use practices in the hinterland, sewage from urban areas, and discharges from industries may have serious consequences on distant estuaries and coastal waters.

The following chapters discuss a range of diverse issues affecting Australia's marine environment: coastal modification and climate change; water quality and marine pollution; and exotic species and marine pests.

Coastal development and climate change

Because Australia's population is concentrated along the coast, development has significantly affected some coastlines (Chapter 40). But a far greater and more widespread potential impact on the coastline is sea level change resulting from global warming, and associated climate changes (Chapter 41).

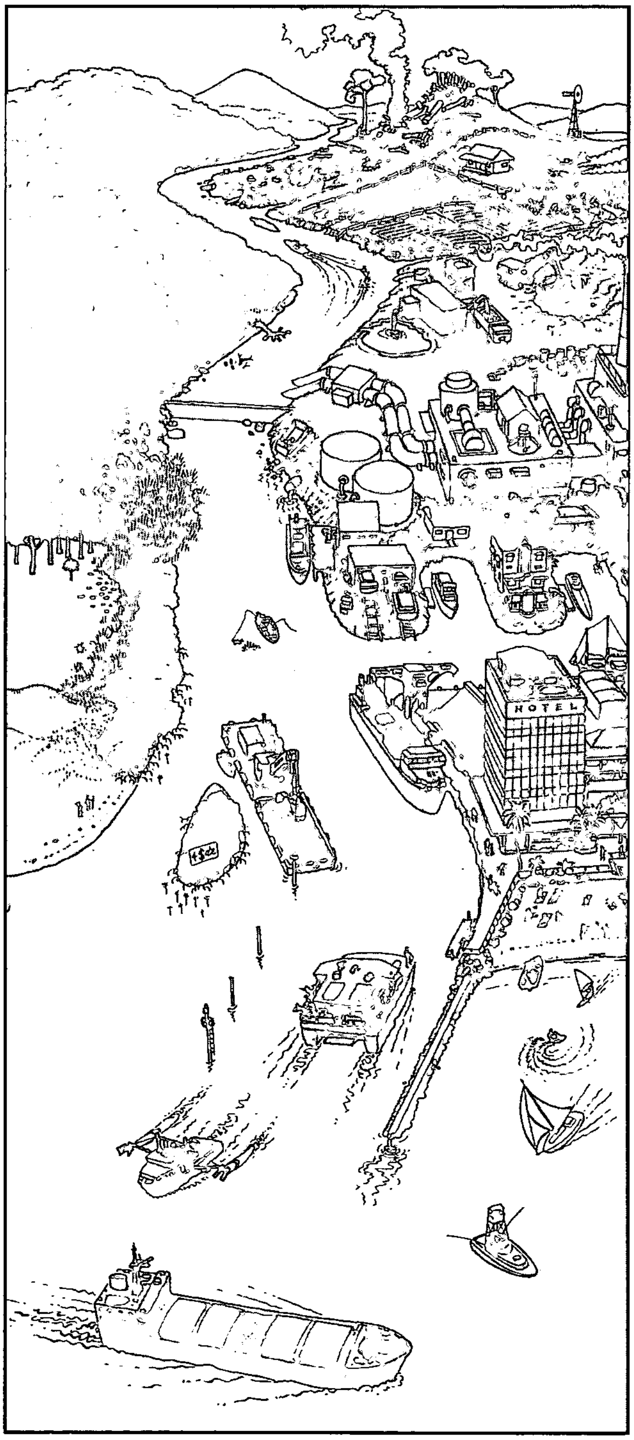
Water quality and marine pollution

Water quality is critical for aquatic organisms and marine pollution is a growing problem in coastal lakes, estuaries and bays near the more developed parts of Australia. Chapter 42 discusses one of the most serious and widespread issues affecting Australia's marine environment, elevated nutrients and sediments.

Most other pollutants pose more localised problems, or 'hotspots'. The problem of hydrocarbons is discussed in Chapter 43; heavy metals in Chapter 44; and organochlorines in Chapter 45. Ocean and beach litter, a very conspicuous problem on many Australian shores is discussed in Chapter 46. The less visible problem of pathogenic micro-organisms and human health are the subject of Chapter 47.

Introduced and native pests

Since European arrival, terrestrial Australia has been devastated by introduced species. Chapter 48 examines the growing problem of exotic diseases and marine pests. Native marine species may also become pests. Best-known of these are outbreaks of the crown-of-thorns starfish on the Great Barrier Reef (Chapter 49) and the small coral-eating *Drupella* snail on Ningaloo Reef in Western Australia (Chapter 50).



Chapter 40. Coastal modifications and impacts

As more than a quarter of the Australian population lives within three kilometres of the coastline, the coastal strip and particularly, the shore, have been significantly affected in many areas by urban, industrial and port development, and a variety of facilities for tourism and recreation. Structures such as breakwaters at ports and river mouths, seawalls built to halt erosion, groynes constructed in the hope of retaining the beach, and outfall drains have particularly affected shore processes in these areas.

This chapter assesses the impacts of humans on the physical nature of Australia's coastline over the past 200 years. It describes the general nature of the modifications of the different coastal features, specifically of breakwaters and harbour structures, artificial beaches, and land reclamations.

Table 40.1 Australia's coastline - some statistics

length of mainland coastline (10 km intercepts)	36,735 km
sand beaches	53%
rocky shores	23%
soft (mud) shore	22%
estuaries, lagoon inlets, seawalls	2%
proportion inhabited	30%
proportion protected (National Parks etc)	14%
number of commercial ports	120
number of major urban settlements	7 (all capitals except Canberra)

Coastal features and their modification

Cliffed coasts

Cliffs are naturally receding where relatively weak geological formations are exposed to strong wave attack, such as the Port Campbell coast of Victoria. The cliff base is undercut by wave action, and cliff recession proceeds intermittently, usually during storms, when slumping occurs.

Basal walls or boulder ramparts have been constructed to slow cliff recession where roads and buildings are threatened by erosion. Since 1900 some 55 kilometres of formerly cliffed coast bordering Port Phillip Bay (Vic) have been protected. However, while cliff recession has been halted, the seawalls have cut off the supply of sand or gravel to adjacent beaches, leading to their depletion.

(Source: E. Bird)

Figure 40.1: Seawall at Black Rock (Vic). Built to stabilise a former cliffed coastline, this has caused the disappearance of the beach because of wave refraction.

Beaches

Australia has many long and gently-curving beaches backed by dunes or dune sandstones of aeolian calcarenites. Shorter beaches, mostly sandy but sometimes gravelly or shelly, are separated by rocky outcrops and shore platforms along steep and cliffed parts of the coast, or interspersed with salt marshes and mangroves where the shores are muddy.

Australian beaches are supplied with sediment from several sources, and lose sediment in various ways. Where the gains exceed the losses, the beach is built upward and outward (progradation), and where the losses exceed the gains, beach erosion occurs. Beaches show short-term alternations of erosion in response to high waves in stormy periods and accretion when low, gentler waves occur in calmer weather.

[1]Based on a paper by Dr E. Bird, Geostudies, Black Rock, Victoria.

Over the past century beach erosion has been a widespread problem worldwide. Over 70% of the world's beaches have been eroding, less than 10% have prograded, and the remainder have either been stable or shown alternations over this period. Similar proportions have been reported from around the Australian coast.

Beach erosion is caused by many factors, both natural and human-induced. These include a reduction of sand supply from rivers on which dams have been built (e.g. on the Barron delta, North Qld); from cliffs that have been stabilised (e.g. the coast of Port Phillip Bay Vic); effects of coastal structures, such as breakwaters and marinas that have cut off the longshore sand drift (e.g. Coolangatta Qld); sea floor dredging (e.g. western shores of Botany Bay); successive cyclones (e.g. Lennox Heads to Tweed Heads, NSW); and high sea level and rainfall associated with the El Niño/Southern Oscillation (e.g. Stanwell Park, NSW).

The onset of erosion has prompted further modifications, such as the building of seawalls and boulder ramparts to protect the eroding shore. These usually result in beach depletion by reflection scour, (e.g. Black Rock and Mentone on Port Phillip Bay, Vic; Warilla, NSW; and Machans Beach near Cairns, Qld). In some places groynes have been built to intercept and retain beach material. These have been successful on low wave energy coasts where there is little longshore drifting (e.g. southern Botany Bay, NSW), but where they have retained beach sediment that was drifting alongshore there is usually an acceleration of erosion on the next, down drift sector (e.g. at Point Lonsdale, near the entrance to Port Phillip Bay, Vic).

(Source: E. Bird)

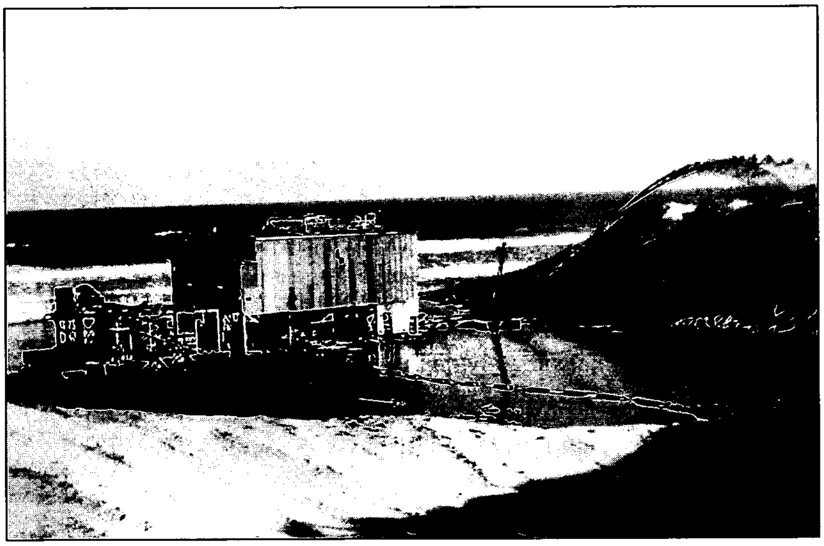
Figure 40.2: Boulders dumped on the shore at Somers (Vic) to protect buildings have resulted in beach depletion at this site and down the coastline.

Sand dunes

Australia has very extensive areas of coastal dunes and has some of the highest dunes and the largest dune islands in the world. The best examples of major dune islands are North and South Stradbroke, Moreton and Fraser Islands (Qld).

Dune blowouts have been increased by human activities such as off-road vehicles, walking tracks, collection of firewood, and grazing by cattle and wild horses. The hydrology of dune lakes has also been affected and the very existence of perched lakes are threatened in parts of Fraser Island.

Coastal sand mining for heavy minerals has been a major issue in northern New South Wales and southern Queensland. Extensive areas of dunes and back-barrier marsh have been dredged, and while restoration and revegetation has taken place, the natural system has been highly altered. Some of the exotic plants used in revegetation are now invading neighbouring, undisturbed heathlands.



(Source: E. Bird)

Figure 40.3: Rutile mining near North Entrance (NSW) has modified the dune systems and generated unstable dunes which require revegetation.

Estuaries

Many Australian estuaries are partly or wholly enclosed by sandy barriers built across their mouths by wave action, so that the rivers drain into coastal lagoons. Others have outlets to the sea constricted by spit growth, for example, Anderson's Inlet at the mouth of the Tarwin River (Vic). In south-eastern Australia many river mouths have sandy thresholds washed in by waves and tidal currents, such as Narooma and Merimbula (NSW).

The simplest estuaries are those which open on to parts of the coast where wave energy is low, either because there are protective headlands, nearshore islands, or coral reefs, such as the Daintree, Fitzroy, and Brisbane Rivers (Qld), or because wave energy is dispersed by a large tidal range such as at the King, Ord, Victoria and Daly Rivers (WA). These estuaries typically have shoals of mud and sand interspersed with tidal channels and creeks, and bordering mangroves and saltmarshes.

Apart from modifications due to changes in the river catchments, the most common artificial features are training walls built to intensify outflow and wash away sand bars and shoals (e.g. Clarence River, NSW) and breakwaters built to stabilise river mouths that were previously apt to vary in width and position on the coast.

Some delta systems have been significantly affected by agricultural expansion, for example the Barron, Herbert and Burdekin River deltas (Qld). Changes include major saltwater intrusion following overuse of groundwater, particularly in drier seasons; widespread modifications to natural estuarine systems by the building of sand barriers to reduce salt water intrusion at the surface; and erosion of naturally accreting shorelines as a result of interference with sediment movement within the delta.

Coastal lagoons

Australia has a large number of coastal lagoons. These were formed during the Late Quaternary marine transgression (sea level rise) when some bays, inlets and estuaries were partly or wholly enclosed from the sea because of the deposition of sandy barriers. These lagoons vary in size, shape and bathymetry, but typically show estuarine features. Their ecology depends largely on the extent of tidal penetration and the salinity gradient that increases towards their natural or artificial outlets. Typically, the inner zones have fresh or slightly brackish water, with reed swamp and associated biological communities. Towards the sea, they become brackish, with saltmarshes and sometimes mangroves.

Many coastal lagoons have been modified during the past few decades through the damming of in-flowing rivers and the diversion of water into irrigation schemes which reduces fluvial in-flow. Dredging of marine entrances to improve navigation has led to increasing invasion by sea water, and consequently greater salinity penetration into lagoons. This has had a major impact in the Gippsland Lakes (Vic) where it has resulted in die-back of freshwater vegetation and an increase in salt-tolerant or halophytic plants.

By contrast, formerly brackish coastal lagoons have been freshened. Lakes Albert and Alexandrina at the mouth of the Murray River (SA) have been freshened since 1940 when barrages were constructed to prevent sea water incursion. Bordering saltmarshes have been replaced by extensive freshwater reed swamp, and shallow areas now have an abundant growth of freshwater weeds such as *Myriophyllum*.

Effects on saltmarsh and mangroves

In some areas, saltmarsh and mangroves have disappeared because of land reclamation and clearing, and because of die-back due to waterlogging, pollution and frost action (Chapters 7 and 8). Marshes have been extensively disturbed by introduced species such as rice grass *(Spartina anglica)* in south-eastern estuaries such as the Tamar estuary (Tas).

Intertidal mudflats, sand flats and rocky areas

Sand flats and rocky shores exposed at low tides often support communities dominated by seagrasses, marine algae and sessile invertebrates (Chapters 9 and 10). Seagrasses promote accretion of sediment and organic materials, and can diminish wave action, thereby helping to stabilise the adjacent coast. Debris from shell-forming marine organisms may be important in form gravelly shoals that can be washed on to backing beaches. Sandy and muddy sediments are moved to-and-fro by waves and currents, and arranged into bars, shoals and ripples.

Where the growth of seagrass is reduced, wave action is less impeded, and wave attack intensifies on the coastline. Fortunately, the extensive embanking, draining and reclamation of intertidal zones which have occurred elsewhere around the world's coastline, and particularly in South-East Asia, have not occurred in Australia.

Fringing and algal reefs

Coral grows extensively in coastal waters around northern Australia, and has formed fringing reefs on headlands, steep coasts and high islands, particularly along the north-east and north-west (Chapter 12).

There is considerable evidence that fringing reefs and other nearshore reefs have declined considerably over the last 60 years, from Moreton Bay and along the Queensland coast as far north as Yule Point near Cairns, and in the Cape Tribulation area to the north (Chapter 42).

Effects of breakwaters and other disturbances

Breakwaters

Many engineering structures on the Australian coast are associated with ports and harbours. Major ports such as Sydney, Melbourne, and Geelong have extensive dockyards and urbanised waterfronts with seawalls, wharves, piers and jetties. Breakwaters have been built to shelter bay harbours in places such as Portland (Vic) and Ulladulla (NSW). Mackay (Qld) has a harbour which protrudes from the coastline between protective breakwaters. Fremantle (WA) has a port in an area where a river mouth has been stabilised by breakwaters. Lakes Entrance (Vic) has a harbour inside an artificial lagoon protected between breakwaters.

(Source: N. Rosengren)

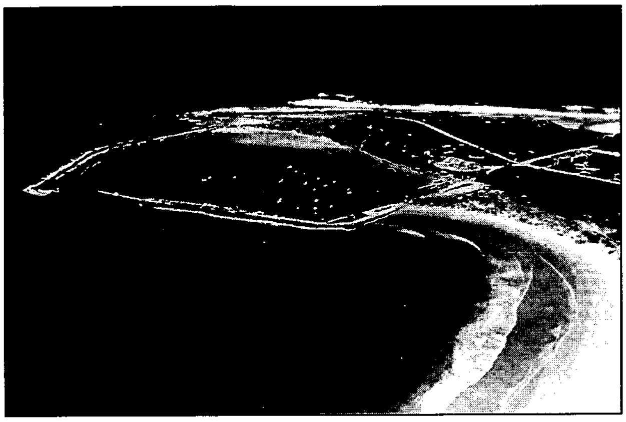


Figure 40.4: The harbour at Apollo Bay (Vic) has caused sand build-up on adjacent beaches. Sand washed into the harbour is routinely dredged.

Sand accretion occurs alongside harbour breakwaters, particularly where there is a strong longshore drift, for example at Brunswick Heads and Tweed Heads (NSW) and Queenscliff (Vic). Sand may move in from the sea floor in some places, for example Port Fairy and Apollo Bay (Vic). Where there is an alternating longshore drift, there has been accretion on both sides of protruding breakwaters in places such as at Forster, Tuncurry, Evans Head and the mouths of the Richmond and Hunter Rivers (NSW), at Lakes Entrance (Vic) and at Onslow (WA).

Marinas and canal estates

The increasing demand for water-borne recreation has led to a proliferation of marinas, piers and launching ramps, particularly close to major urban centres. Marinas have been formed by building breakwaters on the coast in places such as Fremantle (WA), St Kilda (Vic) and many areas of Queensland. The effects of these breakwaters are the same as those built to shelter river mouths or lagoon entrances.

Parts of the Swan estuary (WA), the Derwent estuary (Tas), and the Southport estuary (Qld) have been used for marinas. Multiple piers and small boat harbours have been constructed at Rushcutters Bay and the Hawkesbury River (NSW), and Moreton Bay and Hervey Bay (Qld).

Where saltmarshes and mangroves have been excavated to form marinas, such as at Hastings and Yaringa on Western Port (Vic), there are problems keeping navigable approaches clear of mud accretion and coastal wetlands have been lost. Canal estates have been built by excavating channels in swamp lands in the Patterson Lakes (Vic), and Paradise Waters and the Noosa estuary (Qld).

Boat ramps

The impacts of launching ramps are much less severe, especially if they are built across rocky shores. Where they have been constructed across beaches, longshore drift piles sand up on one side, and beach erosion ensues on the other. In these situations, ramps may be buried by beach accretion, or undermined and destroyed when the beach is lowered and cut back by erosion.

(Source: I. Dutton)

Figure 40.5: Evans Head (NSW) showing modification of the estuary through breakwaters, seawalls and a marina. The beach in the centre has been mined for mineral sands. The dunes at the left are a RAAF bombing range.

Outfall pipes

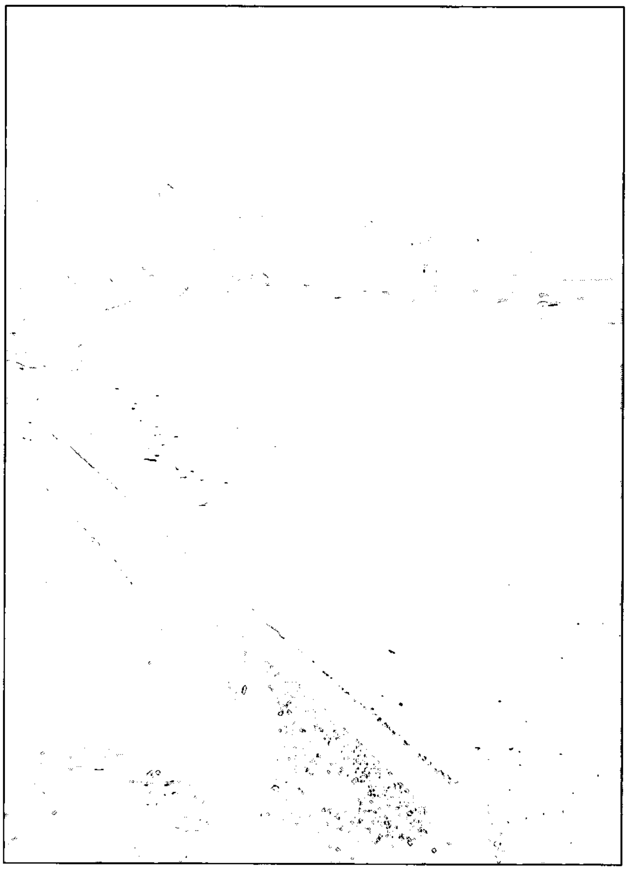
Outfall pipes carrying urban and sometimes industrial waste water into the sea also modify the shore on a small scale where they protrude in such a way as to interfere with the longshore drifting of beach sand. This is significant in Port Phillip Bay (Vic) which has more than 300 outfall pipes. These impacts do not occur where the pipes are buried, such as at Ninety Mile Beach (Vic) where pipes carrying oil and natural gas come ashore well below the beach and dune levels.

Artificial beaches

The erosion of beaches, particularly in resort areas, has prompted demands for artificial beach nourishment in several places around the Australian coast. Erosion of the beach at

Coolangatta (Qld) after the construction of breakwaters at Tweed Heads (NSW) led to artificial renourishment of Coolangatta beach with sand brought from Tweed River estuary. On the Adelaide coast, depletion of beaches because of northward sand drifts has been countered by trucking sand back to the southern end. In Port Phillip Bay (Vic), 18 beaches with a combined length of 19.3 kilometres have been restored with sand obtained from the sea floor and inland quarries. The restored beaches on Port Phillip Bay have been gradually reduced by wave erosion and longshore drifting, and losses of finer sand has occurred to nearshore bars.

Beaches adjacent to replenished beaches may be widened and intertidal shore platforms may be blanketed by sand, affecting their biota.



(Source: E. Bird)

Figure 40.6: Artificial beach. This was inserted in 1994 at Red Bluff, Port Phillip Bay (Vic) to protect a cliffed coastline.

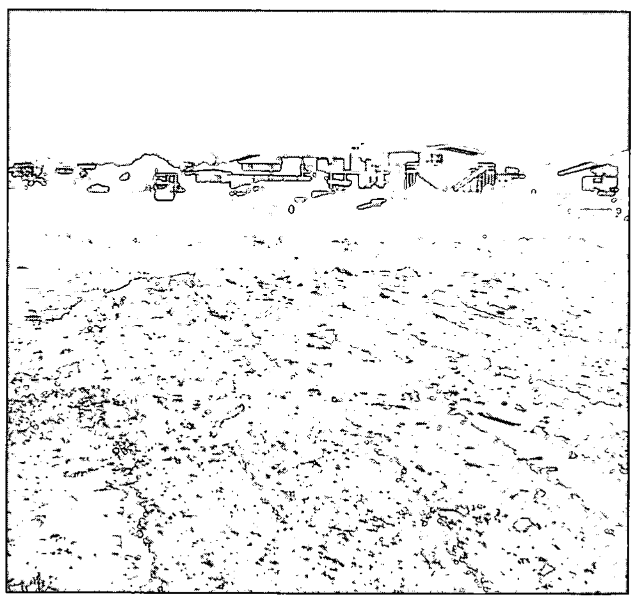
Dredging and dumping

Dredging of sea floor sediment occurs in many port approaches and entrance channels to harbours, for example, at Queenscliff, Geelong and the Yarra mouth in Port Phillip Bay (Vic) and Bunbury Harbour (WA). The deepening of water along dredged channels may have some effect on patterns of sea floor sediment movement, and adjacent benthic communities may be affected by silt and turbidity, for example, the coral reefs off Magnetic Island and Heron Island (Qld).

Land reclamation

There has been relatively little coastal land reclamation in Australia other than in the vicinity of urban and industrial centres. In these areas saltmarshes, mangroves and mudflats have been enclosed and in-filled for port and factory development.

Larger reclamations have been undertaken in Queensland in Cairns for an airport and for agricultural development; in Gladstone for a port, industrial sites and a marina; and in the Brisbane River and parts of Moreton Bay for an airfield, marinas and shipping facilities. In New South Wales extensive reclamations have occurred in Sydney Harbour for urban and industrial development; in Botany Bay for the airport runway extension; and in Eden for a fishing port. In Victoria they have occurred between Williamstown and Brighton on Port Phillip Bay; in Geelong in Corio Bay; in Crib Point and Hastings in Western Port; and in Portland. In Tasmania they have occurred around Hobart. In South Australia they have occurred at Port Adelaide. In Western Australia reclamations have occurred at Peel Inlet at Mandurah. Small scale reclamation has occurred at most other ports, including Darwin (NT).



(Source: E. Bird)

Figure 40.7: Land reclamation over former mangrove swamp, Anglers Waters (Qld).

Coastal reclamation results in the loss of intertidal land and water resources, including saltmarshes, mangroves, seagrasses and other nearshore communities. Indirect impacts may occur on adjacent intertidal and nearshore areas because of scouring by reflected waves or diverted currents, and deposition in any areas that become more sheltered. While the adjacent communities may be damaged, especially while reclamation is in progress, new shoals and mudflats may provide new habitats.

State of surfing beaches in Australia:

In a noteworthy initiative by beach users, young members of the Surfrider Foundation of Australia undertook a survey of the state of the environment of surfing beaches in 1992-93 using questionnaire interviews by Foundation members. While the findings were not scientifically based, they nevertheless give a good idea of the conditions and pressures on our surfing beaches.

Of the 439 beaches investigated:
- 33% had some form of development on the dunal system (around half was residential)
- 18% had some restriction on public access
- 34% had one or more stormwater drains discharging to the beach or associated lagoon
- 12% had an ocean sewage outfall (40% of these were primary treated only)
- 13% had been previously mined (mainly for mineral sands)
- 19% were subject to development proposals deemed by respondents to detract from beach quality
- of 274 freshwater sources discharging at the beaches, 38% were considered by the respondents to have poor water quality.

Regional issues
Survey respondents identified hundreds of local issues such as litter pollution, beach front developments, stormwater and sewage pollution, septic run-off, pollution of rivers and creeks, restrictions to beach access, and beach erosion. The following were considered to be some of the major issues in each State.

Queensland:
Coastal strip development, particularly in the south-east and cumulative impacts of sewage, stormwater and agricultural run-off on the marine environment.

New South Wales:
Proposals for offshore heavy mineral exploration, especially on the north coast; proposals for mining of marine aggregate south of Sydney; coastal strip development throughout the State; cumulative impact of sewage, stormwater and agricultural run-off on the marine environment.

Victoria:
Proposed oil storage facility at Crib Point inside Western Port; pollution of Port Phillip Bay and Western Port coastal strip development along the east and west coasts

Tasmania:
Pollution of the Derwent, King and Tamar Rivers; pollution of beaches in the north-west; exemptions from pollution control standards for 36 public and private outfalls; and poor quality at 45 sewage outfalls.

South Australia:
Pollution of the Spencer and St Vincent Gulfs; and pollution of rivers and creeks (particularly Onkaparinga and Patawolonga Rivers and Christie Creek).

Western Australia:
Oil exploration throughout the north-west; coastal strip development north and south of Perth; and proposed industrial site at Oakagee near Geraldton.

(Source: Surfrider Foundation Australia 1993)

Sea level changes

Sea level has undoubtedly risen and fallen, relative to the land, around Australia during the Quaternary. A major worldwide marine transgression occurred in late Pleistocene to early Holocene times, ending about 6,000 years ago. There have since been minor fluctuations, the sequence and dimensions of which have varied from one sector to another, partly because of tectonic movements in coastal regions, for example, land subsidence in the Port Adelaide district (SA) and Corner Inlet (Vic). Tide gauge records for the Australian coast are scattered and do not give firm evidence in support of the widely-held view that a global sea level rise of about 1.2 millimetres per year has occurred over the past few decades. The Greenhouse Effect is expected to accelerate global sea level rise over the coming century (see Chapter 41).

Monitoring and environmental reporting

Monitoring of coastal changes has generally been sporadic, and analyses of the factors and processes responsible for such changes have been few. Agencies such as the Beach Protection Authority in Queensland and the Port of Melbourne Authority in Victoria have carried out repeated surveys on particular sectors, notably where erosion is a problem, but there has been no comprehensive and systematic data collection on coastline change.

Mapping and monitoring of coastal and nearshore species and communities, identification and explanation of changes occurring, assessment of biodiversity as a basis for ecological management, and more systematic documentation and analysis of coastal flooding and the effects of cyclones and storm surges are required.

Case study

Beach monitoring in Queensland

Prompted by chronic and episodic beach erosion on the Gold Coast, the Queensland Beach Protection Authority has developed a comprehensive data collection program along the coast.

Wave recording (since 1975):
There are 13 wave recording stations (5 permanent) using 'Waverider' buoys.

Storm surge tide recording (operating since 1970s):
There are 20 gauges designed to measure cyclone storm surges now operating between Mooloolaba and Cooktown.

Coastal Observation Program - Engineering (since 1982):
This consists of a network of volunteers who take daily readings of winds, waves and beach conditions. There are presently 48 stations between Coolangatta and Port Douglas.

Aerial photography (since 1960s):
The coastline between Coolangatta and Cooktown is flown every four years and photographed at 1:12,000 and 1:50,000.

Surveying (since 1960s):
Beach profiles from behind the primary dunes to approx 4 km offshore are undertaken at selected stations.

Project work (since 1960s):
Special projects recording currents, turbidity, wind and waves are currently underway off Mackay and in the Southern Gold Coast Beach Nourishment Project.

(Source: Queensland Beach Protection Authority)

Summary and conclusions

1. The coastal environment around Australia's urban areas, particularly those in the south-east, has experienced significant changes.

2. Major impacts have been engineering structures associated with ports, harbour and marinas, and reclaimed areas. Estuaries have been particularly affected by seawall constructions.

3. Around 70% of the coastline is uninhabited and remains in an essentially natural condition.

4. Coastal erosion has been occurring naturally in much of Australia. It will accelerate in the next decades if there is a global sea level rise.

5. Coastal changes have not been adequately monitored and there has been inadequate analysis of factors and processes responsible for these changes.

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Acknowledgments:
The technical paper by Dr E. Bird was reviewed by Professor D. Hopley, Sir George Fisher Centre for Tropical Marine Studies, James Cook University, Townsville, Qld.

Chapter 41. Climate change and sea level rise[1]

During the late 1980s the 'greenhouse effect' made headlines around Australia with stories that coastal towns and cities would be flooded; cyclones would become more severe, more frequent, and more wide-ranging; and our rainfall would become even more erratic. Expert scientific opinion is that atmospheric warming and global climate change due to an enhanced greenhouse effect is likely, although it will probably not be as severe as the extreme scenarios portrayed in the media. Sea level rise and climate change are particularly important issues in coastal zone management today, and are highly likely to be major issues in the twenty-first century.

The greenhouse effect is a natural process in which a number of minor gases in the earth's atmosphere (water vapour, carbon dioxide, methane, nitrous oxide and others) trap heat which would otherwise escape from the earth, thereby keeping the earth's temperature warm. Increases in levels of these gases in the atmosphere because of increasing industrialisation, are expected to significantly increase the earth's temperature through an enhanced greenhouse effect, and affect the planet's climate. It is expected that the coast will be affected by rises in mean sea level and changes in storm tracks, extreme storm events, wave action, rainfall and sedimentation.

This chapter describes recent predictions or scenarios of the extent of climate change and sea level rise, and the national and international responses to the threat.

Scenarios of climate change

While planetary warming as the result of the enhanced greenhouse effect is predicted with some measure of confidence, estimates of the timing and magnitude vary. The range of warming estimated by the Intergovernmental Panel on Climate Change (IPCC) in 1992 would be 1.5 to 4.5°C if carbon dioxide levels have doubled from pre-industrial concentrations. The timing of this would depend on rates of release of greenhouse gases and response of the ocean which stores and transports large amounts of heat, and will not be globally uniform. Because of these uncertainties, CSIRO modellers have provided scenarios of climate change in Australia. These are not forecasts but are plausible, internally consistent pictures of future climate based on certain assumptions.

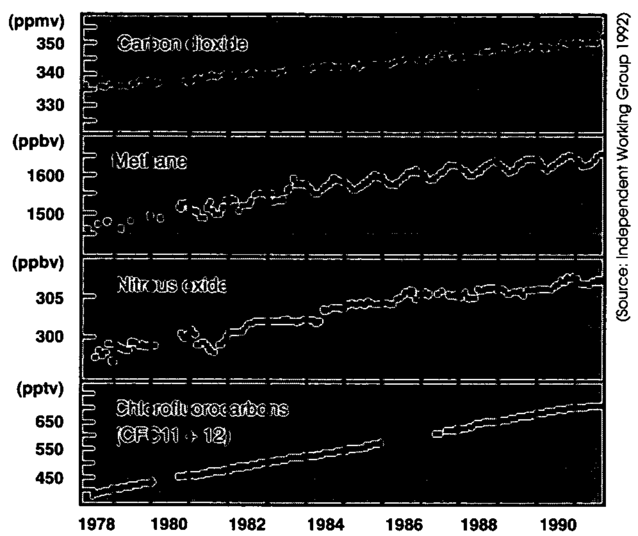


Figure 41.1: Trends in increase in greenhouse gases observed over south-eastern Australia and at Cape Grim Station (Tas).

Climate change in Australia

A recent scenario, released by CSIRO in November 1992, outlines possible changes in Australia by the years 2030 and 2070. It suggests changes in annual average temperature and rainfall, and changes in frequency of rainfall events. While the geographic area affected by tropical cyclones is unlikely to markedly change, the frequency, tracks and average intensities of cyclones may change.

The future behaviour of the El Niño-Southern Oscillation (ENSO) phenomenon under enhanced greenhouse conditions is particularly relevant in assessing regional climatic change. ENSO is a major factor affecting Australia's climatic variability, sea level, ocean temperature, currents and productivity,

[1]Based on papers by Dr C. Mitchell, Climate Change Research Program, CSIRO, Mordialloc, Victoria; and I. Carruthers, Climate Change and Marine Branch, Department of the Environment, Sport and Territories, Australian Capital Territory.

Table 41.1: Scenarios of local temperature change in Australia's north (above 25°S) and south (below 25°S) by years 2030 and 2070

region	response/°C*	2030	2070
north	0.3-1.0	0-1.5	0-4
south	0.8-1.2	0.5-2.0	1-5

* local warming per degree global warming

and influences a wide range of marine organisms and processes (e.g. tuna, rock lobsters, prawns, green turtle, and possibly coral bleaching and crown-of-thorns outbreaks). One model has hinted at possible increasing magnitudes of ENSO events but there is no strong evidence either way for changes to ENSO.

Sea level rise

One of the key consequences of an enhanced greenhouse effect is a rise in global mean sea level because of thermal expansion of the upper oceans and some melting of glaciers and small non-polar ice fields. The magnitude and timing of any rise will depend on the rate of climate change. Other factors, such as possible increases in polar snowfall, may also influence sea level rise.

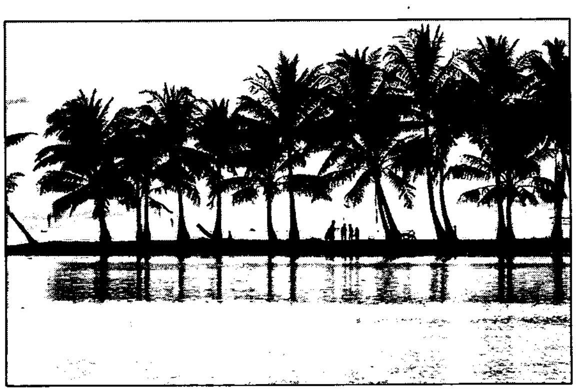
Current IPCC estimates of rises in sea level above the 1990 level range from 5 to 35 centimetres by 2030, and 15 to 120 centimetres by 2100. However, at any given location sea level will vary with local subsidence and uplift, currents and other factors.

A geological perspective on sea level rise

Climate changes over geological and shorter time frames have greatly altered sea levels and coastlines. Only 18,000 years ago, at the end of the last Ice Age, the sea level was at least 130 metres lower than it is today, and it did not reach its present level until around 5,000 years ago. At one stage it may have risen at a rate of 45 mm per year! Geologically the present coastline is very young, and is very dynamic (Chapter 1).

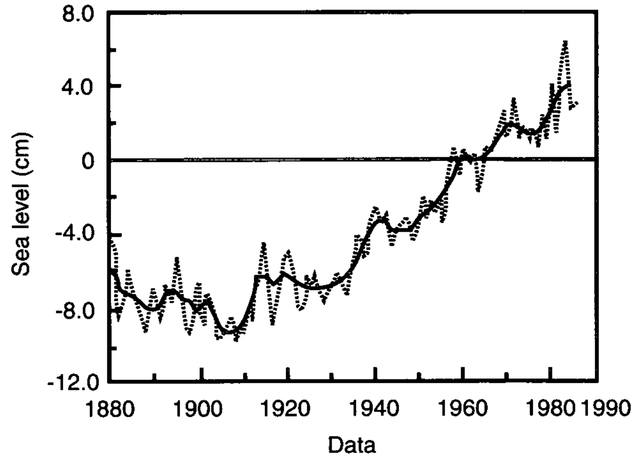
Figure 41.2: Sea level rise is expected to most affect atoll nations. Tarawa Atoll, Kiribati.

(Source: L. Zann)



The historic record

After considering available historical sea level data, the IPCC concluded in 1990 that the global mean sea level has been rising over the past 100 years at an annual rate of 1 to 2 millimetres. This has been more recently estimated at 1.8 +/- 0.1 millimetres per year.



(Source: IPCC 1992)

Figure 41.3: Global mean sea level rise over the past century. The average between 1951 and 1970 were used as the baseline.

In Australia trends in sea level rise have been determined from records of the Permanent Committee for Tides and Mean Sea Level and the National Tidal Facility, but these do not necessarily represent long-term trends or enhanced greenhouse effects.

From scenarios to impact studies

As the uncertainty inherent in the regional scenarios means that environmental impacts cannot be precisely determined, studies have been directed more at the sensitivity of marine and coastal systems to climate variability and climate change. Sea level changes are only one aspect of environmental change resulting from global warming which might affect coastal processes. Other changes include storms (number and pressure of cyclones and intense extratropical lows); wave climate (modal height, energy and direction); temperature (summer, winter); precipitation (summer and winter totals, frequencies of extreme events); potential evaporation (summer, winter); river discharge; and sediment loading.

In trying to predict possible changes to the global oceans, oceanographers are greatly hampered by a relative lack of observations compared with the atmosphere. As the natural variability of ocean properties is poorly understood, identifying changes and then ascribing them to human-induced climate change is problematic. While surveys of two areas of the Tasman Sea have shown significant warming between 1967 and 1990, it is not known if this is a part of the natural variability.

(Source: Bryant and O'Connor 1991)

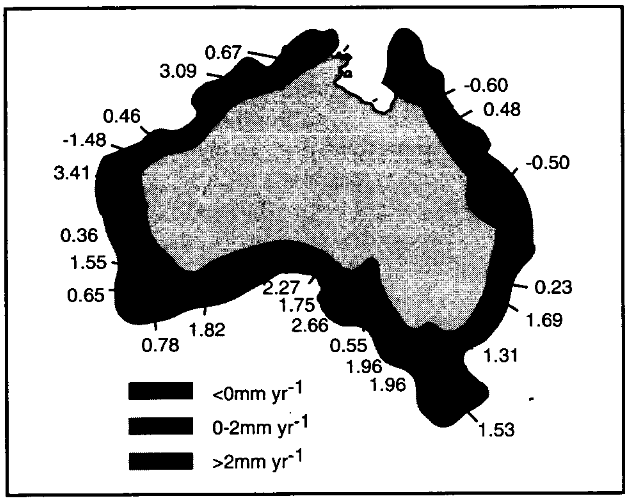


Figure 41.4: Recent Australian trends in sea level rise between 1966 and 1984-85 show rises, but are not long enough to infer enhanced greenhouse effects.

Possible impacts of climate change on coastal and marine environments

Climate impact studies are in their infancy and while some attention has been given to impacts of sea level rises along Australia's coasts, few have also considered regional climate change.

Coastal wetlands

Little research has been undertaken in Australia to evaluate the vulnerability of wetlands to climate change. This is made difficult by variety in wetland forms and function. Accelerated sea level rise and increase in frequency and magnitude of storm surges are major threats, while changes in rainfall and run-off may be particularly important in estuaries and saltmarsh (Chapter 7).

Mangrove forests are sensitive to changes in sea level, climate and atmospheric carbon dioxide concentrations and may be possible indicators of climate change. Community assemblages, dominants, regeneration, growth, reproduction, productivity, rates of litter accumulation and decomposition, turnover of nutrients, and soil acidity may be altered.

Sandy beaches

Potential impacts on sandy beaches have been a major focus. A study in Geographe Bay (WA) found that shoreline change also depends on bay shape, seagrass, sediment budget and other factors (Chapter 40).

Fisheries

A series of case studies suggests that a number of Australian fisheries are potentially sensitive to environmental conditions and climatic variability, and may be influenced by climatic change. For example, banana prawn catches are affected by salt

Overcoming scepticism, implementing long-term planning

Dramatic mass-media coverage of the possible impacts of the enhanced greenhouse effect in the late 1980s led to a wide variety of views and opinions on the issue. While some people see climate change as a major and important issue to be speedily addressed, others remain sceptical. In some cases this scepticism extends to planners and environmental managers. For example, the impacts of climate change on coastal processes was given only the briefest mention in the 1993 Report of the Coastal Zone Inquiry of the Resource Assessment Commission, and was not considered a high priority issue by the SOMER Advisory Committee (Chapter 83).

Scepticism regarding the potential impacts of climate change may be rooted in poor understanding of what is a complex and relatively new subject.

Apart from this, there may be several other reasons for a circumspect attitude:
- the time scales are much longer than those usually considered by planners (changes to the coastal zone may not occur for several decades);
- there is a tendency by environmental managers to respond only to immediate problems associated with Australia's coasts; and
- framing appropriate response measures is difficult (high uncertainty associated with the nature of regional climate change often translates to even greater uncertainty associated with efforts to predict its potential impacts on the coastal zone).

Even though there have been major uncertainties associated with the impact of climate change on Australia's coasts, there are potentially substantial risks which also need to be assessed. Appropriate action will only be possible if the public, coastal planners and environmental managers are aware of the issues.

water inundation, tropical cyclone frequency, and ENSO; tiger prawn catches are affected by rainfall, salinity, turbidity, sea level, and cyclone frequency; and western rock lobster catches are affected by ENSO and currents.

Coral reefs

While it was initially feared that some reefs might be 'drowned' by a very rapid sea level rise, the presently accepted slower rise may generally stimulate reef growth. Relatively barren reef flats which are now exposed to air would be flooded and be reoccupied by corals, while changes in wave action and cyclones may unlock reef sediments and increase cay formation.

Recent global coral 'bleaching' episodes (the widespread loss of symbiotic zooxanthellae from many corals on a reef) have been related to water temperature increases, leading to suggestions that they are already reacting to enhanced greenhouse global warming. While a workshop investigating this found there was insufficient evidence to support the hypothesis, it does indicate that coral reefs may be sensitive indicators of environmental change.

Australian policy on climate change and strategic responses

The threat of global climate change requires coordinated global and national efforts. Australia's policy on global climate change has been developed within the strategic framework of the United Nations Framework Convention on Climate Change, the activities of the Intergovernmental Panel on Climate Change and principles of the National Greenhouse Response Strategy.

United Nations Framework Convention on Climate Change (FCCC)

The objective of the FCCC is to stabilise greenhouse gas concentrations in the atmosphere at a level which would prevent dangerous interference to the climate system, allow ecosystems to adapt naturally to change, ensure food production is not threatened, and would enable economic development to proceed in a sustainable manner. The FCCC was opened for signing at the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro. Australia was one of the 154 signatories at UNCED. After analysis and consultation by Commonwealth and State/Territory governments, Australia ratified the convention on 31 December 1992. Key commitments include preparing national inventories on greenhouse gas emissions and removals by sinks; national programs to mitigate climate change and adaptation strategies; transfer of technologies for emission controls; promotion of ecologically sustainable development; consideration of climate change in relevant policies; and promotion of research on implications and response strategies.

Intergovernmental Panel on Climate Change (IPCC)

Formed in 1988 by the United Nations Environment Program and the World Meteorological Organisation, the IPCC assesses information on climate change, emissions of gases, and modifications of the earth's radiation balance. This will enable environmental and socioeconomic consequences to be evaluated and realistic response strategies to be developed. Coastal and marine issues are the subject of a special group in IPCC. This aims to assess vulnerability of coasts to sea level rise; develop methodologies through case studies; undertake developing-country studies; support the development of Coastal Zone Management plans; and assess assistance required by developing countries. Australia has already undertaken pilot studies to assess vulnerability to sea level rise at Geographe Bay (WA), Cocos (Keeling) Islands, and the Republic of Kiribati.

National Greenhouse Response Strategy (NGRS)

The need for nationally coordinated research has led to the development of the NGRS. This provides the framework for effective action to limit greenhouse gas emissions, enhance gas sinks, improve understanding of the greenhouse effect and prepare for potential impacts of climate change in Australia. It aims to stabilise the emissions at the 1988 level by the year 2000, and reduce these by 20% by 2005, providing that this does not affect the national economy or trade competitiveness in the absence of similar action by the major countries producing greenhouse gases.

There was widespread concern when Australia did not meet its greenhouse emissions objectives in 1994, raising the possibility of a national carbon tax. Australia's greenhouse emissions are currently amonst the highest per capita of any OECD country.

National Greenhouse Advisory Committee (NGAC)

The NGAC was established in 1989 to provide scientific advice to government on climate change issues, to oversee the research program and advise on priority research areas. The Commonwealth allocated $17.8 million for climate change research over the three years to 1993, and is committed for a second triennium.

Monitoring climate change

Systematic monitoring of climate in Australia is undertaken by the Bureau of Meteorology. The composition of atmospheric gases is monitored at the Cape Grim Baseline Air Pollution Station (Tas) administered jointly by CSIRO and the Bureau of Meteorology. CSIRO's Division of Atmospheric Research, the global atmospheric sampling laboratory (GASLAB) analyses samples from a global network

of sites.
Responsibility for the monitoring of sea level rests with the Permanent Committee on Tides and Mean Sea Level, through the National Tidal Facility. A sub-network of high-precision sea level monitoring stations has been established around Australia as baseline stations for the existing tide-gauge network.

Australia is also participating in global climate studies such as the World Ocean Circulation Experiment, and the Joint Global Ocean Flux Experiment. However, Australia has not yet established a systematic monitoring program which would be able to detect or assess impacts arising from the enhanced greenhouse effect on coastal or inshore environments.

Summary and conclusions

1. Because of warming of the earth's atmosphere due to increasing levels of greenhouse gases, a rise in the mean sea level and global climate change is likely. This will probably have a major impact on coastal management.

2. An effective doubling of carbon dioxide in the atmosphere from its pre-industrial level is predicted to increase global average temperature by 1.5 to 4.5°C.

3. CSIRO's 1992 scenarios of Australia's warming by 2030 AD are 0 to 1.5°C in the north and 0.5 to 2°C in the south. The global average sea level rise by 2030 is expected to be between 5 to 35 cm based on 1990 levels.

4. Climate change (changes in rainfall, and cyclone strengths, frequencies and paths etc.) may have a greater impact on coastal environments than sea level rise. Together, they are expected to affect coastal wetlands, beach processes, coral growth and fisheries productivity.

5. Australia's Greenhouse Response Strategy is linked with the UN Framework Convention on Climate Change. It provides a means for identifying and implementing response measures, including greenhouse gas reduction, scientific research and planning for adaptation. Pilot studies on impacts of climate change have been conducted in Australia and the region, and a monitoring program has been developed.

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Chapter 42: Nutrients and eutrophication in coastal waters[1]

In recent years, many of Australia's inland waterways have suffered catastrophic blooms of toxic blue-green algae because of high levels of nutrients from agricultural run-off and urban sewage. Eutrophication, harmful algal growth resulting from elevated levels of nutrients, also becomes a major problem in many of our estuaries and enclosed coastal waters when these polluted rivers reach the sea. The problem is a growing one worldwide, and is potentially one of the most serious, large-scale threats to Australia's coastal environment.

All plants need nutrients, principally nitrogen (N) and phosphorus (P) but also organic carbon, iron and various trace elements, for their growth. In marine ecosystems plant productivity is frequently limited by naturally low concentrations of nutrients, particularly P and N. This is especially true in Australia where our ancient, heavily leached soils contain low levels of P compared with other continents, where there is a lack of upwellings of nutrient-rich cool waters, and where the prevailing tropical water masses are nutrient-limited (Chapters 1 and 2).

Because of the naturally low concentrations of nutrients and sediments, much of Australia's inshore waters are dominated by marine organisms which dominate under low nutrient and sediment regimes, for example, corals in the north and seagrasses in the south. The increase in levels of nutrients and sediments because of human activities has therefore had a serious effect on these communities.

This chapter examines the related problems of elevated nutrients and sediments on Australia's marine environment. It describes the contributions of point-source discharges such as sewage and stormwater, and non point-source or diffuse sources from general catchment uses such as soil erosion, animal wastes and agricultural fertilisers. The effects on seagrass, corals and other inshore ecosystems are assessed and management of eutrophic systems is discussed.

Sources of nutrients in the sea

The major anthropogenic inputs of both P and N into the marine environment are diffuse agricultural run-off from fertilisers, animal wastes and soil erosion, and point source urban discharges from stormwater, sewage, industrial and aerial sources.

Natural nutrient transport and concentrations

Australia has a very low surface run-off. For example, the flow and sediment transport of the Fly River in neighbouring Papua New Guinea is similar to that from all Australia's rivers combined.

Australian rivers have a more variable flow and a more variable annual flood regime than those in other continents. In semi-arid and monsoonal areas, virtually all transport of nutrients and sediments occurs during wet seasons and storm flows. It is therefore not possible to define 'normal' concentrations of nutrients, as concentrations in Australian waters vary greatly with run-off, rainfall, upwellings, nitrogen fixation and currents.

The Australian Environmental Council (AEC 1987) considered that eutrophication is likely to occur if total N equals or exceeds a range of 400-600 µg/l, and/or if total P equals or exceeds 40-60 µg/l. For many water bodies total flux of nutrients to the system may be a better indicator of eutrophication.

Fertilisers

Because Australia's soils are extremely poor in P, large amounts of super phosphate fertilisers are applied to crops and pastures. Application has increased since 1950, from around 150,000 tonnes to 350,000 tonnes per year (Figure 42.1).

Increased usage of P in some catchments has been dramatic. In the Atherton Shire on the Barron River (Qld) it has increased from a negligible amount in the 1950s to around 2,750 tonnes pa today, and may affect the growth of corals on near shore reefs. In the Swan coastal plain (WA), it has increased from around 5,000 tonnes in the 1940s to about 27,000 tonnes in the early 1970s, creating major eutrophication of the Peel-Harvey estuary.

[1]Based on a paper by J. Brodie, Great Barrier Reef Marine Park Authority, Townsville, Queensland.

Application of N fertilisers has also been growing rapidly over the past three decades, to around 370,000 tonnes in 1987, with wheat and sugarcane crops being the largest consumers. Other major sources include animal industries such as piggeries and beef feed lots; urban stormwater containing garden fertilisers, pet faeces and septic system leachate; and sewage.

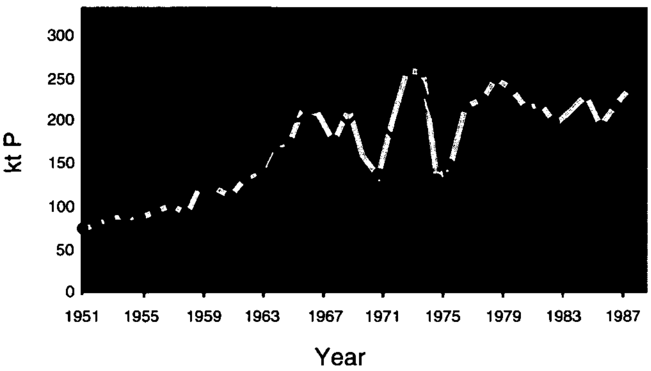


Figure 42.1: Consumption of P in Australia (1951-88) on crops (white line) and pastures (dark line).

Soil erosion

Inputs of natural soil nutrients have been greatly accelerated by erosion following massive land clearing, logging, clear felling and overgrazing over the past two centuries. Around a quarter of arid zone Australia (0.88 of 3.36 million sq km) has suffered enhanced soil erosion.

Table 42.1: Number of catchments cleared in each State, by % cleared

State	<25%	25-50%	50-75%	>75%	?	Total
Qld	170	17	4	3	113	307
NSW	20	31	25	5	-	81
Vic	8	6	6	15	-	35
Tas	17	-	-	-	46	63
SA	-	1	1	12	1	15
WA	125	2	3	1	14	145
NT	136	1	-	-	-	137
Total	476	58	39	36	174	783

? insufficient information

(Source: Bucher and Saenger 1991)

Erosion following changes in land use has caused serious sedimentation of Australian watercourses, and increased sediments and changes in nutrient fluxes in the coastal zone. It has been estimated that since the establishment of agriculture in eastern Queensland catchments, there has been a four-fold increase in sediment, N and P entering the marine environment.

For most of our coastline, agricultural inputs of P and N far exceed those from urban areas. For example, between Cape York and Fraser Island in Queensland (a distance of 2,500 km) agricultural inputs are 30 time greater than urban inputs, but in south-eastern Queensland (Gold Coast, Brisbane and Sunshine Coast) urban inputs are twice that of local agricultural areas.

Figure 42.2: Elevated nutrients have caused blooms of harmful algae in some estuaries and bays.
(a) Nutrients in sewage and storm water have resulted in blooms of the macroalga *Ulva* near metropolitan Adelaide, smothering mangroves. (b) Dieback of mangroves near the Bolivar sewage treatment works near Adelaide.

Sewage

It has been estimated that around 10,000 tonnes of phosphorus and 100,000 tonnes of nitrogen are produced each year in sewage effluent in Australia, much of which enters the marine environment. Much of Australia's sewage is only secondary treated and remains high in nutrients (2 mM N; 0.3 mM P). In some areas it is reused for industrial purposes (e.g. lower Hunter, NSW; Kwinana, WA), for irrigation on golf courses (e.g. Townsville, Cairns and many Barrier Reef resorts, Qld); and for horticulture (e.g. Werribee, Vic).

Many secondary systems reduce N content below 1 mM by aeration control. Nutrient removal (reduction) tertiary treatment plants are now being introduced in many inland situations because of river eutrophication but few operate in coastal areas.

Because of eutrophication and human health problems associated with sewage outfalls in rivers, coastal lakes and estuaries, many of the major outfalls have been relocated in deep water on open and hydrodynamically active coasts to maximise dilution and dispersion, (e.g. at Devonport (Tas); Geelong, Latrobe Valley, Cape Schanck (Vic); Sydney's North Head, Bondi and Malabar; and Lake Macquarie, Tuggerah (NSW)).

Stormwater

Nutrients in stormwater may be high, for example, over 0.15 mM N and 0.04 mM P in one study in Victoria, and may equal sewage output from an urban population. Much of this comes from pets' wastes.

Industrial effluents, emissions

Some industrial effluents contain N but these have been significantly reduced by regulation in recent years. However it has been found that in catchments with substantial heavy industry, significant amounts of N from air emissions may be exported to coastal waters via rainfall.

Environmental impacts of nutrients

The effects of eutrophication in coastal waters varies with the nature of the pollutant and the species involved, and the exchange rate of the water body.

Effects on plants

While coral zooxanthellae, seagrasses, phytoplankton and benthic algae may all respond positively to elevated nutrients in isolation, where several are present together, one might dominate the others. For example, small increases in nutrients stimulate the growth of seagrasses while larger increases promote epiphytic algae which overgrow the seagrasses, cutting the light and causing their demise. This appears to have occurred in Cockburn Sound (WA) and Gulf St Vincent (SA).

Effects on enclosed water bodies

Water bodies with long residence times are particularly affected. Overseas, the northern Adriatic, Baltic, and Black Seas, and the Inland Sea of Japan have become increasingly eutrophic.

The coastal lagoons which occur along 11% of the Australian coastline are particularly prone to eutrophication. Lakes such as the Peel-Harvey system (WA), Gippsland Lakes (Vic) and New South Wales coastal lakes have been seriously affected by eutrophication, and embayments such as Cockburn Sound (WA), Gulf St Vincent (SA), Western Port (Vic), Botany Bay (NSW) and Moreton Bay (Qld) are moderately affected. Although it has been suggested that the Great Barrier Reef lagoon is becoming eutrophic, convincing evidence is still lacking.

Declines in seagrasses

Eutrophication is responsible for major losses of seagrasses in southern Australia (Chapter 9).

Western Australia
Between 1954-1978 around 3,300 ha or 97% of the seagrass in Cockburn Sound was lost from algal overgrowth resulting from nutrients from sewage and urban run-off. Establishment of a new outfall outside the Sound has halted the decline but there has been minimal recovery. Beds in the Peel-Harvey Inlet, Princess Royal Harbour and Oyster Bay also appear to have been affected.

South Australia
Sewage from the main Adelaide outfalls at Glenelg, Bolivar and Semaphore are responsible for the loss of over 5,000 ha of seagrass in Gulf St Vincent. Port Lincoln beds have also declined.

Victoria
Western Port has suffered almost complete destruction of seagrass beds since 1973. Between 1973-84 coverage of large benthic plants declined from 25,000 ha to 7,200 ha.

New South Wales
Declines in seagrasses have been documented in Lake Illawarra, Botany Bay, Tuggerah Lakes, Lake Macquarie, and the estuaries of the Georges, Clarence and Tweed Rivers.

Queensland
Some losses have occurred in Moreton Bay and have recently been reported in Hervey Bay. Whereas elevated nutrients have been responsible for the decline in temperate seagrasses, they are causing some seagrasses in tropical Queensland to increase. Beds have expanded at Green Island off Cairns where nutrients from a sewage outfall have been trapped. Seagrass turnover is much more rapid in the tropics, resulting in the shedding of the smothering algae. Recovery after physical disturbance such as cyclones is also rapid while that of temperate beds is slow.

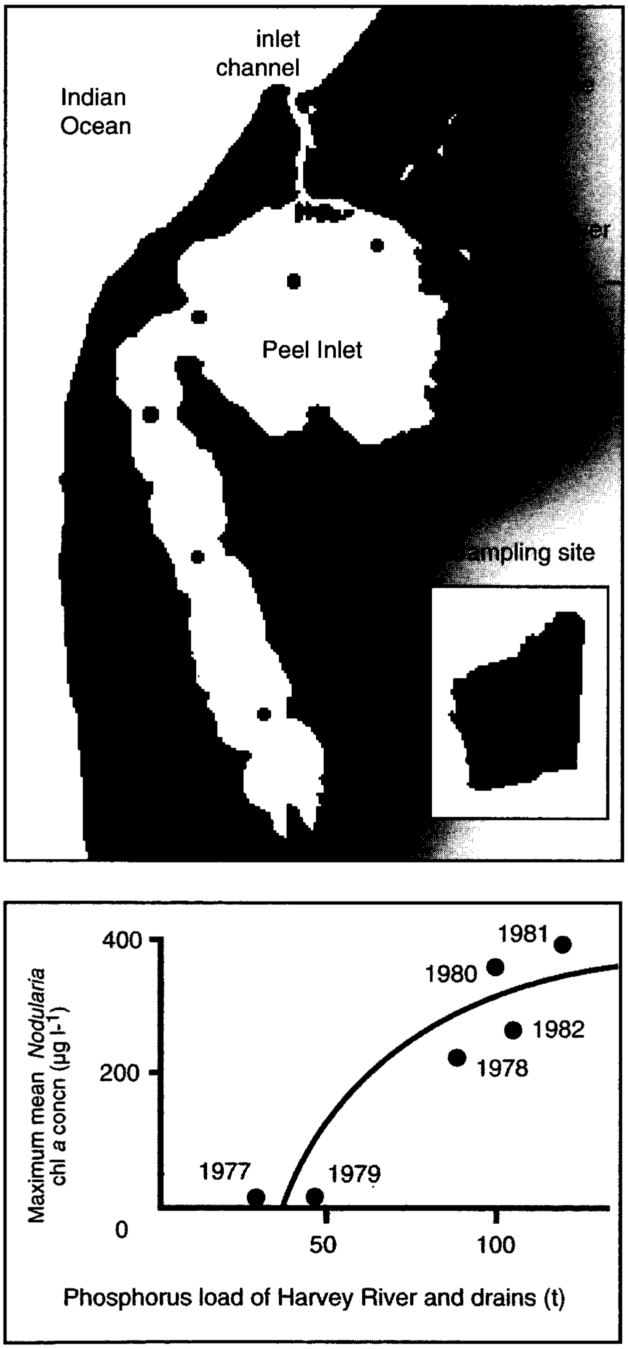
Algal blooms

Over the past 30 years in Australia, many estuaries have experienced increasing blooms of phytoplankton and benthic macroalgae, some of which are toxic and caused fish kills.

The Peel-Harvey Estuary

One of the best known cases of eutrophication occurred in the Peel-Harvey estuary south of Perth. Here, intensive agriculture in the catchment increased

P entering the Serpentine and Murray Rivers by nine fold and 50 fold respectively, between 1949-78. As a result, the Peel Inlet became clogged with macroalgae or seaweeds, initially *Cladophora* but later *Chaetomorpha* and *Ulva*. The connected Harvey Estuary, while too turbid for seaweed, experiences massive blooms of the blue-green alga *Nodularia* every year in late spring and early summer. The commercial fisheries in the Harvey declined because of the toxic scum whereas those of the Peel increased because of the greater benthic algal biomass.



(After McComb and Lukatelich 1986)

Figure 42.3: Peel Harvey system (WA). Relationship between amount of *Nodularia* algae in the Harvey River and the amount of phosphorus entering in winter, between 1977-81.

New South Wales lakes

In New South Wales, nuisance blooms have occurred in Tuggerah Lakes, Narabeen Lagoon, Dee Why Lagoon, Harbord Lagoon, Avoca Lake and Lake Illawarra. The more remote Myall Lakes and Smith Lake remain relatively unspoiled. Tuggerah Lake, a 80 square kilometre lake with limited tidal flushing (around 1% exchange per tidal cycle), is prone to eutrophication as its catchment drains agricultural lands, including orchards, it is partially urbanised, and the Lake is used for cooling by the Munmorah power station. It is affected by the macroalgae *Enteromorpha*, *Chaetomorpha* and *Rhizoclonium*.

Bays and estuaries

Macroalgal, blue-green or phytoplankton blooms have been experienced in many bays and estuaries, including Moreton Bay (Qld); Sydney Harbour, Hawkesbury River and estuary, Lake Macquarie, Lake Illawarra and Tweed River (NSW); Port Phillip Bay and Gippsland Lakes (Vic); and the Derwent estuary (Tas).

Table 42.2: Waters around Australia affected by eutrophication, and their impacts

Locality	Effects
Queensland	
Moreton Bay	phytoplankton blooms
Great Barrier Reef (lagoon)	macrophyte growth, coral decline?
New South Wales	
Lake Illawarra	seagrass loss, macrophyte growth
Botany Bay	seagrass loss
Avoca Lagoon	phytoplankton blooms
Tuggerah Lakes	seagrass loss, macrophyte growth
Lake Macquarie	phytoplankton blooms
Clarence Estuary	seagrass loss
Tweed River	seagrass loss
Victoria	
Port Phillip Bay	macrophyte growth, toxic algae
Western Port	major seagrass loss
Gippsland Lakes	phytoplankton blooms
Tasmania	
Derwent Estuary	phytoplankton blooms, toxic marine algae
Huon Estuary	phytoplankton blooms
South Australia	
Albany Harbour	seagrass loss
Port Lincoln	seagrass loss
Gulf St Vincent	major seagrass loss, toxic algae
Western Australia	
Swan River Estuary	phytoplankton blooms
Peel-Harvey Estuary	phytoplankton, macroalgal blooms
Cockburn Sound	seagrass loss

Toxic red tides

Toxic phytoplankton blooms, intensified by eutrophic coastal conditions, are a growing problem worldwide. Blooms of the toxic dinoflagellate *Gymnodinium catenatum*, a probable introduction via ships' ballast waters, have been occurring in Tasmanian and Victorian waters since 1986, causing temporary closure of shellfish farms in Tasmania. *Alexandrium minutum* now blooms annually in the Port River near Adelaide and *A. catenella* blooms in Port Phillip Bay (Chapters 14, 48 and 53).

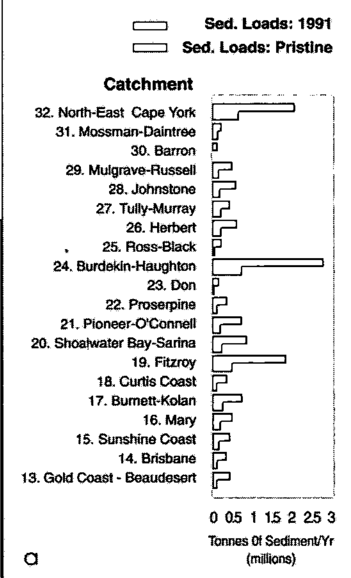
Is the Great Barrier Reef Lagoon becoming eutrophic?

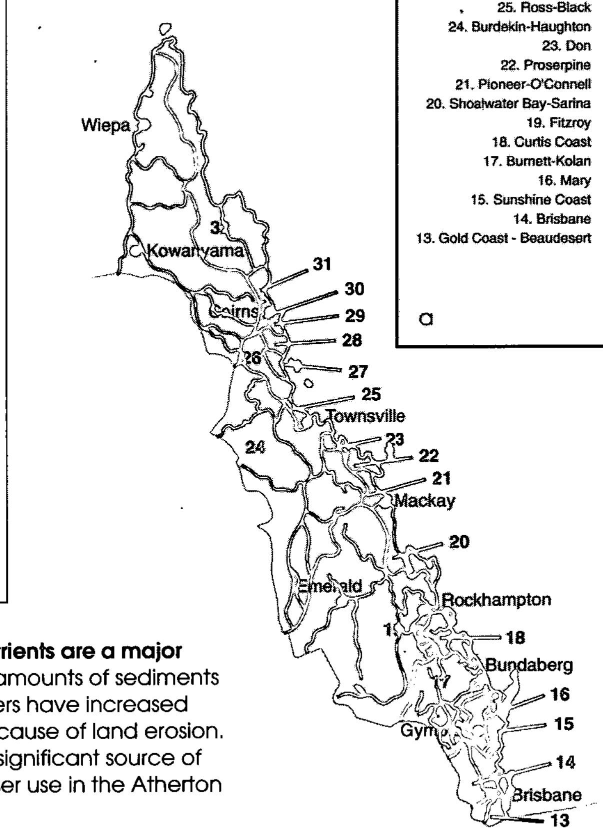
The only major area of enclosed waters in Australia which has been suggested as becoming eutrophic is the Great Barrier Reef lagoon, which lies between the mainland and the outer reefs on the continental shelf edge.

Queensland's coastal catchments have been extensively modified by clearing, grazing, sugarcane cultivation, forestry, and to a lesser extent, urbanisation. Each year around 15 million tonnes of sediments, 77,000 tonnes of N and 11,000 tonnes of P are carried into the lagoon, about four times that of the pre-European settlement period. This increase in nutrient loads is similar in magnitude to that which has occurred in the eutrophic Black and North Seas.

Concerns are held as coral reefs normally grow in low nutrient waters and are particularly sensitive to nutrient pollution. Coral calcification rates are decreased by P; phytoplankton blooms reduce light reaching the corals; and benthic algae smother them.

Anecdotal information suggests that some inner reefs (e.g. Whitsunday Group, Magnetic Island, Low Isles) are declining in coral cover. Scientific studies of cores taken from long-lived massive corals off Cairns indicate that changes in growth occurred some 50 years ago, around the time when intensive agriculture began on the adjacent Barron catchment. The subject has been controversial as nutrient and plankton data do not suggest elevated nutrients. The available information is scant and systematic, long-term data is lacking.





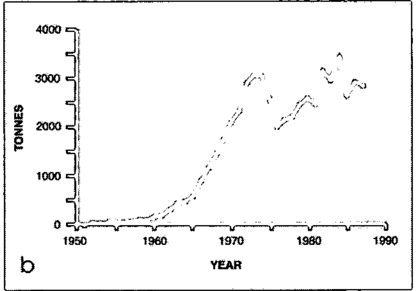
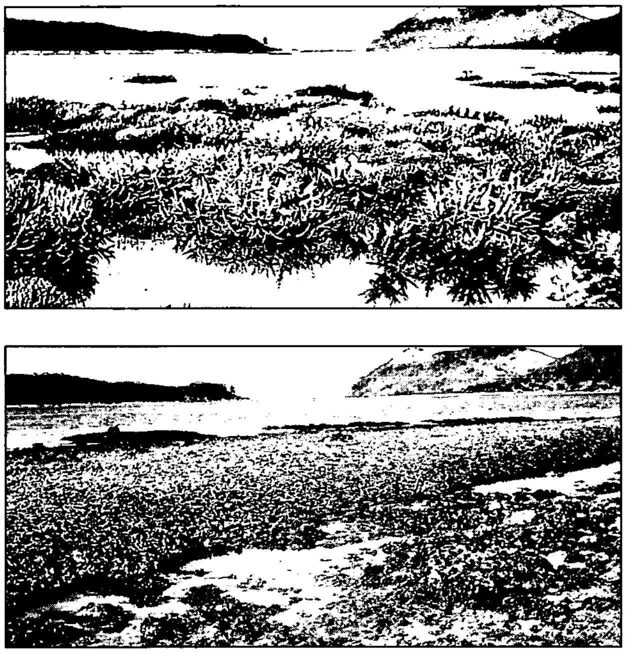


Figure 42.4: Elevated sediments and nutrients are a major issue on the Great Barrier Reef. (a) The amounts of sediments entering the sea from Queensland's rivers have increased greatly since European colonisation because of land erosion. (b) Agricultural fertilisers may also be a significant source of nutrients entering the sea. Annual fertiliser use in the Atherton Shire since 1950.

(Source: GBRMPA)

(Source: GBRMPA)



a

b

Figure 42.5: There is growing evidence of a widespread die-back of reef top corals on inshore reefs. A Whitsunday reef around 1950 (a) and in 1994 (b).

(Source: L. Zann, GBRMPA)

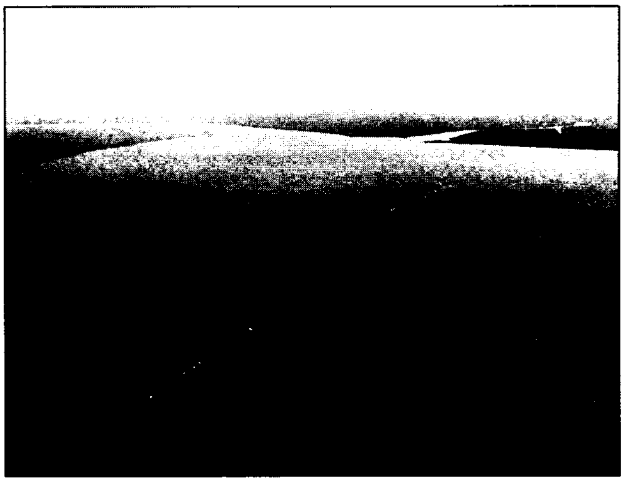


Figure 42.6: A flood plume bringing sediments from the Tully-Murray Rivers into the Great Barrier Reef Lagoon after cyclone Winifred in 1986.

Management of eutrophic systems

The philosophy of nutrient management varies from State to State in Australia, and ranges from 'assimilative capacity' to 'ecosystem approach'. These approaches have tended to change with time, circumstances and governments.

Primary management

Primary management strategies for eutrophic waters include the reduction of levels of nutrient-rich effluents from the land, better dispersal of existing discharges by preventing soil erosion, more efficient use of fertilisers, removal or use of nutrient discharges, diversion of discharges into less sensitive or better flushed environments, and improved engineering for flushing.

Case study 1

Strategy for managing Peel-Harvey Inlet (WA)

1. Catchment management using controls over fertiliser usage, increased use of slow-release fertilisers (such as 'Coastal Superphosphate', a mixture of superphosphate, rock phosphate and sulphur), and controls over land clearance.

2. Mechanical clearance of algae.

3. Improved flushing by cutting the 1.5 km Dawesville Channel from the Harvey Estuary to the ocean. The channel cost around $70 million and was completed in 1994.

Integrated catchment management

Catchment management programs to reduce soil erosion are underway throughout Australia, for example, the Total Catchment Management Program in New South Wales and Integrated Catchment Management Programs in Queensland and Victoria.

Case study 2

Strategy for managing Tuggerah Lakes (NSW)

A four year restoration project costing around $10 million will reduce sediment and nutrient inputs, remove sediments and nutrients, and improve tidal exchange through:

1. Construction of sediment traps and nutrient filters on streams and drains discharging into the lake.

2. Clearing of aquatic plant accumulations from beaches.

3. Removing silt and aquatic plants from the inshore lake bed.

4. Deepening channels to improve water circulation and navigation access.

5. Improving tidal flushing by deepening entrances.

6. Managing catchment through sewage upgrades, erosion control, stormwater treatment, stream bank stabilisation and wetland preservation.

These programs involve local landholders, local government and State organisations and include strategies such as minimum tillage and stubble retention agriculture practices; control of stocking rates; contour cultivation; improved fertiliser management (for example, better timing, sub-soil injection and use of slow release types); revegetation of stream banks' buffer strips; control of road-side erosion; sewage system upgrades; preservation of wetlands as sediment and nutrient 'traps'; and reduction of erosion during urban development.

Sewage nutrient minimisation

Sewage nutrient minimisation strategies include minimisation of nutrients entering the sewage system; better dilution and dispersion methods; re-use of effluents; and nutrient reduction before discharge.

Controls on detergents

Phosphates from detergents may contribute up to 65% of the phosphorus from domestic effluents. Their ban by the US Environment Protection Agency around the Great Lakes in the 1970s has been relatively successful in reducing nutrient loadings. Similar controls have been suggested along the Murray-Darling, and in the Great Barrier Reef Region.

Relocation of outfalls

A common management response in recent years has been the relocation of sewage outfalls from streams, rivers, lakes and shorelines into waters with better dilution and dispersion characteristics, such as deep offshore sites. This stategy has been adopted in the Latrobe Valley scheme, Lake Macquarie and Tuggerah Lakes scheme, and the Sydney Offshore Outfall program.

Tertiary treatment

Tertiary treatment of sewage to reduce N and P loads in effluents, whilst not widely practiced in Australia, is being introduced in many inland plants because of the blue-green algae problem. Nutrient reduction methods have been introduced in some coastal plants, for example, at Port Macquarie and several resorts on the Great Barrier Reef.

Re-use of effluents

Re-use of effluents for land irrigation has been undertaken at a large scale at Werribee near Melbourne since 1897. Re-use of effluent for residential non-potable use is increasing overseas but is not permitted in Australia under current regulations. A pilot project to assess operating requirements, risks and community acceptance was undertaken at Shoalhaven Heads (NSW) from 1989-91, and was considered to be viable and without health risks.

Economic costs

The economic, as well as the ecological costs of eutrophication are great. The Sydney Clean Waterways Program is budgeted for $7.1 billion over

Urban stormwater management

The recent focus on sewage discharges and their impacts on coastal environments has resulted in the application of more stringent discharge requirements and sewage plant improvement schemes. Urban stormwater has now become the major source of pollutants entering waterways along developed coastlines. Stormwater quality is a product of population density, land-use patterns, sanitation and waste disposal practices, soil types climate and hydrology, and stormwater management.

Contaminants in stormwater (grouped according to their water quality impacts) are:

- suspended solids and particulates (sewage overflows and surface run-off);
- nutrients (phosphorus and nitrogen);
- biological and chemical demanding materials (organic debris such as decomposing food and garden wastes, and sewage overflows);
- micro-organisms (bacteria and viruses from septic and sewage overflows and animal wastes: Chapter 47);
- toxic organics (pesticides, industrial chemicals and landfill leachate: Chapter 45);
- toxic heavy metals (lead, zinc, chromium and copper from motor vehicles, pavements degradation, and water pipe and roof corrosion: Chapter 44);
- oils and detergents (from road surfaces and washing of vehicles: Chapter 43); and
- litter (including paper, plastic, glass, metal and other packaging materials: Chapter 46).

Little data exist on the level of pollutants coming from urban catchments. Pollution levels in stormwater are difficult to assess as they vary considerably due to pollutant availability, rainfall intensity and duration. Pollutant concentrations in the first flush of a storm may be three times higher than those during the peak flow.

The majority of environmental impacts associated with stormwater come from poor public behaviour in relation to disposal of litter, application of fertilisers and chemicals and agrochemicals, and disposal practices. Public education programs are required to change community attitudes and behaviour, and promote best management practices.

(Source: D. Gayler, Commonwealth Environment Protection Agency)

20 years. A $80 pa household levy to improve the sewage system is underway to raise $485 million over five years. Engineering measures to reduce algal growth cost $170 million in Cockburn Sound.
A toxic algae bloom in the Gippsland Lakes in the summer of 1987/88 cost around $6.5 million in lost tourist revenue. Effects on fisheries are difficult to estimate. In the Peel-Harvey, fisheries in one estuary declined, and in the other increased. In New South Wales, oyster farming benefits from faster growth in eutrophic estuaries, but not from the occasional gastrointestinal epidemics among consumers.

Monitoring and databases

Systematic monitoring is required to detect changes in nutrient status and the onset of eutrophication. The monitoring should include long-term monitoring to determine ambient conditions and detect trends; monitoring of known or suspected eutrophic systems; monitoring of developments and discharges; and monitoring of ecological processes.

Long-term data sets

In Australia, few systematic, long-term data sets exist for nutrients, phytoplankton concentrations or benthic conditions. CSIRO have long-term data (ranging from 7-50 years) on water quality of 13 sites around Australia, but only four sites are still active. Various government agencies, and university researchers have time-series information on particular areas. Monitoring nutrient status has been investigated using remote sensing from satellites (US Coastal Zone Color Scanner (now defunct), Advanced Very High Resolution Radiometer, the US LANDSAT and the French SPOT) and aircraft. CSIRO is pioneering the latter in this country.

State authorities undertake routing monitoring in a number of eutrophic areas, for example, Peel-Harvey and Cockburn Sound (WA); eastern Gulf St Vincent (SA); Lake Illawarra, Lake Macquarie and Tuggerah Lakes (NSW) and in coastal water bodies such as Port Phillip Bay, Western Port, and Gippsland Lakes (Vic).

Compliance monitoring

Monitoring of outfalls and other developments is also often required as part of Environmental Impact Assessment, for example, at Jervis Bay, the Sydney off-shore sewage outfalls, power station discharges into New South Wales coastal lakes, and marinas and refineries on the Great Barrier Reef. While many of these programs are not carried out by independent agencies, are limited in scope and the results are not widely disseminated, some are now producing valuable, long-term data sets, for example, the Cape Schanck sewage discharge and the New South Wales coastal lakes programs.

Systems studies

Ecological and oceanic studies by CSIRO, Australian Institute of Marine Science and other research agencies have also produced long-term information on nutrient levels, and of ecosystem effects, for example, in the Central Great Barrier Reef, Jervis Bay, Ulladulla, Hawkesbury Estuary, Port Phillip Bay and Western Port. Because of the complexity of processes and interactions, modelling has particular potential to integrate information on physical, chemical and biological processes to assist in understanding the system. Models may be numerical, physical or prototype.

Databases, information systems

While no central database of monitoring results exists, this is planned under the aegis of the National Water Quality Management Strategy. The national Environmental Resources and Information Network (ERIN) and CSIRO's Coastal and Marine Resource Information System (CAMRIS) are also attempting to coordinate the storage of such data.

Summary and conclusions

1. Australian coastal ecosystems evolved under very low nutrient and sediment regimes and are sensitive to anthropogenic elevations of these.

2. Eutrophication is considered one of the most serious and widespread threats to Australia's coastal ecology.

3. Estuaries and coastal lagoons whose catchments drain areas with intensive agriculture and major urban developments are at particular risk. Major effects have already been experienced in many systems.

4. Major losses of seagrasses have occurred in southern Australia since 1950 due to increases in nutrients and sediments.

5. Corals are particularly sensitive to elevated nutrients. There is some evidence that the Great Barrier Reef lagoon, Australia's largest semi-enclosed water body, may be eutrophic. Adjacent coastal nutrient inputs have increased about four-fold.

6. The establishment of a national monitoring program and development of appropriate management strategies is a high priority.

7. Management strategies have been commenced for total catchment management, and to reduce nutrients in sewage in some of the most extreme cases.

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Chapter 43. Hydrocarbons in the marine environment[1]

The catastrophic effects of accidental oil spills on marine organisms are well known. However, less well known are the long-term effects of low but persistent levels of hydrocarbons which are characteristic of many ports and waters adjacent to urban and industrial areas. Oil and other hydrocarbons contain a variety of toxic compounds, some are carcinogenic, and even at very low concentrations can cause diseases in aquatic organisms.

This chapter describes the characteristics of some of the petroleum products which enter the sea and examines their levels in the marine environment and marine organisms in Australia.

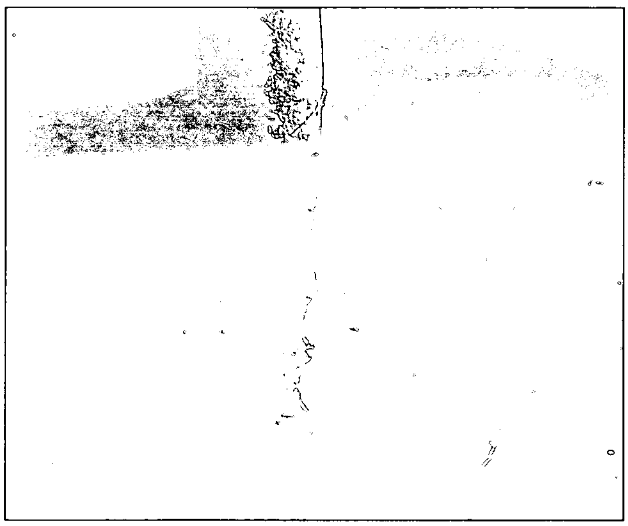
Characteristics of petroleum products

Crude oil and refined petroleum are complex substances made up of hundreds of compounds of two classes: alkanes and aromatic hydrocarbons (Table 43.1). The former have a low toxicity; the latter include the environmentally harmful polycyclic aromatic hydrocarbons (PAHs) which are carcinogens and have been implicated in a wide range of human health problems, and in diseases in aquatic organisms.

Table 43.1: Characteristics of some petroleum products

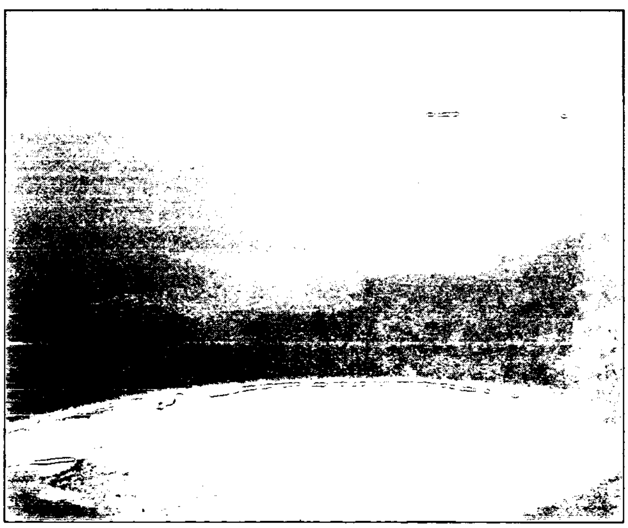
Product products	Hydrocarbon types	Boiling point °C	Carbon atoms
natural gas	alkanes	<20	1-6
petrol	alkanes aromatics	20-200	4-12
kerosene, jetfuel, diesel	alkanes aromatics	185-345	10-20
lubricating, cranking oil	alkanes	345-540	18-45
asphalt, residual	complex aromatic	>540	>40

Although weakly soluble in water, PAHs are strongly bioaccumulative in aquatic organisms. Naphthalene, for example, has a bioconcentration factor of 426. PAHs and other hydrocarbons also have strong affinities with organic material in sediments, e.g. up to one million times the concentration of surrounding water.



(Source: GBRMPA)

Figure 43.1: Most hydrocarbons in the marine environment come from urban run-off, sewage and minor spills in ports. A typical, minor port spill.



(Source: Coastwatch)

Figure 43.2: Oil slick from ship, *Piper Reef*, Great Barrier Reef.

[1]Based on a paper by Professor D. W. Connell, Division of Environmental Sciences, Griffith University, Brisbane, Queensland.

Levels in the marine environment

Petroleum hydrocarbons are present at different concentrations in water, sediments and biota in Australia's marine environment (Table 43.2).

Sea water

Surveys on the Great Barrier Reef found normal background concentrations in water (<1 µg/L total hydrocarbons). Surveys in Port Phillip Bay and Western Port (Vic) found largely background levels, but some areas were contaminated. PAHs have been detected in the Brisbane (Qld), Parramatta (NSW) and Yarra (Vic) Rivers and are thought to result from urban run-off, sewage and petrochemical industries.

Sediments

Concentrations of PAHs in marine sediments similarly range from background levels in remote areas (e.g. on the Great Barrier Reef) to localised contamination in urban areas (e.g. in Yarra, parts of Western Port). The low level of contamination on the remote Rowley Shelf off Western Australia may result from petrochemical extraction and transport in the area.

Table 43.2: Occurrence of petroleum hydrocarbons in Australian waters and sediments

Location	Concentration & hydrocarbon type (µg/L)
Waters	
Great Barrier Reef	0.29 petroleum
Port Phillip Bay	0.2-22.6 petroleum
	0.25-0.7 total hydrocarbon
Western Port	<0.1-7.1 petroleum
Yarra River	0.05-0.41 PAHs
Parramatta River	0.17-0.41 PAHs
Brisbane River	0.10-0.28 PAHs
Sediments	
Great Barrier Reef	0.2-0.8 dry wt hydrocarbons
Brisbane River	3.9-16.1 dry wt PAHs
Parramatta River	0.1-13.6% grease
Mallacoota Inlet	0.80-0.11 PAHs
Western Port	2.3-5,271 dry wt tot hydrocarbon
Corio Bay	0.49-3.0 PAHs
Corio/Geelong/ Port Phillip Bay	6-1516 petroleum hydrocarbons
Yarra Estuary	0.12-10.9 PAHs
Rowley Shelf	0.015-0.05 dry wt alkanes

Marine biota

Background levels of hydrocarbons in biota are difficult to establish because many organisms produce natural compounds similar to petroleum hydrocarbons. The levels on the Great Barrier Reef probably represent background levels, but fish and birds sampled in southern Queensland were contaminated (to 270, and to 1038 mg/kg, respectively). Biota in Western Port and Port Phillip Bay ranged from relatively free of contamination, to contaminated.

Table 43.3: Occurrences of petroleum hydrocarbons in some Australian marine biota

Biota	Location	Hydrocarbon	Conc (mg/kg)
Fish	S. Qld	kerosene	270.0
Fish	GBR	hydrocarbons	to 0.3
Mussels	Western Pt. Port Phillip	petroleum	to 4.4 lipids
Oyster	Rowley Sh.	petroleum	to 4.9 lipids
Corals	GBR	hydrocarbons	0.06-3.1 lipids
Clams	GBR	hydrocarbons	0.06-0.1 lipids
Seabirds	Brisbane R.	petroleum hydrocarbons	to 1038

Status of monitoring and management

No systematic monitoring of petroleum occurs in the marine environment of Australia. A range of chemical, histopathological and ecological indicators can be used to monitor the occurrence and effects of petroleum on the marine environment. As concentrations in water are very low and highly variable, the most valuable chemical indicator is petroleum levels in sediments.

A national program is required to monitor sediments in vulnerable areas, and in areas free of contamination to establish background levels. Where elevated levels are detected, histopathological investigations should be instituted. Should this indicate significant effects, an ecological program monitoring population, community and ecological effects would be appropriate.

Discharges from sewage plants and industrial operations are specified in licence conditions and kept to a minimum. Because of the significance of urban run-off as a source of hydrocarbon pollution, local government management is necessary to reduce discharges.

Summary and conclusions

1. Petroleum contamination occurs in urban areas in Australia and where petrochemical industries operate.

2. Polycyclic aromatic hydrocarbons (PAHs) in petroleum are most bioactive in terms of toxicity and bioaccumulation. Levels are highest in sediments.

3. No systematic monitoring of hydrocarbons is undertaken in Australia. Monitoring of levels in sediments in vulnerable areas and control sites is needed.

4. Specific attention is required to ensure that discharges from sewage plants and industrial operations are specified in licence conditions and kept to a minimum.

5. Because of the significance of urban run-off as a source of hydrocarbon pollution in Australia, local government management of discharges is required.

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Acknowledgments:
The technical paper by Professor D. Connell was reviewed by Dr J.T. Baker, Senior AIMS Fellow, Australian Institute of Marine Science, Townsville, Qld.

Chapter 44. Heavy metals and organometals[1]

Pollution of the marine environment by heavy metals was identified as a major problem following a number of international disasters involving heavy metals in the 1960s. The Derwent River in Tasmania, severely affected by metallurgical wastes, pulp mill effluents and partially treated sewage, was regarded as one of the most polluted areas of the world. However, significant advances have been made in reducing the extent of heavy metal pollution over the past 20 years.

Heavy metals such as copper (Cu), lead (Pb), cadmium (Cd), zinc (Zn), mercury (Hg), arsenic (As), cobalt (Co), nickel (Ni) and chromium (Cr) from urban run-off, industrial effluents, mining operations and atmospheric fall out, and organometals such as tributyl tin from antifouling paints, are major anthropogenic contaminants of the world's estuarine and coastal waters. While many metals are essential trace elements for living organisms, they may become very toxic above certain concentrations.

This chapter examines the problems posed by heavy metals and tributyl tin in Australia's marine environment, and the management of the problems in this country. It only briefly discusses the issue of heavy metal contamination of Australian seafood.

Nature of the problem

The oceans are often, mistakenly, seen as a boundless sink for heavy metals. While levels are very low in oceanic waters, concentrations may be much higher in shallow, nearshore waters where dispersal and dilution processes are less effective. As heavy metals readily attach to suspended particles, they accumulate in bottom sediments. This is particularly so in estuaries where increasing salinity causes the precipitation of iron hydrous oxides which scavenge and coprecipitate soluble metal species.

Organisms are affected by particular chemical forms or species of a heavy metal. As the chemistry is complex and incompletely understood and the analyses difficult, most analyses in Australia are for the total metal concentration.

Extreme caution is required in sampling marine waters for heavy metals. Concentrations may vary greatly within sites and over time. Because of the very low concentrations involved, contamination during sampling and analysis is also a major problem. Few laboratories are able to detect ultra trace metal concentrations in sea water (below 1 microgram per litre). Because certain organisms accumulate heavy metals, and analysis is less difficult, these are frequently used as indicators. Australia has undertaken important pioneering work in heavy metal analysis.

Heavy metals in Australian waters

The problems and potential problems of heavy metals in Australia are relatively minor compared with the widespread contamination of coastal waters in the northern hemisphere. Heavy metal 'hotspots' are restricted to fewer than a dozen cities in Australia. These include most of the State capitals and major industrial cities such as Wollongong and Newcastle. It may also be a potential problem in areas where there has been mining within catchments, adjacent to refineries and in ports.

While there have been a number of studies of heavy metals in Australia in recent years, most are documented only in internal reports of monitoring agencies, and a detailed compilation is beyond the scope of this chapter. In addition, some data are of uncertain significance because of the methodological problems.

Heavy metals in estuarine waters

Concentrations in some of Australia's key estuaries are compiled in Table 44.1. In most instances levels are below the recommended Australian and New Zealand Environment and Conservation Council (ANZECC) guideline concentrations. Exceptions are Port Pirie (SA) which is affected by a lead-zinc smelter, and Lake Macquarie (NSW). While most concentrations are unlikely to have any acute effects on aquatic life, chronic impacts (moderate, but sustained concentrations) may have an adverse effect through bioaccumulation by fish, mussels, oysters and seagrass.

[1]Based on a paper by Dr G.E. Batley, CSIRO Centre for Advanced Analytical Chemistry, Menai, New South Wales.

Table 44.1: Heavy metals in selected estuaries, coastal waters (µg/L) and sediments (µg/g) in south-eastern Australia

Place	Cu	Pb	Cd	Zn	Hg	As	Co	Ni	Cr
[redacted]									
Estuaries									
Mid Port Phillip Bay (Vic)	0.6	<0.8	<0.05	<2 .0	<0.002	2.8	-	-	-
Corio Bay (Vic)	1.1	<0.8	0.2	<2.0	<0.002	3.2	-	-	-
Port Hacking (NSW)	0.5	0.4	0.2	-	-		-	--	-
N. Lake Macquarie (NSW)	1.5	1.6	1.9	5.2	-	-	-	--	
Lake Macquarie South (NSW)	1.2	0.1	0.2	1.0	-	-	-	-	-
Lake Munmorah (NSW)	1.5	0.2	0.1	2.7	0.02	1.7	-	-	2.1
Port Augusta (SA)	0.45	0.54	0.37	<10.0	-	-	-	-	-
Port Pirie (SA) offshore	0.25	5.1	0.32	47.0	-	-	-	-	-
Macquarie Harbour (Tas)	7		0.03	2.0	-	-	-	0.5	-
Derwent River (Tas)	1.2	0.23	0.05	3.4	0.034	<6	0.03	0.27	-
Coastal waters									
Pacific deep water	0.17	0.002	0.11	-	-	-	-	0.61	-
Bate Bay (NSW)	0.3	0.2	0.06	-	-	-	-	-	-
8 km E. Port Jackson (NSW)	<0.2	0.04	0.01	0.1	0.02	1.4	-	-	0.1
off Maroubra (NSW)	0.09	0.03	0.01	0.2	0.01	1.0	0.04	0.2	0.3
Lizard Is. (GBR)	0.13	<0.06	<0.01	0.10	<0.002	-	-	-	-
Estuarine sediments									
Corio Bay offshore	2-50	2-210	0.1-13	4-400					
Corio Bay mid	4-35	14-100	0.2-9	14-166					
Port Phillip Bay offshore	8	22	2	40					
Port Phillip Bay near shore	1.5	8	0.8	21					
Port Phillip Bay Werribee	<5-75	<20-140	<5	9-300					
Lake Munmorah*	70	40	-	150					
Tuggerah Lakes*	20	40	-	110					
Lake Macquarie north*	170	1200	160	2400					
Lake Macquarie south*	20	68	4	150					
Blackwattle Bay, Sydney**	180	520	3	1150					
Quilbray Bay, Botany Bay**	3	10	0.5	25					
Port Kembla Harbour**	113	113	2	380					
Sydney coast (100m depth)	14	15	-	60					

(* 5 cm depth ** 10 cm depth)

Figure 44.1: Mining and industrial effluents are sources of heavy metals.

Heavy metals in coastal waters
Concentrations in Australia's coastal waters are low (Table 44.1), and much lower than in equivalent northern hemisphere waters. Interestingly, levels in Great Barrier Reef waters sampled are even lower than in oceanic waters, probably because of the very high productivity of the GBR waters.

Heavy metals in bottom sediments
Estuarine and inshore bottom sediments have enriched heavy metals (Table 44.1). Concentrations are greatest in sediments close to estuaries, reflecting their role as a contaminant source. While no definitive guidelines exist, most concentrations exceed the guidelines suggested for dredged sediment disposal for Canada.

Heavy metals in biota
There are extensive data on metals in Australian biota because of the importance of food chain bioaccumulation and human consumption. The National Health and Medical Research Council (NHMRC) has set guidelines for fish, crustaceans and molluscs.

The isolated cases exceeding these have generally been attributable to point-source pollution from urban or industrial sources. Fish from Port Phillip Bay (Vic) exceeded mercury guidelines (0.5 µg/g) in 1981 because of the proximity to industrial effluents. Oysters from the Georges River (NSW) exceeded copper guidelines (70 µg/g) in 1988 and is attributed to contamination from antifouling paints.

Concerns exist regarding relatively widespread, high levels of cadmium in prawns, and mercury in sharks. The former is potentially a major issue in Australia's export fisheries and requires further research.

Heavy metals in Torres Strait

The possibility of heavy metal contamination of the Torres Strait from tailings from Papua New Guinea's Ok Tedi, Porgera and Mt Kare gold mines has been of concern in recent years (Chapter 74).

A pilot study by the Great Barrier Reef Marine Park Authority in 1993 found that the Fly River was a source of fine-grained sediments containing a number of major and trace metals such as aluminium, chromium, copper, iron, manganese, nickel, lead, silica and zinc.

Concentrations of cadmium in various molluscs were higher than on the Great Barrier Reef but those of copper, mercury, nickel, lead and zinc were similar. The concentrations of arsenic, cadmium and selenium in the edible portions of food consumed by Islanders were close to or above the National Health and Medical Research Council's Maximum Permitted Concentrations for seafood. Further surveys are underway.

(Source: W. Gladstone, GBRMPA)

Figure 44.2: Ports and marinas are sources of tributyl tin.

Tributyl tin in Australian waters

Tributyl tin (TBT) has been used in Australia as an active ingredient in antifouling paints since the early 1970s, and has largely replaced copper-based paints. TBT is leached from the paint at around 4 micrograms per square centimetre per day. It has a half-life of around six hours in sea water, and around 3.5 years in sediments.

During the 1980s TBT was found to affect the growth of oysters and cause imposex (changes to the reproductive system, resulting in sterility) in gastropods. A worldwide ban was recommended on its use on vessels below 25 metres in length. In most Australian states the ban took effect around 1988.

Tributyl tin in estuarine and coastal waters

The guideline concentration for TBT in marine waters is 2 nanograms (ng) of tin per litre. Prior to the ban, areas around dockyards and marinas showed concentrations in excess of 100 ng/L, and confined waterways not used by shipping ranged from 10-100 ng/L. Since the ban, concentrations have dropped appreciably, to below the guideline level.

Table 44.2: Tributyl tin levels in Australian waters

Place	level (ng Sn/L)
Georges River (NSW)	8-40 (pre-ban)
	1-11 (post-ban)
Kogarah Bay (NSW)	100 (pre-ban)
Port Phillip Bay (Vic)	3-23 (pre-ban)
Southport (Qld)	45 (pre-ban)

Tributyl tin in sediments

As with heavy metals, greatest concentrations of TBT are found in sediments. Concentrations are generally low and of minor environmental concern but may be locally exceptionally high, i.e. exceeding one microgram per gram, close to marinas and slipways where paint flakes are hydro-blasted from hulls and accumulate in the sediments. Values are now lower in the upper one to three centimetres of sediments (depending on local sedimentation rates) and higher beneath.

Tributyl tin in biota

The most significant impacts in Australia have been on intertidal oysters, possibly because of enrichment of TBT in the surface microlayer. It has been shown to cause imposex in gastropods in Victoria, New South Wales and South Australia, and has been implicated in declines in scallops.

Management of heavy metals and tributyl tin

The establishment of water quality guidelines for effluents has significantly lowered the levels of heavy metals in Australia's estuaries and coastal waters. This is particularly evident in estuarine sediments near urban and industrialised areas, where the surface generally contains lower levels than the upper subsurface which is contaminated by heavy metals, especially lead and zinc.

The restrictions on the use of TBT since 1988 have substantially reduced levels in Australia's coastal waters and in sediments around marinas.

Status of monitoring of heavy metals and tributyl tin

Many of the State/Territory environment protection agencies and other environmental organisations are monitoring selected heavy metals on an *ad hoc* basis. Research on analytical techniques is being undertaken by CSIRO. The National Health and Medical Research Council has set guidelines for human consumption and undertakes regular market basket surveys. The Torres Strait Baseline study has been undertaken on a systematic basis.

The Australian Water Quality Guidelines for Fresh and Marine Waters and The National Water Quality Management Strategy

The Australian Water Quality Guidelines for Fresh and Marine Waters outlines the water quality required to sustain a range of environmental values (also known as beneficial uses). These environmental values include protection of aquatic ecosystems, recreational water quality and aesthetics, agricultural water use and industrial water use.

The guidelines discuss levels for hydrocarbons, heavy metals and organometals, organochlorines, nutrients, micro-organisms and other parameters, which generally should not be exceeded in order to protect the environmental values. Due to a wide range of ecosystem types and conditions throughout Australia, local site specific information will be needed to supplement the broad information provided in the document, particularly for ecosystem protection.

The Water Quality Guidelines are an important component of the National Water Quality Management Strategy, being jointly developed by the Agriculture and Resource Management Council of Australia and New Zealand and the Australian and New Zealand Environment and Conservation Council (ANZECC). This Strategy is significant in bringing together the resource and environment interests of State/Territory and Commonwealth Governments. The Strategy will include documents on the management of sewerage systems, the rural environment and stormwater as well as guidelines for specific industries.

The National Environment Protection Council (NEPC) is a Ministerial Council being established under the Intergovernmental Agreement on the Environment to develop National Environmental Protection Measures for marine and fresh water quality. The Council will consist of one Minister from each of the States and Territories and the Commonwealth and will have the ability to make decisions that are binding on all members on a 2/3 majority basis. Once National Environment Protection measures are passed by NEPC, they will be automatically picked up in each of the State and Territory environmental laws. NEPC will have the flexibility to consider the most effective means of achieving the required environmental outcomes.

The Australian Water Quality Guidelines for Fresh and Marine Waters published by ANZECC as part of the broader National Water Quality Management Strategy provide numerical and narrative criteria to assist in managing water resources sustainably. They include guidelines on nutrients (Chapter 42), hydrocarbons (Chapter 43), heavy metals and organometals (this chapter), organochlorines (Chapter 45) and micro-organisms (Chapter 47).

(Source: K. Dal Bon, Commonwealth Environment Protection Agency)

Summary and conclusions

1. Heavy metals are a localised problem in estuaries near state capitals and industrial cities. Levels are highest in sediments, but are minor compared with the industrial northern hemisphere.

2. Rural areas of Australia have generally very low levels.

3. Levels in the marine environment have been reduced over the past 20 years through environmental legislation and effluent guidelines.

4. Levels in the marine environment and in edible marine organisms are monitored on an *ad hoc* basis. Concerns have been expressed on high levels of cadmium in prawns, and mercury in sharks.

5. Tributyl tin from antifouling paints has been a localised problem around docks and marinas. Levels have declined since the restrictions on usage in 1988.

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Chapter 45. Organochlorines[1]

Some 60,000 different synthetic organochlorine compounds have been produced for agricultural and industrial usage over the past 50 years, and an additional 500 to 1,000 new compounds are being produced each year. The persistence and toxicity of the organochlorines have made them effective pesticides. It has also made many of them potential environmental problems. While organochlorine compounds are present in very low concentrations in the sea, some are preferentially soluble in animal fats within which they may reach as much as 500,000 times the concentration in surrounding waters. They may also bioaccumulate in food chains, being most concentrated in higher consumers such as predatory fish, marine mammals, seabirds and humans. Kills have occurred in fish and crustaceans, and birds-of-prey have been affected through egg shell thinning.

Organochlorines have been widely used in Australia as insecticides (DDT, lindane, chlordane, dieldrin, aldrin, heptachlor), fungicides (hexachlorobenzene, chlorinated phenols), and herbicides (2,4-D, 2,4,5-T), and as insulating fluids in transformers and capacitors (polychlorinated biphenyls). Compounds such as dioxins and dibenzofurans have also been unwittingly produced as by-products.

Because of their harmful environmental effects, various controls have been placed on organochlorine usage in Australia. However, environmental effects of organochlorines on Australian marine life are not well known and data on their concentrations in the environment are relatively limited.

Table 45.1: Past and present use of organochlorines in Australia

Organochlorine	use
insecticides	
DDT, Endrin. HCBs other than Lindane Lindane (-BHC) etc.	• no permitted uses • banned in WA • withdrawn in all States for use in control of inset pests in stored seeds • used to control white grubs & symphylids in pineapples (Qld), ectoparasites on foods (all States other than NSW) Tas & WA), and head lice on humans (except in Vic & WA)
Chlordane	• quarantine purposes (Vic). • control on termites in all States except Tas
Heptachlor	• control of funnel ant in some cane growing areas of Qld, by permit • control of termites in all States except Tas.
Aldrin	• no longer used
Dieldrin	• no longer used
Herbicides	
2,4-D	• used to control broad-leafed weeds in crops, water weeds and vegetation near drains, and in domestic gardens
2,4,5-T	• used in past as a herbicide against broad-leaved woody plants, and as a defoliant • Dioxins found as a contaminant in some commercial preparations. • use and manufacture in Australia has ceased.
Fungicides	
Hexachloro-benzene (HCB)	• use well controlled in past • does not present problems based on wide-scale use in northern hemisphere • now banned in Australia
Chlorinated phenols	• Widely used in Australia • readily degrade in aerobic environments • formulations of pentachlorophenol contaminated by dioxins and bibenzofurans
Polychlorinated Biphenyls (PCBs)	• never manufactured in Australia; imported for use • Use restricted since 1975 to 'closed system' uses where contact with the environment is unlikely

(Source: ANZECC 1991)

Organochlorines in the marine environment

Organochlorines enter the marine environment through point sources (sewage or factory effluents) and diffuse sources (land run-off, ground water and atmospheric fallout). Industrial effluents may contain dioxins which are produced during the chlorination of wastes, combustion, paper bleaching and metal refining. Sewage effluents contain organochlorines from industrial and domestic wastes, and furans from the chlorination of sewage. Chlorination also produces a suite of little-known organochlorine compounds referred to as AOX (adsorbable organic halides).

[1]Based on a paper by Assoc. Professor Bruce Richardson, Deakin University, Victoria.

Concentrations around Australia

Despite Australia's past and present heavy usage of these compounds and the extent of run-off from rural and urban usage into the sea, little is known of levels of organochlorines in Australia's marine environment. Most investigations have concentrated on localised areas or 'hotspots' near cities.

Research indicates that pesticides and their residues (e.g. DDT, DDE and lindane) are widely present in marine organisms in Australia, but that concentrations are very low away from urban discharges and intensively farmed rural areas.

In Queensland, very low concentrations of lindane were found in Great Barrier Reef corals, molluscs and fish. Considerably higher levels have been found in Moreton Bay which receives the discharge of the Brisbane River.

In South Australia only six of 85 fish specimens examined in the 1970s were pesticide free, and maximum residue limits (MRLs) for dieldrin and DDTs were exceeded in some specimens. Although levels were found to be relatively low in Victorian sites studied, concentrations in Australian fur seals were at least as high as in northern hemisphere species.

Most research in Australia has centred on levels around Sydney sewage outfalls. Fish caught off the Malabar outfall (which has the highest proportion of industrial waste) contained high concentrations of organochlorine pesticides. The red morwong *(Cheilodactylus fuscus)*, for example, exceeded maximum permissable levels of BHC by 122 times, and heptachlor by 52 times. In 1989 fishing was prohibited within 500 metres of the main outfalls. Studies of the new deepwater outfalls in 1991 found widespread contamination of fish: 65% of rubberlip morwong *(Nemadactylus douglasii)* exceeded maximum limits set by the National Health and Medical Research Council. The situation has improved since the relocation of the outfalls (Chapter 52).

Polychlorinated Biphenyls (PCBs)

Few surveys of PCBs have been undertaken in Australia. In Port Phillip Bay (Vic) PCBs were found in all 87 samples of shellfish and 27 samples of sediments examined in the late 1970s. Highest concentrations were found off the densely populated and industrialised areas of Melbourne and Geelong. A limited resurvey in the late 1980s indicated that levels had fallen in Corio Bay near Geelong, but those near Melbourne remained high.

PCBs have been detected in fish samples from the Brisbane River, and in low concentrations in corals, fish and dugongs from the Great Barrier Reef. In New South Wales they were found in mullet *(Mugil cephalis)* from Port Jackson and Botany Bay, and in red morwong off Sydney sewage outfalls in the late 1970s. Recent surveys off the outfalls indicate continued improvements in PCB levels, presumably due to restrictions placed on their use in the mid-1970s.

PCBs have been detected in offshore surface waters, increasing towards the coast but concentrations were lower than in equivalent Atlantic waters.

Dioxins and dibenzofurans

Although these compounds are recognised as significant waste problems in Australia, few studies have been made in the marine environment, largely because of a lack of local analytical capability.

In Sydney dioxins have been found in fish and sediments in Homebush Bay adjacent to contaminated landfill sites, leading to a ban on fishing. In Melbourne they have been found near sewage outfalls. Dioxins have been found in the effluents of three of four paper-pulp mills using chlorine bleaching processes.

Management of organochlorines

The major problems with managing hazardous wastes (including organochlorines) in Australia include the lack of uniformity in the States and Territories; a 'piecemeal' basis in legislation; and 'sectoral' regulation, with different legislation for the protection of the public, of workers' health, and of the environment. For example, in New South Wales 72 pieces of legislation administered by 17 government departments relate to the control of toxic and hazardous chemicals.

Monitoring of organochlorines

Monitoring of organochlorines in Australia's marine environment has been limited to localities near major urban centres (such as Sydney, Melbourne and Brisbane), or to areas deemed sensitive by their uniqueness (such as the Great Barrier Reef) which may be adversely affected by agricultural run-off.

Problems in monitoring include insufficient sites to ascertain spatial and temporal trends in Australia; limited analysis of compounds such as dioxins and dibenzoflorans; limited analytical capability (especially for dioxins); inadequate commitment to coordination and funding of monitoring; and a lack of firm and consistent national regulations of organochlorines.

Commonwealth legislation relating to toxic and hazardous chemicals

The Commonwealth legislation and regulations on agricultural and veterinary chemicals includes:

The *Agricultural and Veterinary Chemical Act* 1988, by which the Australian Agricultural and Veterinary Chemicals Council evaluates chemical products.

The *National Industrial Chemicals (Notification and Assessment) Act* 1989; by which the National Industrial Chemicals Notification and Assessment Scheme protects workers, the public and the environment from the harmful effects of industrial chemicals.

The *Hazardous Waste (Regulation of Exports and Imports) Act* 1989, which allows Australia to meet its international agreements under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. The Independent Panel on Intractable Waste established in 1991 has examined alternative technologies for the disposal of intractable wastes.

The *Environment Protection (Sea Dumping) Act* 1981, which covers Australia to fulfil its international obligations under the London Dumping Convention.

Summary and conclusions

1. A range of organochlorine compounds, including herbicides, insecticides, fungicides and PCBs, have been widely used in Australia in the past.

2. Although organochlorines are recognised internationally as important contaminants in marine environments, there have been relatively few detailed studies to determine the magnitude and extent of the problem in Australia.

3. Based on available data and on the situation in the better-known northern hemisphere, it is likely that organochlorines occur in highest concentrations close to urban and industrialised centres, or where run-off from rural areas has a major influence.

4. Techniques for assessing the chronic toxicity of organochlorines in local waters require development.

5. Nationwide monitoring programs for the surveillance of organochlorines are necessary in order to develop and maintain an adequate level of environmental protection in Australia.

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Acknowledgments:
The technical contribution by Dr B. Richardson was reviewed by G. Shaw, National Research Centre for Environmental Toxicology, University of Queensland, Brisbane, Qld.

Chapter 46. Ocean and beach litter[1,2,3]

The flotsam and jetsam along the upper tide line provides a window into the sea and its mysteries ... intricate shells of all shapes and colours, crab claws, lobster casts, mounds of kelps, driftwood sculptures, a plank from a wrecked boat, or perhaps a treasure such as a beautiful paper nautilus. Nowadays however it is more likely the beachcomber will be confronted by a variety of plastic bags, bottles, six-pack yokes, tar balls, tangled fishing lines and fragments of nets, glass bulbs and tubes, and other human garbage. Even our most remote beaches and islands are not free of litter.

The oceans provide the ultimate sink for many of the by-products of human activities, many of which end up on our beaches. Shore and ocean litter is unsightly to beachgoers and is a serious hazard for small vessels as plastic bags in a cooling pipe can blow up a motor. It is also harmful to sea life. Seabirds, turtles and cetaceans may ingest plastic bags, or may become entrapped in old netting, ropes and six-pack yokes.

This chapter describes beach litter from both oceanic and local sources, the composition of the litter, its effects on wildlife and its possible management.

Ocean litter around Australia[1]

Ships at sea are a major source of ocean litter. It is estimated that each day over 600,000 plastic containers are discarded by ships into the world's seas, a total of around 6.4 million tonnes per year. Much of this litter is buoyant and may drift for months and years, until cast ashore. Some of the plastic items are virtually indestructible, and may take centuries to degrade.

Few systematic surveys have been undertaken on ocean litter in Australia. The following is only an indicator of the extent of the litter problem on our oceans and beaches.

Eastern Australia

On the Great Barrier Reef the prevailing winds and currents carry ocean litter from the Coral Sea and the equatorial south-west Pacific. Litter from fishing

Four sources of beach litter:

1. 'Tourist 'trash' left by beach goers (e.g. food packaging, cans and bottles, disposable plates, rubber thongs, board wax, tangled fishing line).

2. Land litter washed from catchments via storm water drains and streams (e.g. items of domestic garbage, light bulbs, fluorescent tubes, sewage, industrial wastes).

3. Maritime litter from inshore shipping, small boats, oil rigs (e.g. ships' domestic rubbish, light bulbs, fluorescent tubes, fishing gear, bait boxes, nets, lines, floats).

4. Oceanic litter from distant sources beyond the continental shelf (e.g. as above, but distinguished by foreign labels, heavy encrustations).

(Source: Dept. Conservation and Natural Resources, Vic)

Figure 46.1: A heavily littered shore of Port Phillip Bay (Vic).

[1]Based on a paper by Dr N. Wace, Australian Department of Biogeography and Geomorphology, National University, Canberra, Australian Capital Territory. [2]Based on a paper by A. Reynolds, Greenpeace Australia, Sydney, New South Wales. [3]By Dr L. Zann, SOMER Coordinator.

vessels and shipping has increased in recent years and it is even common on remote Coral Sea cays and in Princess Charlotte Bay. Near Bundaberg in southern Queensland around 500 items were recorded per kilometre of beach.

In New South Wales plastic and glass bottles are ubiquitous, and tourist trash is usually abundant and persistent. In eastern Tasmania 68% of beach litter came from fishing and boats: rope comprised 30% of the plastics.

North and west coast

Little information is available from these coasts. Away from settlements, fishing litter largely comes from the Gulf of Carpentaria prawn fisheries. Fishing litter is common on the Pellow and Wellesley islands. No information is available from the Kimberley coast. Roebuck Bay and Eighty Mile Beach are considered clean. The coastline from North West Cape to Shark Bay carries litter from the Indian Ocean. The Houtman Abrolhos Islands further south are littered with old craypots, ropes and other debris from the lobster fishery.

South coast

Ocean litter originates from a huge area of the Southern Ocean, from the southern Indian Ocean to the Atlantic coast of South America, and from Indonesia via the Leeuwin Current. A survey of one kilometre of beach at Eyre Bird Observatory (WA) in 1990-91 resulted in 494 items, the majority of which was fishing gear. The litter consisted of 5% glass, 47% moulded plastic, 41% flexible plastic (12% of which was rope), 4% metal and 3% wood.

In South Australia, annual surveys along the 26 kilometres of Anxious Bay beach in northern Eyre Peninsula between 1991-93 resulted in from 9-15 kilograms of litter per kilometre of beach. Most of this was discarded fishing gear from the Great Australian Bight fisheries. It included plastic ropes, floats, strapping, containers, cod-end nets from trawl fisheries, longline floats, lobster pots and bait baskets.

In Victoria, beaches west of Port Phillip Bay are heavily polluted by plastic food and drink containers, plastic sheeting and rope. Around 66% of litter was locally generated tourist junk. Inaccessible beaches at Cape Liptrap were heavily littered with fishing and offshore wastes.

More systematic surveys of litter have been undertaken in Tasmania. Between 1990 and 1991, 150 surveys undertaken on 88 beaches resulted in 50,111 items (i.e. 300-350 items per kilometre). In the uninhabited south-west, part of the World Heritage Area, most of the debris (61%) was ocean-sourced plastic, of which 80% was plastic fishing debris. Most of the plastic items came from the offshore fisheries. 'Adopt-a-Beach' (below) clean-ups of seriously

Table 46.1: Ocean litter on Australian beaches

	East coast		**North coast**	**West coast**	**Southcoast**		
	Qld	*GBR*	*Arnhem Land*	*Abrolhos*	*East Bight*	*Bass Strait*	*W .Tasmania*
Offshore currents	East Australian		Equat.	Leeuwin Counter-current		Antarctic Circumpolar	
Current direction	N to S	NE to SW	E to W	N to S	W to E (strongest in winter)		
Human beach litter							
hard plastic	33% (f,b)	scarce (s,f)	locally abund	-	0% (fsb)	38%	>55%
soft plastic	3% (b)	scarce (f)	-		>32%	36%	- (fb)
foam plastic	5%	rare (f)	-	-	-(fb)	4%	3%
glass	40% (b,r)	common (s)	+	-	31% (fbrd	4%	3%
metal	2% (b)	rare (f)	-		5% (sb)	4%	23% (b)
wood	8% (b)	common (s)	-	-	+(s)	+	+
fabric, footware	8% (b)	common (s)	-	+	+(b)	+	+
Ocean litter							
site	Deep	Swains Rf			Anxious Bay	C. Schanck	SW Heritage
items/km beach	455	-	-		-	-	350
wt/km beach (kg)	7.6	-	-		-14		
Litter generating fisheries	tuna trawl	prawn trawl		lobster	trawl, tuna squid, lobs.	trawl, scallop	squid lobster

+: present. -: no imformation. : beach litter generators: beachgoers (b); recreational (r); fisheries (f); shipping (s) littered urban beaches in Tasmania in 1992 yielded around 600 items per kilometre, of which 65% were plastics. Beach surveys of isolated subantarctic Heard and Macquarie Islands averaged 13 and nine items per kilometre, respectively.

(Source: N. Wace)

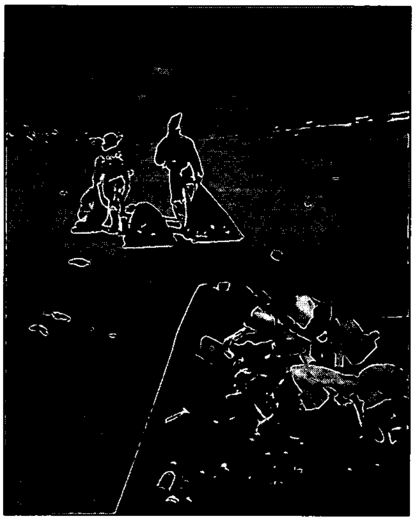


Figure 46.2: Studies of ocean litter on remote Australian beaches show that most of the litter there comes from fishing boats and foreign vessels. At Anxious Bay (SA) around 25 kilograms of ocean litter was found per kilometre of beach.

Beach litter in Australia[2]

The beach and ocean litter problem is mainly a product of our consumer society. The average Australian generates almost 900 kilograms of litter per year, some of which may find its way into the sea.

The total amounts of stranded beach litter (of both local and oceanic origins) are relatively well known because of the 'Adopt-a-Beach' program which has been undertaken by Greenpeace Australia since 1990.

Because of growing concerns about increasing amounts of litter in the sea and its effects on wildlife, Greenpeace began a nation-wide campaign to raise community awareness of the problems, to undertake community clean-ups of recreational beaches, and to identify the main sources of marine debris.

Volunteers from schools, conservation groups, fishing clubs, army units, local councils and others around Australia 'adopted' a local beach and undertook the systematic removal of litter. Details of the type and composition and origin were recorded in a questionnaire, and returned to Greenpeace. The campaign was well publicised by the press and television. A newsletter, the 'Daily Thong', was published bimonthly to provide feedback to the

Statistics from Adopt-a-Beach clean-ups 1990-92

123 beaches were cleaned;

300 km total length was cleaned;

414 litter surveys were undertaken;

118,490 'intact' articles were collected;

224,084 fragments of litter were collected;

participants, together with information on other marine issues to raise community awareness. Initially intended to run for 12 months, the highly successful program is still operating, although data on the amount and composition of litter is no longer being collected.

Composition of litter

Greenpeace found that plastics constituted 61% of all items collected, and around 70% of the top ten articles (Figure 46.3). This was followed by glass and aluminium. Packaging materials formed the bulk of the litter (65%). Some 52% of all the articles collected around Australia were beverage containers which had been sold as disposable products. Of these, 35% were made of plastic, 30% glass, 20% aluminium and 16% were paper. Greenpeace noted with concern the apparent failure of industry-funded litter campaigns such as 'Do the Right Thing'.

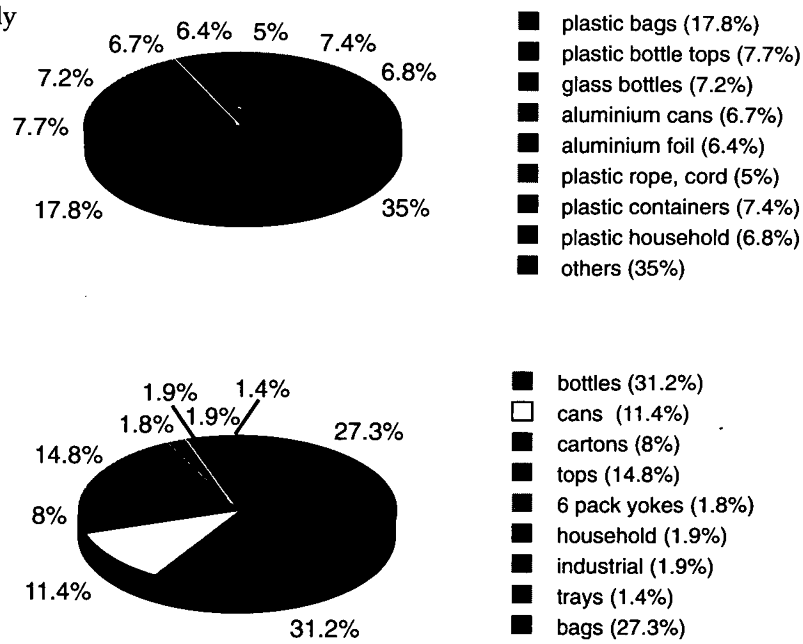


Figure 46.3: Beach litter by composition and type.
(Source: Greenpeace Adopt-a-Beach surveys)

Plastic bags, particularly bait bags, were abundant in the surveys. Greenpeace later contacted many of the suppliers of these bags to encourage them to distribute information on the problems of marine debris. They reported a positive response from around half of those contacted. Six-pack yokes, which may choke seabirds and fish, were also common, as were bottle caps, plastic drinking straws and disposable nappies for babies.

Sources of beach litter[3]

A survey of litter in 1993 by the Victoria Institute of Marine Sciences (VIMS) for the Plastics Industry Association identified the major sources of litter on beaches near Brisbane, Sydney and Melbourne using scientific field surveys, questionnaires, consultation with user groups and other techniques. The study found that all user groups were well aware of the problem, and particularly of the resulting ecological and social impacts of litter. Frequent beach users were the most aware. The level of compliance with anti-littering laws by all user groups was good, but was least among the occasional recreational fishers. Predictably, each user group blamed others for the problem.

The major findings contradicted the popular perception that water-based user groups (recreational and commercial fishers, ship crews, picnickers) were responsible for the bulk of stranded litter near urban areas. Most beach litter found actually came from land-based sources (street refuse, garbage dumps, poorly maintained land fill) and had been carried into the sea by stormwater drains, creeks and rivers. Often the street-sweepers in the city hose litter down the drains, and the beach-sweepers pick it up again.

The study identified the major sources of litter as the 'general public' through their land-based littering practices, and inadequate waste management by local authorities.

Fishing debris[3]

The International Maritime Organisation has estimated that around 150,000 tonnes of fishing gear is dumped or lost in the sea each year. The extent of the problem in Australia has been recently reviewed by the Bureau of Resource Science (Jones 1994).

Amounts of fishing litter on beaches vary. The 'Adopt-a-Beach' program found around 20% of all items collected were related to recreational and commercial fisheries: plastic bait bags, floats and buoys, clear sheet, pieces of net, fishing lines, ropes and cordage, strapping tape etc.

In the VIMS study the proportion of fishing litter at the six study sites averaged 27% of the total, ranging from 2.4% at Redcliffe Beach (Qld) to 46% at Point Talbin (Qld). There was slightly more recreational fishing litter (average 8%) than commercial (6.5%).

In south-west Tasmania, 80% of the plastic debris comes from fisheries. At Anxious Bay (SA) where very few people visit the beach, almost all of the nine to 17 kilograms per kilometre of litter comes from fisheries. In a survey in the Marmion Marine Park (WA) in 1992, fishing litter made up 41% of the total weight of litter.

The Bureau of Resource Sciences study recommended that the problem in the south-east could be reduced through an industry education program, improved port disposal facilities, plastic-free bait boxes and net recycling. It also recommended that Australian observers on Japanese tuna longline vessels report on compliance with MARPOL, and that this be presented to Japan each year at the bilateral tuna negotiations.

Effects on wildlife[3]

Many thousands of marine mammals and seabirds die each year around the world as a result of plastic litter. Plastic granules are now a small, but significant part of beach sand. In one study it was found that 90% of Laysan albatross chicks contained plastic litter in their guts, with an average of 35.7 grams in each affected chick. Most research has been undertaken in the more polluted northern hemisphere, and effects on wildlife in Australia are not well known.

During the 'Adopt-a-Beach' clean-ups many reports were received by Greenpeace of dead and injured marine organisms, some of which had been killed by litter. Dead fish were frequently reported, most of which were thought to be discards from the commercial by-catch. Of 141 dead birds examined, around a dozen had been entangled in debris. Of 11 dead turtles reported, two were entangled. Of four dead dolphins, one was entangled in a gillnet. A pygmy sperm whale found in the central coast of New South Wales had died from an ingested plastic bag lodged in the oesophagus. A juvenile false killer whale beached in Botany Bay in 1986 had been entangled in packaging tape.

The VIMS study noted that in 1991 some 45 Australian fur seals at Phillip Island's Seal Rocks (Vic) had collars of net fragments, while in Tasmania it is estimated that around 500 seals have 'collars' of net fragments at any one time.

Three species of cetaceans have been affected by entanglements in Western Australia. The Department of Conservation and Land Management found that eight common dolphins and seven bottlenose dolphins had died in entanglements in nets or rope, and two southern right whales had been entangled.

Case study

Entanglement of Australian fur seals in synthetic debris

The entanglement of Australian fur seals in synthetic debris in Tasmanian waters has been monitored since 1989 at Australian fur seal breeding colonies, and on an opportunistic basis at haul-out sites in Bass Strait and southern Tasmania.

A total of 136 Australian fur seals *(Arctocephalus pusillus)* and one New Zealand fur seal *(A. forsteri)* with neck collars were observed over the four-year study period. The mean incidence of entanglement of Australian fur seals was 1.6±1.0% which was probably an underestimate as many would die before reaching haul-out sites.

Polyethylene trawlnets accounted for 42% of neck collars, polypropylene straps (packaging straps) 29%, monofilament gillnets 15% and nylon rope 11%. Other incidental items included steel rings (two cases) and a rubber loop.

The high rate of entanglement of seals in packaging straps has continued despite the successful development of a bait box which does not require straps, by SAFCOL and the Department of Parks, Wildlife and Heritage, Tasmania. Whilst the strapless bait box was accepted by some sectors of the industry, they are not being used to a significant extent. Some straps probably originate from other nations fishing either in Australian waters or on the high seas west of Tasmania, indicating that attempts to reduce the amount of debris have to be directed at both national and international levels.

Trawl nets continue to be the major source of entanglement materials affecting seals in Tasmanian waters. This form of entanglement is probably the most lethal as the typically large pieces of entangling netting are both resilient to wear and buoyant. The frequency of occurrence of trawl net entanglements has increased in southern waters and is now similar to that in Bass Strait. The orange roughy fishery shifted from operating over soft bottom to fishing over rocky seamounts off southern Tasmania, resulting in an increase in the number of nets lost due to 'hook-ups'.

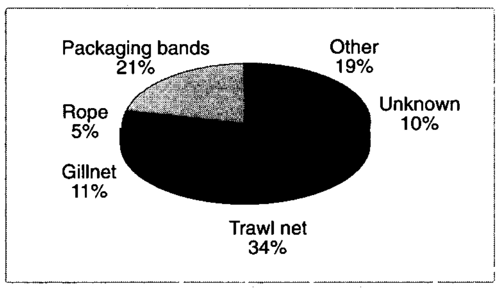
The majority of entangled seals were juvenile and subadult animals (75%); of the adults affected, 23% were females and 2% were males. While some seals do survive entanglement, a total of 15% of seals classified as 'entangled' had circular scars around their necks indicating recovery from previous entanglements.

The high rates of entanglement of Australian fur seals is considered to be a threat to the status of the population, and is consequently a conservation problem. Because entanglement results in gross wounding to the seals and prolonged suffering over years, there is also a moral responsibility by wildlife organisations to alleviate the suffering of individual animals.

(From a contribution by D. Pemberton, Parks and Wildlife Service, Tasmania)

(Source: D. Pemberton)

Figure 46.4: Fishing litter such as net fragments, ropes and bait straps may entangle marine animals, strangling or drowning them. In southern Australia, seals often get discarded or lost fishing gear entangled around their necks. This young Australian fur seal from Tasmania has a rope 'collar'.



(Source: Jones 1994)

Figure 46.5: Composition of neck 'collars' on entangled seals. (75 seals, 1989-91).

Management of ocean and beach litter[3]

Beach litter management

Following the 'Adopt-a-Beach' surveys, Greenpeace recommended that the ocean and beach litter problem should be managed through re-use, recycling and deposits on containers; replacement of PVC containers; development of a comprehensive national waste minimisation strategy; adherence to marine pollution controls such as MARPOL Annex V (Chapter 36 and below); and community education programs on the above. Greenpeace believes that products which cannot be completely recycled should not be manufactured.

The VIMS study places the responsibility back on 'the general public' rather than the packaging industry.

Recommendations included more, and better-situated, rubbish bins along the shore; litter traps and booms in some stormwater drains, creeks and rivers; better management of garbage collection, recycling facilities and landfill sites; better public education on the dangers of litter; litter warnings on disposable containers, bags etc.; design of containers to ensure lids and drinking straws cannot be separated; and monitoring of litter to better identify sources.

Greenpeace disagrees with the emphasis in the VIMS study on the littering habits of 'the general public' and is critical of the omission of the responsibilities of government and the packaging industry. It has called for a more comprehensive national waste minimisation strategy for Australia.

Ocean litter management

The disposal of plastics into the sea, including fishing gear such as nets, rope, lines and strapping bands is prohibited under Australian law *Protection of the Sea (Prevention of Pollution from Ships) Act* 1983 which implements MARPOL.

The International Marine Pollution Convention (MARPOL) regulates the dumping of rubbish at sea, and bans the jettisoning of all plastics. Monitoring of ocean litter in remote Tristan da Cunha in the south Atlantic indicates that rubbish dumping is still increasing exponentially, despite MARPOL.

Monitoring by the Australian Fisheries Management Authority's observers on foreign fishing vessels found that in 1992, about 50% of the Japanese tuna longlining vessels complied with MARPOL.

Monitoring ocean and beach litter[1]

With the exception of Tasmania, monitoring of ocean and beach litter in Australia is limited. In Tasmania surveys have been undertaken since 1990 by the Department of Parks, Wildlife and Heritage. Sampling sites are representative of the range of coastal and island sites, and degrees of human uses. In South Australia ocean litter has been monitored at Anxious Bay as part of a private research project.

Greenpeace established a database on total beach litter in the 'Adopt-a-Beach' campaign from 1990-92 but no longer collects data. The detailed VIMS survey of Brisbane, Sydney and Melbourne is intended as a baseline for future monitoring.

Systematic surveys of ocean litter are necessary in Australia to monitor compliance with MARPOL. They may be undertaken using ship-borne neuston or surface nets (a slow and costly technique), or by systematic resurveys of appropriate beaches. These beaches should face into prevailing winds and currents; be of sand or gravel; back into dunes; be free of strong surf and dense terrestrial vegetation; and be remote from human settlements, so local tourist junk is minimal.

Summary and conclusions

1. Ocean litter is widespread and locally serious around Australia. It poses a threat to seabirds, turtles, seals and whales. The threat to Australian fur seals is considered serious.

2. Beach litter ranges from light in remote areas, to extreme in urban areas. It seriously reduces the recreational and tourist values of many Australian beaches.

3. The major source of beach litter near urban areas is land-based litter from streets, dumps and land fills which is washed into the sea via stormwater drains, streams and rivers.

4. While there is some debate on strategies to reduce beach litter (viz. reduction of packaging, versus better disposal practices), it is apparent that both strategies are necessary.

5. Management of ocean litter, and the reduction of seal entanglements, will require a national and international program to enforce MARPOL regulations, and also cooperation from the fishing industry.

6. Systematic monitoring of beach and ocean litter is necessary to better identify sources of litter and to develop appropriate management strategies.

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Chapter 47. Human health risk from micro-organisms in the marine environment[1]

In Australia, where over 80% of the population reside in large coastal cities with ageing sewerage systems, human health issues associated with the sewage pollution of beaches have heightened awareness of general marine pollution. Swimmers and surfers and seafood gourmets risk a range of illnesses such as carditis, fever, diabetes, conjunctivitis, encephalitis-meningitis, gastroenteritis, hepatitis, respiratory infection, and skin and wound infection from bathing in polluted waters or eating polluted seafood.

Little is known of disease-causing micro-organisms or pathogens in most of the marine environment. This chapter summarises current knowledge regarding the pathogens found in the marine environment which are of public health concern, and discusses the use of indicator organisms. Because of the paucity of information, the geographic focus is the Sydney area where pathogens in sea water has been a major issue.

Important pathogens in the marine environment

Microbial groups of significance may be introduced from animal and human wastes, or be naturally occurring or indigenous. These groups contain opportunistic pathogens which present a health hazard if a person's normal defences are reduced, for example, through a wound, or if they are in high densities in organic wastes. Introduced viral, bacterial, helminth and protozoan pathogens from faecal material enter the sea from sewage, septic seepage, boats, stormwater and diffuse run-off. They may be freely suspended or, more likely, associated with particulate material which enhances their survival.

Use of indicators

As a range of micro-organisms may be present in coastal waters, it is not feasible to monitor all pathogens. In Australia, faecal pollution in sea water is inferred from the presence of certain indicator bacteria such as faecal coliforms and/or enterococci which correlate reasonably well with some of the bacterial pathogens in temperate waters. However, inherent problems with using bacteria as indicators are that most illnesses are actually caused by human viruses or parasitic protozoa. There is often little relationship between these and the indicator bacteria and their survival may be longer than that of the indicators (Table 47.1). At times indicator bacteria may also be non-culturable, but still viable.

Secondary sewage treatment may reduce up to 99.9% of pathogens, however viruses or protozoa may still be present to a level to cause infection without a further thousand-fold reduction by disinfection or dilution.

Table 47.1: Key faecal micro-organisms in sewage and typical % removals by treatment processes.

Source	*Escherichia coli*	*Salmonellae Campylobacters*	Enteric viruses	*Giardia* cysts
raw sewage (/l)	108-109	40,000	100-15,000	5,200-22,700
% removed by:				
primary treatment	50-90	50-90;	0-30	20-80
secondary treatment	91-99	96-99	76-90	80-99
tertiary ponds	99.99-99.99999	99.99-100	99.99-100	99-99.9

Major potential pathogens/indicators

The pathogenic viruses, bacteria, protozoa, and helminth worms which may be present in sea water have the potential to cause a range of symptoms including carditis, fever, diabetes, encephalitis-

[1]Based on a paper by Dr N.J. Ashbolt, AWT Science & Environment, West Ryde, New South Wales.

meningitis, gastroenteritis, hepatitis, respiratory infection, skin infection and wound infection. Indigenous or locally occurring toxic dinoflagellates may cause paralytic shellfish poisoning and ciguatera fish poisoning.

How long do introduced pathogens survive in the sea?

The survival of faecal pathogens entering the marine environment depends on sediment-association, predation, parasitism, and inactivation by sunlight, temperature, osmotic stress or toxic chemicals. Survival is expressed as T90 or T99.9 values, the times for one or three log reductions in numbers. Cooler water and lack of sunlight such as that in subsurface sewage outfalls may increase bacterial survival (T90) by days, and that of viruses by many months.

Viral pathogens

There is a lack of information on swimming-associated viral illnesses, largely because there are such a large number of enteric viruses (>120 have been classified), many of which cannot be cultured. Enteroviruses (polioviruses, coxsackie viruses, echoviruses), hepatitis A and E viruses, adenoviruses, rotaviruses and caliciviruses have all been associated with swimming. Only the enterovirus group are monitored in beach waters overseas, while the presence of cultivable and non-cultivable enteric viruses in Sydney sea water is currently under investigation.

The majority of shellfish-associated illnesses are of unknown causes. In the United States the largest identified group is unculturable Hepatitis A (20% of illnesses), and another small proportion are due to unculturable Norwalk viruses. In Australia Norwalk-like viruses have been the main cause of viral food poisoning from sewage-contaminated oysters.

Viruses in water generally sorb to solids. For example, marine sediments may sorb over 99% of poliovirus suspension, and may contain 10 to 10,000 times the concentration of viruses in overlying waters. Filter-feeding shellfish near sewage outfalls effectively bioaccumulate these sediment-bound viruses.

Because of the variability in counting enteric viruses, samples are generally described on a presence/absence basis. In Sydney, tests on 100 litre-samples indicated that enteric viruses were present in 20% of city beach waters prior to the commissioning of the deepwater ocean outfalls, and in <1% of samples since then.

Bacterial pathogens and environmental strains

Of the bacterial pathogens, salmonellae and shigellas probably survive the longest in sea water. *Vibrio cholerae* 01 which causes cholera is now endemic to many countries. Although it is not in Australia there is some concern that it could enter via ships' ballast waters (Chapter 48). *V. parahaemolyticus* and *V. vulnificus*, which are endemic to temperate Australian waters, are the most common cause of bacterial food poisoning from shellfish. Other endemic *Vibrio* species have been reported in Australia as the cause of swimmer's ear, which may follow contact with warm sea water.

Indigenous marine vibrios are the major cause of wound infections worldwide. *Mycobacterium marinum* is the major cause of infection to fish handlers. It is not known whether these and other indigenous wound bacteria are enhanced by marine pollution. *Staphylococcus aureus* is associated with skin infections of bathers at densely populated bathing beaches. Inhalation of sea water containing *S. aureus* and certain other bacteria may also cause pneumonia, although concentrations are considered too low in sea waters around Sydney to be a risk under normal conditions.

'Viable non-culturable bacteria'

Laboratory studies show that traditional cultural methods do not detect all viable bacteria present. The portion which do not grow in culture are termed 'viable but non-culturable' or somnicells. Lack of correlations between pathogens and indicator bacteria may in part be due to light-stress somnicell formation in *Escherichia coli* and the enterococci. Culturing methods may underestimate *E. coli* up to a hundred-fold.

Parasitic protozoa and helminths

For the general public, the most important parasites in Australian sewage are cysts of *Giardia* and oocysts of *Cryptosporidium*. While no information on survival in sea water is available, seeded cysts may remain viable in fresh water for weeks, and both parasites have caused illness to swimmers. High numbers of these oocysts (up to 40 per litre) have been detected in the Georges River, Sydney. A range of other parasites may also be of concern to immunocompromised people.

Airborne pathogens

Illness may be transmitted through inhalation of aerosols (fine spray) from contaminated waste water. Surf aerosols may contain 200 times more viruses than equivalent volumes of sea water.

Algae

Algal blooms may contain toxic compounds. 'Red tides' caused by the toxic dinoflagellates *Alexandrium minutum* and *Gymnodinium catenatum* have become regular occurrences in parts of Tasmania, Victoria and South Australia since the 1980s. Toxins accumulating in edible shellfish may cause paralytic shellfish poisoning in humans. It is likely that the dinoflagellates have been dispersed via ships' ballast, often comprising water from overseas ports (Chapters 14 and 49). The toxic dinoflagellate *Gambierdiscus toxicus* is endemic to tropical Australian waters where it is responsible for ciguatera fish poisoning.

Indicators, standards and monitoring

The microbiological standards for recreational waters in Australia agreed by ANZECC are expressed in terms of concentrations of colony forming units (cfu) of faecal coliforms and enterococci. The standards are similar to those reported around the world for faecal indicator bacteria, but doubts exist on the usefulness of these standards. However, the faecal indicator bacterium *Clostridium perfringens*, present at significantly elevated concentrations at sewage or sludge disposal sites, may be a suitable indicator of long-lived micro-organisms. Nevertheless, standards for viruses, parasitic protozoa and indigenous pathogens are lacking and there is a need for interpretation in an Australian context making use of local epidemiological data.

Monitoring programs

Although nearshore water microbiology has been extensively monitored at some sewage discharge sites in Australia, most of these data have not been condensed into useful information or established within computer databases. Studies are geographically clustered in potential problem areas and there are very few systematic studies of coastal waters. While government agencies require monitoring of discharges and bathing beaches, streams, lagoons and nearby stormwater drains are generally not monitored. Normal microbial levels are generally not known and monitoring programs are not well related to the decision-making and resource-allocation processes, or to Health Department data.

The establishment of national goals and water quality guidelines by ANZECC is an important advance, although the lack of guidelines for viruses and other parasites remains an urgent problem.

Summary and conclusions

1. Discharge of non-disinfected primary and secondary sewage effluent to bathing waters represents a local health risk unless further diluted, or die-off at least a thousand-fold.

2. Traditional bacterial indicators do not reliably reflect the presence or absence of enteric pathogens in sea water or sediments. Hence, despite little epidemiological evidence of health problems, the microbial status of Australian marine waters is unclear.

3. Enteric viruses should be regarded as indicators of faecal contamination. These are probably more closely related to the causative agents of infections acquired by users of recreational waters than are faecal coliforms or enterococci. Presence of bacteriophages may be a useful surrogate for enteric virus survival in seeding experiments.

4. A national, coordinated effort is needed to collect and use monitoring and epidemiological data, including the impact of toxic algae.

5. Research is required on the usefulness of new index organisms such as *Clostridium perfringens*, bacteriophages and key enteric viruses; the significance of underestimation of faecal bacteria due to viable but non-culturable forms; and the prevalence of the parasitic protozoa *Giardia* and *Cryptosporidium* in the marine environment.

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Chapter 48. Exotic marine species and the ballast water problem[1,2]

Introduced species of plants and animals have had a catastrophic effect on Australia's unique fauna and flora, and on agricultural production. Although marine introductions have been limited to date, the threat of exotic marine diseases, plants and animals on Australia's marine environment and growing aquaculture industry is serious. Victoria and Tasmania have recently experienced blooms of exotic toxic marine algae; introduced Pacific oysters have displaced native species on oyster farms in Tasmania, Victoria and New South Wales; and a Japanese starfish poses a very serious threat to scallop fisheries and aquacultured bivalves in Tasmania, and possibly Victoria.

While there have been some deliberate marine introductions into Australia, most have been accidental, via ships' ballast water and hull encrustations. Most new species that become established will have some negative effects on the environment, either direct effects as competitors, or indirect ones through the introduction of pathogens to native and established populations. Worldwide experience has illustrated the disastrous effects introduced pathogens can have on natural ecosystems and on aquaculture, and commercial and recreational fishing.

This chapter examines the problem of marine introductions in Australia, exotic pests and diseases and their management, and the particular problem of ballast water introductions.

Marine introductions to Australia[1]

Vertebrates

Four deliberately introduced species of marine finfish are established in Australian waters: brown trout, rainbow trout, Atlantic salmon and chinook (or quinnat) salmon. Brown trout have populations which run to the sea, and rainbow trout and Atlantic salmon are successfully farmed in the sea around Tasmania.

At least four marine finfish have been introduced accidentally in ballast water: two gobies and a sea bass native to Japan, and an Arabian Sea bream. The introductions are thought to be via ballast waters from shipping from Japan and from live-sheep freighters travelling from the Persian Gulf. None appear to have brought disease. Neither have they had a significant effect on the environment to date.

Tilapia, also known as African mouth-brooders (*Oreochromis mossambicus* and *Tilapia mariae*), illegally imported as an aquarium fish are now established in many Queensland waterways. Although tilapia are a prolific freshwater species, they may invade estuaries and coastal lakes, eating the fry of mullet and other native species. A severe penalty (maximum $60,000) may be incurred for releasing noxious fish into Queensland waterways.

Invertebrates

Around 50 species of exotic marine invertebrates have probably been introduced to Australia, either deliberately or through ballast water or hull fouling, with oysters, or by other means. Some six species are considered to be pests.

Table 48.1: Exotic marine organisms introduced to Australia, and possible mode of transport

Microalgae
Gymnodinium catenatum (2) (A)
Macroalgae
Undaria pinnatifida (2) (B)

Invertebrates
Bryozoa etc
Bougainvillia ramosa; Anguinella palmata; Bugula flabellata; Conopeum tubigerum; Schizoporella unicornis; Watersipora arcuata

Polychaeta (sea worms):
Hydroides norvegica; Mercierella enigmatica (2) (C); *Boccardia proboscidea* (2) (D); *Polydora ciliata; Pseudopolydora paucibranchiata* (2); *Sabella spallanzanii*

Mollusca (shellfish):
Bivalvia (clams)

[1]Based on a paper by Dr L. Lehane, Science Communication Services, Canberra, Australian Capital Territory; and [2]L. Arundell, Bureau of Resource Sciences, Canberra, Australian Capital Territory; with additions by Dr L. Zann, SOMER Coordinator.

Table 48.1 continued

Crassostrea gigas (1); *Musculista stenhousia* (1,2) (E); *Perna canaliculus* (1); *Neilo australis; Paphirus largillierti; Theora lubrica* (2) (F); *Ostrea lutaria*

Polyplacophora (chitons)
Amaurochiton glaucus

Gastropoda (snails and slugs)
Aeolidiella indica (2) (G); *Janolus hyalinus; Maoricolpus roseus; Okenia plana; Polycera capensis; Polycera hedgpethi; Thecacera pennigera; Zeacumanthus subcarinatus*

Crustacea
Decapoda (crabs and shrimps)
Carcinus maenas (1); *Palaemon macrodactylus* (1); *Cancer novaezealandiae; Halicarcinus innominatus; Proymaia tuberculata* (2) (H)

Isopoda (slaters etc.)
Cirolana hardfordi; Eurylana arcuata (2) (I); *Paracerceis sculpta; Paradella dianae; Sphaeroma serratum; Sphaeroma walkeri*

Mysidacea (shrimps), Tanaids
Neomysis japonica (2) (J); *Tanais dulongi* (2) (K)

Cirrepedia (barnacles)
Balanus improvisus; Megabalanus rosa; Megabalanus tintinnabulum; Notomegabalanus algicola

Brachiopoda (lamp shells):
Terebratella inconspicua

Echinodermata (starfishes etc.):
Patiriella regularis; Asterias amurensis(1,2) (L)

Ascidiacea (sea squirts):
Molgula manhattensis; Styela clava; Styela plicata

Pisces (fish):
Acanthogobius flavimanus (2) (M); *Tridentiger trigonocephalus* (2) (N); *Lateolabrax japonicus* (2) (O); *Sparidentex hasta* (2) (P)

1: existing or potential pest
2: probable ballast water transport
(from Pollard and Hutchings 1990b, and Jones 1991).

A-P: see Figure 48.2 for locations of these introductions.

Exotic pests[1,2]

A growing number of introduced species have had known harmful effects on Australia's marine environment. Particular concern exists regarding the introduction and further spreading of these species via ballast waters.

Algae

The introduction of toxic dinoflagellates is a potentially very serious problem. *Gymnodinium catenatum*, a species that forms toxic blooms ('red tides'), was probably introduced via ballast waters around Hobart in 1971. It is now established along the Tasmanian east coast, where it is a problem for aquafarms (Chapter 14). *G. catenatum* blooms under conditions of elevated nutrient levels, high temperatures and stable water column. Blooms may kill other marine organisms through oxygen depletion, toxins and physical damage to gills. On aquafarms, severe damage is caused to the caged fish as they cannot escape. The sale of shellfish during blooms is prohibited.

There are around 30 other toxic species of dinoflagellates in the world, some of which may be fatal to humans by causing paralytic, neurotoxic or amnesic shellfish poisoning. The presence of a resting-cyst dispersal phase makes toxic dinoflagellates prone to ballast water transport. A toxic native species, *Alexandrium minutum*, may have been translocated by shipping within this country.

The Japanese giant kelp 'wakamme', *Undaria pinnatifida*, was also introduced into Tasmania, where it now forms large monospecific beds, displacing native species. It was commercially harvested in 1992 for export to Japan.

Bivalves

The Pacific oyster *Crassostrea gigas*, introduced to Australia by CSIRO in the late 1940s and early 1950s for cultivation in the southern States, has displaced native species and modified much of the intertidal zone of Tasmania, Victoria and New South Wales. It is now the basis of a successful oyster industry in Tasmania, and production is expanding in South Australia. In an effort to control its spread, Queensland made its culture illegal.

The Asian mussel *(Masculista senhousia)* has similarly become established in Western Australia. It is now well established in the Swan River estuary and has spread to the port of Fremantle. The main effect of the species is to blanket soft sand flats with a solid crust of dense mussel masses, making them unsuitable for their previous occupants. The introduction of the zebra mussel into the Great Lakes in the United States via ships' ballast waters has been an ecological and maritime disaster. It is estimated that the economic cost of the fouling of pipes, intakes, ships' hulls and other equipment by carpets of this mussel will have totalled $5 billion by the year 2000.

Starfish

The Northern Pacific seastar, *Asterias amurensis*, a voracious shellfish feeder and a serious pest in Japan, is now widely established in Tasmania. It is believed to have been transported via ships' ballast water from Japan.

A New Zealand starfish *Patiriella regularis* has also become abundant in the Derwent Estuary, displacing an endemic starfish, *Marginaster littoralis*. The latter is one of Australia's most endangered marine species.

Invasion by Northern Pacific seastar

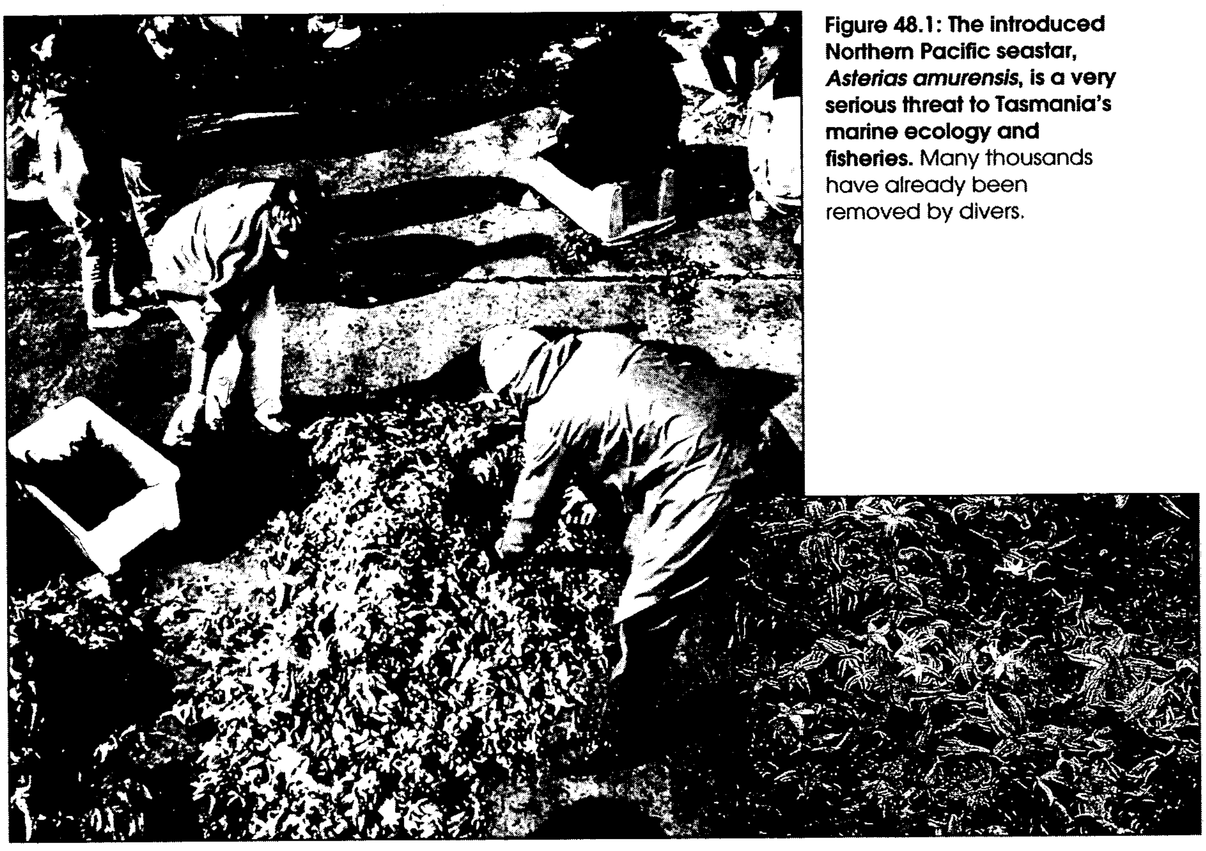
First recorded in Hobart in 1986, *Asterias amurensis* was not correctly identified until 1992. By November 1993, the seastar was widely distributed along south-eastern Tasmania: in the Huon River estuary; the D'Entrecasteaux Channel into the Derwent River estuary; Frederick Henry Bay; and near Triabunna, Maria Island in the north and possibly near Coles Bay.

Effects on fisheries and the environment
The seastar is a serious pest in Japanese shellfish farms. Fears are held for Tasmania's bivalve aquaculture and scallop fisheries as the seastar has been found on scallop longlines, scallop spat bags, in mussel and oyster farms, and feeding on fish hanging in fishing nets. The seastar is also a great potential threat to the marine environment as it may affect populations of prey species and natural competitors.

Further spread feared
The seastar has a long-lived larval stage and may be transported considerable distances on currents. It has been widely dispersed into Russian, Alaskan and Canadian waters, and oceanographic modelling suggests it could be dispersed considerable distances along the Australian mainland coastline. The Northern Pacific seastar is regarded as a major threat by fisheries management authorities in Victoria.

Controls attempted
Attempts have been made to control the seastar. In July 1993 a group of 22 scuba divers collected over 6,000 of the seastars from an area less than 300 by 20 metres. In August 1993 over 24,000 seastars (weighing about three tonnes) were collected near the Hobart wharves. Experience in attempting to control the crown-of-thorns starfish on the Great Barrier Reef suggests that eradication by divers is not feasible.

National Seastar Task Force formed
The Tasmanian Department of Primary Industries and Fisheries formed a taskforce in July 1993 to coordinate sightings reports, research, and controls. A major research program is now underway.



(Source: T. Bogue, Tasmanian Museum)

Figure 48.1: The introduced Northern Pacific seastar, *Asterias amurensis*, is a very serious threat to Tasmania's marine ecology and fisheries. Many thousands have already been removed by divers.

Sea worms

The mudworm *Polydora websteri* may have been introduced with imports of oysters from New Zealand in the 1870s, with ships' fouling, or it is indigenous and changed conditions have favoured its spread. Its effects (loss of condition and shell blistering) were first seen in Hunter River oysters in about 1870. The mudworm spread to other New South Wales estuaries, and by 1898 was causing major problems in oyster shells in Moreton Bay (Qld).

In the past few years, the tube worm *Sabella spallanzani*, a possible exotic species, has spread rapidly in Victoria and south-western Western Australia, where it forms dense carpets. While the taxonomic status remains uncertain, there is conjecture that it may be another ballast water introduction.

Exotic diseases[1]

In the past, Australia's isolation was its main natural protection against the introduction of exotic diseases. The numbers of fish involved in the original deliberate importations were small and the transportation times were lengthy. Now live aquatic animals and their products can arrive by air from any part of the world in less than two days, greatly increasing the risk of them bringing disease. Numerous species of marine aquarium finfish have been imported legally from elsewhere in Australia, and from the Indo-Pacific, Caribbean Sea, the Red Sea and the Mediterranean Sea. This problem of diseases must be viewed very seriously in the light of the almost certain irreversibility of successful introductions to marine waters.

Salmon and trout diseases

The salmon and trout family were introduced into Australia towards the end of the last century, before the emergence and international spread of a number of serious diseases of salmonids. These species are now farmed in Australia free of a number of diseases that now occur in rival salmonid-exporting countries such as Canada, Scotland and Norway. Aquaculture populations of salmonids are at particular risk of contracting an exotic disease because the fish are congregated in large numbers under confined conditions.

Infectious haematopoietic necrosis (IHN) was introduced to Victoria's Snob Creek hatchery with a shipment of chinook salmon eyed ova imported from California, in 1963. The affected Australian fry were destroyed and no further cases have occurred. This was a very lucky escape, saving the Australian salmonid industry from a major disease problem.

Disease risks

The movement of live fish (rather than products or gear) presents the greater disease risk. Fish that look normal may be carrying pathogens. Infectious agents are often more pathogenic in atypical hosts. Transmission to the offspring via the gametes occurs in several diseases, and so ova, sperm, and fertilised ova or embryos also represent potential disease vectors as in the case of IHN infection (above). The importation of genetic material from overseas should be possible, provided there are adequate safeguards of microbiological security, quarantine, and disease surveillance and testing.

As other pathogens are undoubtedly imported with marine fish and, since freshwater species are subject to a two-week quarantine and observation period following import to Australia, it is considered that marine fish should be similarly quarantined. The keeping of imported marine fish in open-circuit aquariums should be controlled because of the risk of losing fish, eggs, viruses or bacteria into the sea.

Other sources of diseases include fish meal (in which infectious agents of various sorts may survive processing) and ballast waters. Fish meals available commercially in Australia have come from as far away as Denmark, Norway, Scotland, Iceland, Canada and Chile.

The disease risks involved with the movement of live aquatic animals can be reduced, but rarely eliminated, by rigorous health testing and certification of populations before movement takes place. The threat associated with some species is so severe, or detection methods are so unreliable, that import - even subject to testing - is generally considered to pose unacceptable risks.

Exotic disease management

International movements of marine animals, especially bivalve molluscs, prawns and salmon, are increasing, largely as a result of expanding aquaculture industries. These have frequently been accompanied by the dissemination of pathogens. The international animal health reporting organisation, the Paris-based Office International des Epizooties (OIE), develops codes to facilitate international trade in animals and animal products while minimising risks of disease transmission.

Risk assessment relating to trade in aquatic animals and their products has been hampered by lack of data relating to diseases and the ability of disease-causing organisms to spread between species, be carried by natural means, and survive in products. However, the past decade has seen a rapid increase in knowledge relating to diseases and pathogens of aquatic animals. At the international level, the OIE has recently included in its Animal Health Code a series of chapters on diseases of fish, crustaceans and molluscs.

Legislation and quarantine practices in Australia

On the advice of the Advisory Committee on Live Fish, the Australian Nature Conservation Agency determines which live species will be permitted entry to Australia through the *Wildlife Protection (Regulation of Exports and Imports) Act* 1982. The Act has objectives of complying with Australia's obligations under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and otherwise furthering the protection and conservation of the fauna and flora of Australia and other countries.

Under the *Quarantine Act* 1908, the Australian Quarantine and Inspection Service (AQIS) operates to facilitate the entry of approved species and related products, while ensuring maximum practicable protection against the entry and spread of unwanted pests and diseases.

Control on the importation of items of quarantine concern into Australia is based on an assessment of the risks of disease introduction. All pertinent scientific information available is used to assess the risk in a step-by-step procedure. The need for the risk-assessment process to stand up to intensive scrutiny, both domestically and internationally, is recognised, as is the need to make it as fair as possible to all interested parties. When sufficient scientific information is not available, AQIS takes a conservative approach.

At present, all living aquatic animals are prohibited from entry to Australia unless they are species listed as approved by the Australian Nature Conservation Agency, or have been granted entry under a special permit for scientific purposes, which allows them to enter approved premises under quarantine control. Marine aquarium fish are not placed in quarantine on arrival, but are inspected for purposes of species identification (where possible), to ensure they show no obvious signs of disease and that they are not contaminated with other living material. A review of marine quarantine problems and procedures is currently underway.

The ballast water problem[2]

Attached or sessile marine species may be translocated via ships' hulls as fouling, and larvae and cysts may be transported in ships' ballast waters. The latter is a growing problem as disease-causing

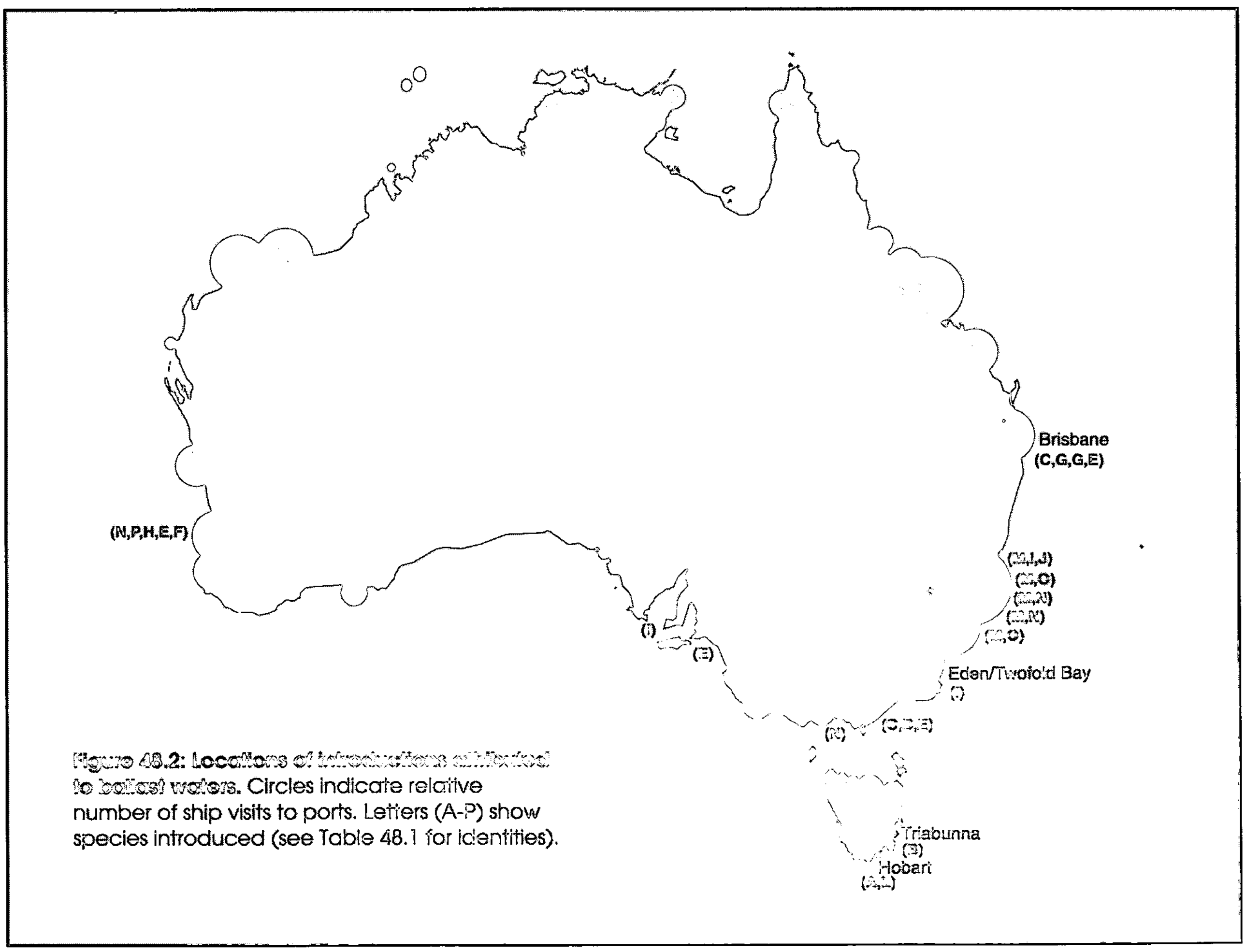


Figure 48.2: Locations of introductions attributed to ballast waters. Circles indicate relative number of ship visits to ports. Letters (A-P) show species introduced (see Table 48.1 for identities).

(Source: AQIS 1994)

micro-organisms (e.g. *Cholera vibrio*, which has been found in ballast waters) and spores of toxic marine algae may be translocated. So far 19 exotic species have been identified as being introduced via ballast water.

Bulk iron ore, coal and woodchip carriers from Japan, other Asian ports and elsewhere in the world annually discharge around 120 million tonnes of ballast waters in Australia.

Management of ballast waters

Management aims to prevent entry, rather than rely on post-entry eradication or control. There are no known cases of successful eradication of an established exotic marine species. The current emphasis is on dumping potentially infected waters at sea, and replacement with safer ocean water.

In February 1990 AQIS introduced voluntary guidelines for vessels entering Australian ports to reduce the possibility of introductions. These were used as a model for the International Maritime Organisation (IMO) Marine Environment Protection Committee's guidelines in 1991. The rate of compliance with the guidelines is reported to be 80%.

The most cost-effective treatment method for infected or suspect tanks is ballast water exchange. This costs around US $900 for a ship carrying 7,000 to 10,000 tonnes of ballast. Conventional chemical treatment costs US $300 to $700 per thousand tonnes. Ocean exchange of ballast waters by emptying and refilling is not a safe option for larger vessels, but exchange by continuous flushing is safe and around 90% effective. Treatment costs can be reduced greatly if contaminated vessels can be identified by a rapid diagnostic test before they discharge, or if algal blooms are monitored in ports where ships are ballasting.

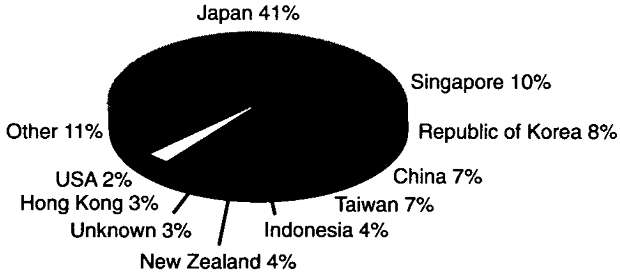


Figure 48.3: Origin of ballast waters entering Australian ports.

Status of knowledge and monitoring of introductions, diseases and ballast waters[1,2]

Introductions

There is a lack of baseline data on endemic marine fauna in Australia, which has made it difficult to identify feral populations. Reasons for this include the incomplete taxonomy (particularly of invertebrates), the vast length of the Australian coastline, and limited research funds for these studies. Guidelines for the conduct of surveys for detecting introductions of non-indigenous marine species by ballast water and other vectors, and reviewed marine species introduced to Australia, have been prepared.

Diseases

Monitoring for introduced or unusual fish and diseases in wild stock is currently carried out by fishers and depends on them reporting their observations to authorities. Monitoring for disease in aquaculture facilities depends mainly on the 'goodwill' of managers in reporting disease, although facilities are inspected regularly by State fisheries inspectors.

In recent years, the Commonwealth and State Governments have recognised the need for specialised diagnostic facilities, reagents, reference micro-organisms and trained and qualified personnel to diagnose diseases of aquatic animals. The Australian Fish Health Reference Laboratory in Geelong, and State animal health laboratories now provide fish disease diagnostic services, and a fully referenced, complete inventory of diseases, pathogens, parasites and commensals of Australian aquatic animals is being prepared. Such a database will facilitate improved diagnosis of endemic diseases and help define exotic diseases.

Ballast waters

The AQIS analyses samples of ballast waters discharged in Australia. Between November 1987 and March 1990, 340 samples from ships at 12 Australian ports were examined: 65% contained sediment; all 65% contained diatoms; 50% contained non-toxic dinoflagellate cysts; and 5% contained toxic dinoflagellate cysts. Two hundred samples were collected in 1992-93.

Summary and conclusions

1. At least 55 species of fish and invertebrates have been intentionally and accidentally introduced through fouling on ships' hulls, and ships' ballast waters.

2. The principal organisms of concern are *Vibrio cholerae*, the toxic dinoflagellate *Gymnodinium catenatum*, the seaweed *Undaria pinnatifida*, the starfish *Asterias amurensis* and the fish pathogens *Aeromonas salmonicida*, *Myxosoma cerebralis*, and *Renibacterium salmoninarum*.

3. The dinoflagellate and starfish have caused substantial damage to aquafarms and the general marine environment of Tasmania. Concerns are held on their further spread.

4. Management is focusing on prevention of introductions by ocean exchange of ballast waters. The development of rapid diagnostic tests for ballast waters is important for management.

5. Australia - free from serious aquaculture fish diseases and with only localised problems from toxic marine algae - has undertaken a leading role in ballast water management, and in quarantine control.

Editor's note: The mass mortality of pilchards in southern Australia and New Zealand in mid-1995 has been attributed by some scientists to an introduced virus.

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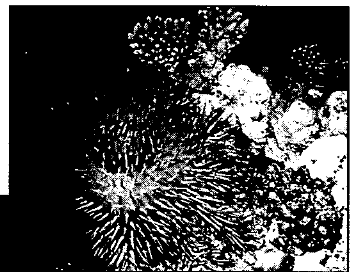
Chapter 49. Crown-of-thorns starfish outbreaks on Australian coral reefs[1]

Over the past thirty years outbreaks of the coral-eating crown-of-thorns starfish have caused widespread damage on reefs in the Indo-Pacific, severely affecting the Great Barrier Reef and some of the Coral Sea and Tasman Sea reefs. The causes of the outbreaks, and whether they are natural or the result of human influences, remain unknown. The outbreaks have become a major management and scientific issue in Australia, characterised at times by quite acrimonious debate.

The crown-of-thorns starfish, *Acanthaster planci*, is one of the largest starfish in the world (average 25 to 35 centimetres in diameter, reaching 70 centimetres), it has 14 to 18 arms, and its upper surface is covered by sharp, venomous spines. It feeds primarily on hard corals by everting its stomach through its mouth and digesting corals' living tissues externally. It has separate sexes, an extremely high reproductive potential, and a planktonic larval stage for dispersal. Normally present in low numbers, major population increases or outbreaks have occurred on the Great Barrier Reef since 1962. Reefs in the Tasman Sea have also suffered serious outbreaks, and other areas have experienced moderate populations.



(Source: both L. Zann GBRMPA)

Figure 49.1: On the Great Barrier Reef small scale, strategic controls of crown-of-thorns starfish (inset) are undertaken on reefs of particular importance to tourism or scientific research.

This chapter discusses the '*Acanthaster* phenomenon' in Australia. It describes the extent of damage to coral reefs around Australia, the theories on their causation, and current research and management.

Reefs affected in Australia

The crown-of-thorns starfish inhabits most reefs in tropical northern Australia, from the Ningaloo Reefs off North West Cape, to those off Gove Peninsula, to those in Torres Strait and the Great Barrier Reef (GBR), Coral Sea Reefs, and Tasman Sea reefs to Lord Howe Island.

Great Barrier Reef

The Great Barrier Reef has been affected by two major outbreak episodes since the 1960s: the first from 1962 to around 1975, and the second from 1979 to around 1992. Numbers are once again building up in the area between Cairns and Cooktown, giving rise to fears that a new episode has commenced in 1994.

The 1979-92 outbreak affected mainly the central one-third of the Great Barrier Reef, between Lizard Island

[1]Based on a paper by Dr P.J. Moran, Australian Institute of Marine Science, Townsville, Queensland; and Dr B. Lassig, Great Barrier Reef Marine Park Authority, Townsville, Queensland; with additions by Dr L. Zann, SOMER Coordinator.

and reefs just south of the Whitsunday Group, and the more isolated Swain Reefs. Around 17% (+/- 4%) of the Great Barrier Reef's 2,900 reefs have been affected to varying degrees, making the crown-of-thorns the largest cause of damage over the last decade. During 1991-92 around 8.5% of surveyed reefs were still affected, half of which were situated in the Swains.The 1979-92 outbreak episode appeared to originate on reefs in the proximity of 16°S (near Cooktown) in 1979. Outbreaks reached up to about 150 kilometres northwards by 1984, but most occurred southwards, reaching around 500 kilometres by 1991, as successive generations of planktonic larvae were carried on the prevailing southwards summer currents.

During 1993 and 1994, increased numbers of starfish have been reported on a number of reefs between Lizard Island and Cairns. Reefs in this region are being monitored closely in case a new series of outbreaks begins.

Table 49.1: Crown-of-thorns starfish abundances in Australia, 1980s and 1990s

Location	Abundance*
Tasman Sea Reefs	
Elizabeth Reef	l-h
Middleton Reef	l-h
Lord Howe Is	l-m
Solitary Is	l
Coral Sea Reefs	
Flinders reefs	l
Holmes Reef	l
Great Barrier Reef	
Far Northern	l-m
Northern/Central	l-m-h
Southern	l-h
Torres Strait	l-h
Northern Territory	
Gove Peninsula	l-m
Groote Eylandt	l-m
Western Australia	
Dampier Archipelago	l-m
Monte Bello	l
Ningaloo	l
Rowley, Scott	l

* l (low: isolated individuals); m (medium: small groups); h (high: outbreaking populations)

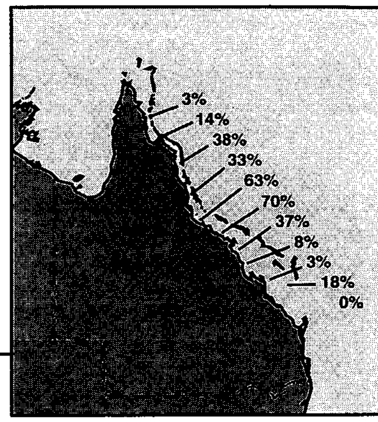
Coral damage

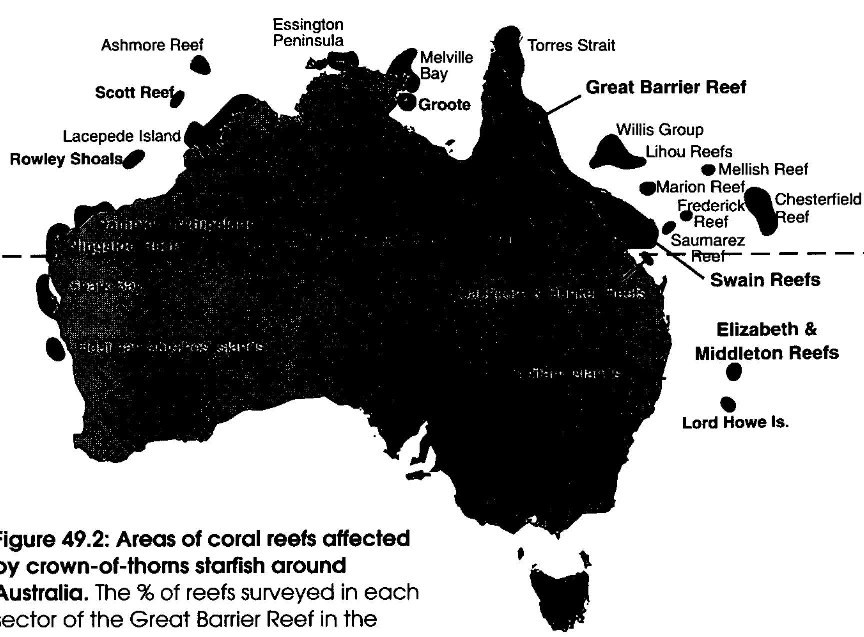
The extent of damage to reefs on the Great Barrier Reef ranges from light to very severe. Detailed surveys by the Australian Institute of Marine Science since 1986 found that 57% of the reefs affected suffered a high coral mortality (>50% of coral killed) on over a third of their perimeters. Around 10% of affected reefs had a high coral mortality over most of their perimeters. Overall, the starfish increased the amount of dead coral on individual reefs of the Great Barrier Reef by three to fourfold. Only 1 to 5% coral cover remained on the worst affected reefs (Green Island off Cairns, John Brewer Reef off Townsville).

Although the fast-growing branching and plate *Acropora* are preferred prey and suffered highest mortality in outbreaks, up to two-thirds of the slow-growing massive corals such as *Porites* were affected on severely impacted reefs.

Coral recovery

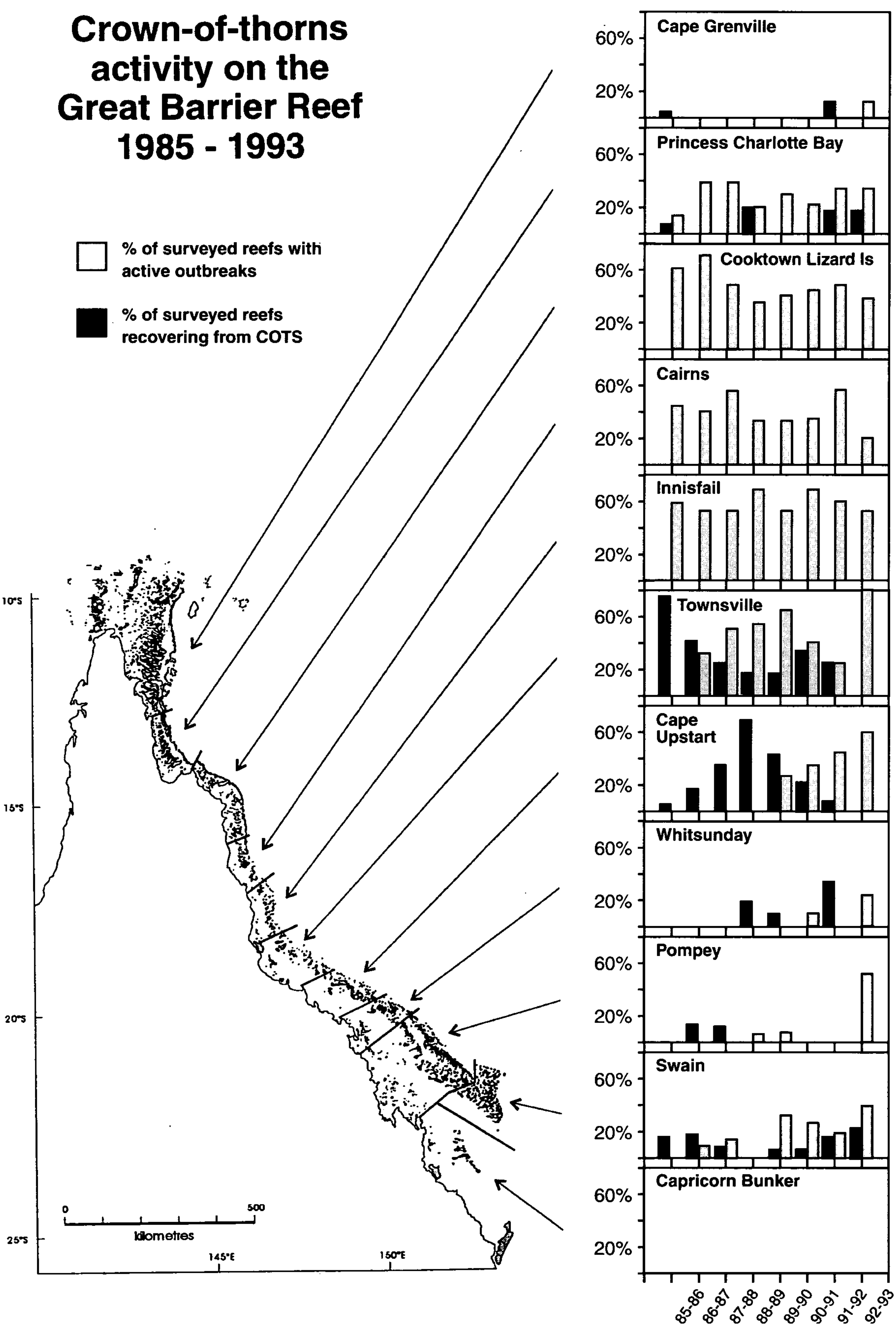
Reefs regain a high coral cover in between 12 to 15 years through regeneration and recolonisation, although this is mainly composed of the faster growing colonies such as *Acropora* and *Montipora*. Mathematical models of population dynamics indicate that it may take over 50 years for populations of the massive, slow-growing *Porites* to recover.





(Source: AIMS 1993)

Figure 49.2: Areas of coral reefs affected by crown-of-thorns starfish around Australia. The % of reefs surveyed in each sector of the Great Barrier Reef in the 1979-92 episode are indicated (inset). The extent of damage to affected reefs ranges from slight to serious.



(Source: AIMS)

Figure 49.3: Crown of - thorns activity on the Barrier Reef 1985 - 1993.

Cause(s) of outbreaks?

Despite much research over recent decades, it is still not known why outbreaks have occurred in recent times. Several hypotheses have been advanced:

Adult aggregation hypothesis

This proposes that adult starfish aggregate after some reef disturbance such as a cyclone, flood, or blasting. There is little evidence to support this.

Larval recruitment hypothesis

Laboratory studies suggest that the survival rates of starfish larvae increase under certain conditions of lowered salinity (about 30 ppt) and temperature (28°C). There is no direct field evidence to support this.

Terrestrial run-off hypothesis

Correlative studies suggest that outbreaks occur three years after heavy rainfall which had been preceded by drought. The high nutrients produced by river run-off increase phytoplankton, and thereby contribute to increased larval survival. The correlation has not been demonstrated on the Great Barrier Reef and experimental evidence on larval food requirements is contradictory. However, the most recent research indicates larval growth and survival is enhanced by elevated concentrations of relatively large phytoplankton.

(Source: AIMS)

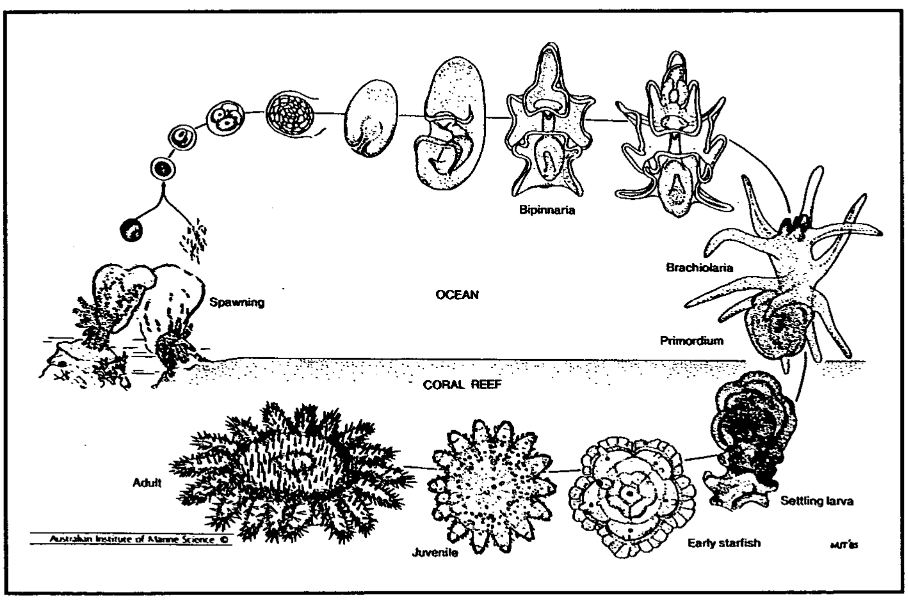


Figure 49.4: Life history of crown-of-thorns starfish.

Predator removal hypothesis

This proposes that human activities such as fishing and shell collecting have depleted the natural predators of juveniles and adults. Mathematical models suggest that this is feasible but there is little field data in support.

Multiple causes?

All of these hypotheses propose single-factor explanations of the cause of outbreaks. Many scientists are now suggesting that this is too simplistic, and that outbreaks may be due to a combination of different factors, both natural and human-induced.

Unpublished recent research suggests that outbreak episodes in the Indo-Pacific are correlated with ENSO events, but their effects may be exaccerbated by human activities.

Starfish studies: multidisciplinary, integrated research

Coral reefs are among the most complex ecosystems on earth, and the '*Acanthaster* phenomenon' is a complex issue. To systematically address the key issues, a major, multidisciplinary, integrated program of research has been undertaken on the Great Barrier Reef since 1986. Almost $10 million has been allocated by the Commonwealth Government for some 90 research projects involving 70 scientists around Australia and overseas.

The research effort has focused on four main areas: general biology and ecology of the starfish; causes of outbreaks; starfish control; and extent of outbreaks and their effects. Funds were allocated through an expert advisory committee, and progress has been regularly reviewed. Some 230 scientific publications have been produced to date, adding greatly to the knowledge of the phenomenon, as well as the state of knowledge about coral reefs.

Gaps in knowledge

While there have been some major advances, many important questions remain unanswered. Research priorities identified by several different advisory committees on crown-of-thorns starfish include larval behaviour, larval nutrition and water quality; testing of hydrodynamic models; control methodologies; dynamics of massive coral; starfish population dynamics and importance of predation; and dynamics of low-density starfish populations.

Figure 49.5: Underwater fences to exclude the starfish from coral-viewing sites have been tested by GBRMPA.

(Source: L. Zann, GBRMPA)

Management under uncertainty

While some countries have channelled considerable funds into controls, these have had limited value. In Australia efforts have been devoted more to finding the causes of the outbreaks rather than controls.

The Great Barrier Reef Marine Park Authority has maintained a policy that, unless it is proven that outbreaks are caused, or exacerbated by human activities, intervention should be limited to localised tactical measures in areas of importance to science or tourism. This policy is founded on cost-benefit principles, viz. small-scale controls are feasible and the interference is localised while broad-scale controls are ineffective, costly and are of unknown benefit to the Great Barrier Reef. Despite its sound rationale, the policy of limited intervention has attracted criticism from some scientists and members of the public.

Status of knowledge and monitoring

Details of the first outbreak episode on the Great Barrier Reef are only sketchily known as Great Barrier Reef studies were then in their infancy. During the second episode, the Great Barrier Reef Marine Park Authority monitored outbreaks using reports from reef users and dedicated reef surveys between 1979-85, and established a database of records. The first systematic survey of starfish abundances and coral cover was undertaken by the Australian Institute of Marine Science in 1985-86 using towed divers. The scale of the survey is unparalleled in marine studies: 228 reefs were examined; 7,800 kilometres were steamed; and 2,500 kilometres of underwater tows were undertaken. Since then a sample of reefs has been monitored annually under the Great Barrier Reef

'Outbreaks' of other echinoderms in Australia

'Outbreaks' of other echinoderms have been recently recorded on a smaller scale in southern Australia, raising similar questions about human influences as those brought up by the crown-of-thorns starfish and *Drupella* snails.

Starfish

Aggregations of the Indo-Pacific temperate starfish *Coscinasterias calamaria* were recorded in Port Phillip Bay in Victoria in the mid-1980s (McShane and Smith 1986). In areas of greatest abundance densities reached 40 per square metre. They were feeding on organisms such as algae, sponges, tunicates, crabs, abalone, mussels, sea urchins and each other. Although concern was held for the Bay's lucrative abalone resource (sometimes exceeding 150 tonnes per year) they proved not to be a persistent problem. As aggregative behaviour is common in asteroids, it is possible that the phenomenon was a natural one.

Outbreaks of the exotic *Asterias amurensis*, a northern Pacific species thought to have been introduced into Tasmania via ships' ballast water, occurred around Hobart in mid-1992. This species outbreaks in Japan in huge numbers in three- or ten-year cycles, causing great damage to mollusc fisheries (Turner 1992; also see Chapter 48).

Sea urchins

Major outbreaks of sea urchins have occurred in New Zealand, Canada, and California in recent decades, seriously affecting important kelp communities. In these instances there is some evidence of human causation.

In 1979 dense aggregations of the urchin *Heliocidaris erythrogramma* were observed in *Poisidonia australis* seagrass beds south of the new port in Botany Bay (Anink et al. nd). Densities in a 300 metre long feeding front averaged 85 urchins per square metre, consuming around 0.8 hectare of seagrass per month. Grazing by the urchins resulted in the loss of 65 hectares (50%) between 1979 and 1985. Seagrass losses were contained by the manual removal of around 500,000 urchins between Bonna and Towra Points, in 38 diving days over 11 months in 1985-86. A severe storm (1 in 60 years intensity) in August 1986 smothered or washed ashore the remaining urchins. The unusual settlement was attributed to extensive dredging works at Port Botany which altered the bottom from a predominantly sand/silt to a shelly one.

(Source: L. Zann)

MPA Research Program. The Crown-of-thorns starfish Database is held on an ORACLE system and currently contains 61,000 records on 414 reefs.

Summary and conclusions

1. The crown-of-thorns starfish is regarded as one of the most serious management issues in the Great Barrier Reef Marine Park.

2. Two outbreak episodes of the crown-of-thorns starfish have seriously affected the Great Barrier Reef since the 1960s. Several reefs in the Tasman Sea have been seriously affected and some other areas moderately affected.

3. In the recent Great Barrier Reef episode, around 17% of all reefs were affected; damage has been greatest in the central one third.

4. The Great Barrier Reef Marine Park Authority began a major, multidisciplinary integrated research program in 1986 and strategic controls on reefs of special importance to science and tourism have been undertaken.

5. Although significant advances have been made, the cause(s) of the outbreaks remain unknown. Many scientists now believe that there is no single, simple cause.

6. The region between Cairns and Cooktown is being surveyed regularly as starfish abundance has increased on several reefs in 1993/94, raising concerns about another outbreak episode.

7. Increases in populations of other echinoderms (the starfish *Coscinasterias calamaria* and the urchin *Helicidaris erythrogamma*) have been reported in other parts of Australia but their significance and causes are not known. The Northern Pacific seastar which was introduced into Tasmania, outbreaks in its native Japan.

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Acknowledgements:
The technical paper by Dr P. Moran and Dr B. Lassig was reviewed internally in AIMS and GBRMPA, and externally by Dr C. Johnson, University of Queensland, Brisbane, Qld.

Chapter 50. Outbreaks of coral-eating snails on Australian coral reefs[1]

In a disturbing parallel with the crown-of-thorns outbreaks on the Great Barrier Reef, an 'outbreak' of an estimated half a billion *Drupella* snails has devastated around 100 kilometres of the Ningaloo fringing reefs in Western Australia, raising similar questions on outbreak causation, possible human influences, and the feasibility of controls.

This chapter describes the biology and ecology of *Drupella* snails, effects of outbreaks on Ningaloo and Great Barrier Reef coral reefs, and theories on their causation.

Biology and ecology of *Drupella*

Drupella cornis and *D. rugosa* (family: Muricidae) are small corallivorous gastropods. They sometimes occur in dense aggregations capable of causing significant damage to coral communities over areas of hundreds of square metres, and inflicting damage as great as that due to the grazing activities of the notorious crown-of-thorns starfish.

Studies in Western Australia show that *D. cornus* begin to breed at an age of about three years. Females lay egg capsules that release free-swimming veliger larvae into the plankton after about 30 days, and can produce about 60,000 larvae annually. The larvae spend up to two months in the plankton before settling amongst the fingers of clump-forming *Acropora* coral colonies. The long larval life suggests that this species has the capability of wide dispersal; genetic similarity studies confirm that populations from the Abrolhos Islands to Dampier in Western Australia (a distance of 1,200 kilometres) are relatively similar.

Ningaloo outbreak

Surveys of the proposed marine park at Ningaloo in 1980 found coral communities were particularly rich and diverse. *Drupella* were present but had not caused any significant coral damage. The outbreak apparently commenced in the early 1980s. Surveys in 1987 found that the coral cover had been greatly reduced over large areas, and had been reduced to less than 10% over a 100-kilometre length of reef, from Tantabiddi Creek to Winderabandi Point. Dead-standing hard corals, mainly comprising plate *Acropora*, covered over 60% of the bottom. Many of the remaining live corals were infested with large numbers of *D. cornus* that were actively grazing on the coral tissues. The snails were very clumped, but averaged over 12 per square metre in the sites surveyed. In extreme cases over 300 individuals were present on a single small *Acropora* colony, and over 1000 on a large plate *Acropora*. The *Drupella* were feeding on a wide variety of coral species but preferred the *Acropora* plate species. Once these were depleted they turned to the other species.

The range of corals eaten almost exactly paralleled those eaten by crown-of-thorns. The mean feeding rate was about 2.5 square centimetres of the plate area per snail per day. Between 1980 and 1987 the coral

(Source: GBRMPA)

Figure 50.1: *Drupella* snails feeding on *Acropora* corals on Ningaloo Reef.

[1]Based on a paper by Dr A. Ayling, Sea Research, Daintree, Queensland; with additions by Dr L. Zann, SOMER Coordinator.

cover over 100 kilometres of the reef tract had been reduced by about 86% on the back-reef and lagoon, and by 47% on a front-reef-slope site.

In 1989 a survey by the Western Australia Department of Conservation and Land Management (CALM) was undertaken of the entire Ningaloo Marine Park and snail numbers were found to be high over the entire reef. Coral cover in the back reef was reduced by over 75% on two-thirds of the reef, with the north being worst affected.

High-density *Drupella* populations have since been observed in other areas of Western Australia, presumably as a result of recruitment from existing populations rather than movement of adults. Since 1987 destructive *Drupella* aggregations have been recorded from the Abrolhos Reefs at 29°S (800 kilometres south of Ningaloo) to the Montebello Islands 200 kilometres north of North West Cape. In late 1991 high densities of *Drupella* (16 per square metre) were only found in the extreme south of the Ningaloo Park, and coral cover was low over most of the rest of the back reef from North West Cape to Coral Bay.

Drupella on Great Barrier Reef

Following the Ningaloo outbreaks, surveys were undertaken in the Great Barrier Reef Marine Park. *Drupella* was found to be common from the southern Swains to Torres Strait, with *D. rugosa* more abundant than *D. cornus.* Densities reached 1.1 per square metre on Norman Reef off Cairns and 20 per square metre at Low Isles off Port Douglas. Systematic surveys made on 50 reefs in the Cairns Section in 1991 found that overall damage ranged from an insignificant 0.4% to over 26% of coral colonies (with mean damage level of 6.6%).

There was a significant south to north increase in the extent of *Drupella* damage on mid-shelf reefs of the Cairns Section, but not on outer-shelf reefs. The maximum recorded damage was on the front-reef of Nymph Island where 48.3% of corals were damaged. This survey suggested that these snails are present on at least some parts of the Great Barrier Reef in sufficient numbers to cause substantial coral death.

Causes of *Drupella* outbreaks

Although it is often proposed that *Drupella* outbreaks are a new problem and anthropogenic effects must somehow be responsible, the biology of *Drupella* is not sufficiently understood to be able to determine what causes high-density, destructive aggregations to appear in some areas.

Natural phenomenon?

The *Drupella* phenomenon may be a natural event. All ecosystems are in a constant state of flux and predator-prey systems often display cycles involving a build up of the predator, a decline in the prey, a decline in the predator because of malnutrition, and a gradual build up of the prey again.

Or induced by humans?

Alternatively, outbreaks may be caused by human disturbances. Outbreaks in Japan and the Philippines were attributed to siltation from coastal development but this is most unlikely given the desert hinterland of Ningaloo. The highest-density populations on the Great Barrier Reef are likewise remote from centres of population and from possible human-induced water quality changes.

It has been suggested that removal of the natural predators such as lethrinids (sweetlips) and labrids (wrasses) by fishing pressure might also be responsible for the outbreaks. Lethrinids are potential predators, at least of small *Drupella,* but surveys suggest that high numbers of *Drupella* are not correlated with low numbers of their potential major predators. Densities of lethrinids and labrids on North West Cape were many times greater than in any Great Barrier Reef sites and yet destructive populations of *Drupella* are not widespread on the Great Barrier Reef. Densities of lethrinids on the northern Cairns Section reefs were greater than those on the southern reefs: the opposite of what might be expected if these fish were affecting *Drupella* numbers.

It is clear that the problem is not as simplistic as some previous studies have suggested. As with the crown-of-thorns phenomenon, more information on the biology and ecology of *Drupella,* especially of what determines the success of particular cohorts of recruits, is required before the causes of the outbreaks can be understood.

Management: feasibility of controls

A very approximate estimate of the numbers of *Drupella* within the Ningaloo Marine Park in 1987 was almost 500 million, suggesting that even if it was deemed to be necessary, control of *Drupella* populations will not be a simple matter. In a trial control of *Drupella* by hand removal by divers, it was found that an experienced diver could remove 75% of the snails present from a 25 metre square in about three days of intensive diving. At that rate it would require almost 50 diver-days to clear 75% of snails from a hectare of reef, or almost 200,000 diver-days for the entire Ningaloo reef. Clearly, control using this method is not viable except for very small areas of particular interest or importance.

Status of knowledge and monitoring

Detailed surveys of *Drupella* abundances and effects were undertaken along Ningaloo in 1987, 1989 and 1991. Since the Ningaloo outbreaks, *Drupella* have been included in the Great Barrier Reef Marine Park monitoring program (Chapter 69). All line transects include estimates of coral-feeding scars: if they are common, detailed quadrat searches are then undertaken for *Drupella*.

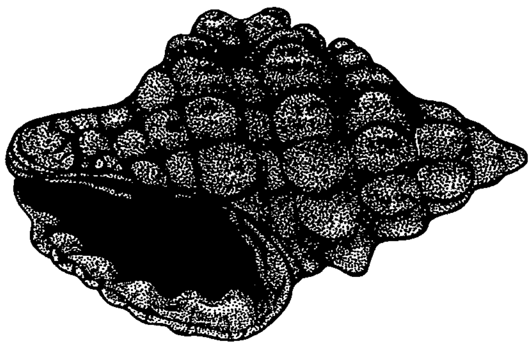

Figure 50.2: *Drupella cornus*.

Summary and conclusions

1. *Drupella* outbreaks have caused very severe damage to Ningaloo reef and are progressing in other areas of Western Australia.

2. Damage on the Great Barrier Reef has been localised.

3. The phenomenon raises identical questions to that of the crown-of-thorns starfish (i.e. on causation, desirability and feasibility of controls, and the difficulties of achieving a scientific understanding of a very complex phenomenon, in a relatively short time frame.)

4. The causes of outbreaks (whether natural or human-induced) are unknown and more research is necessary before a definite conclusion can be reached.

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Acknowledgments:
The technical paper by Dr A. Ayling was reviewed by U. Engelhardt, Great Barrier Reef Marine Park Authority, Townsville, Qld.

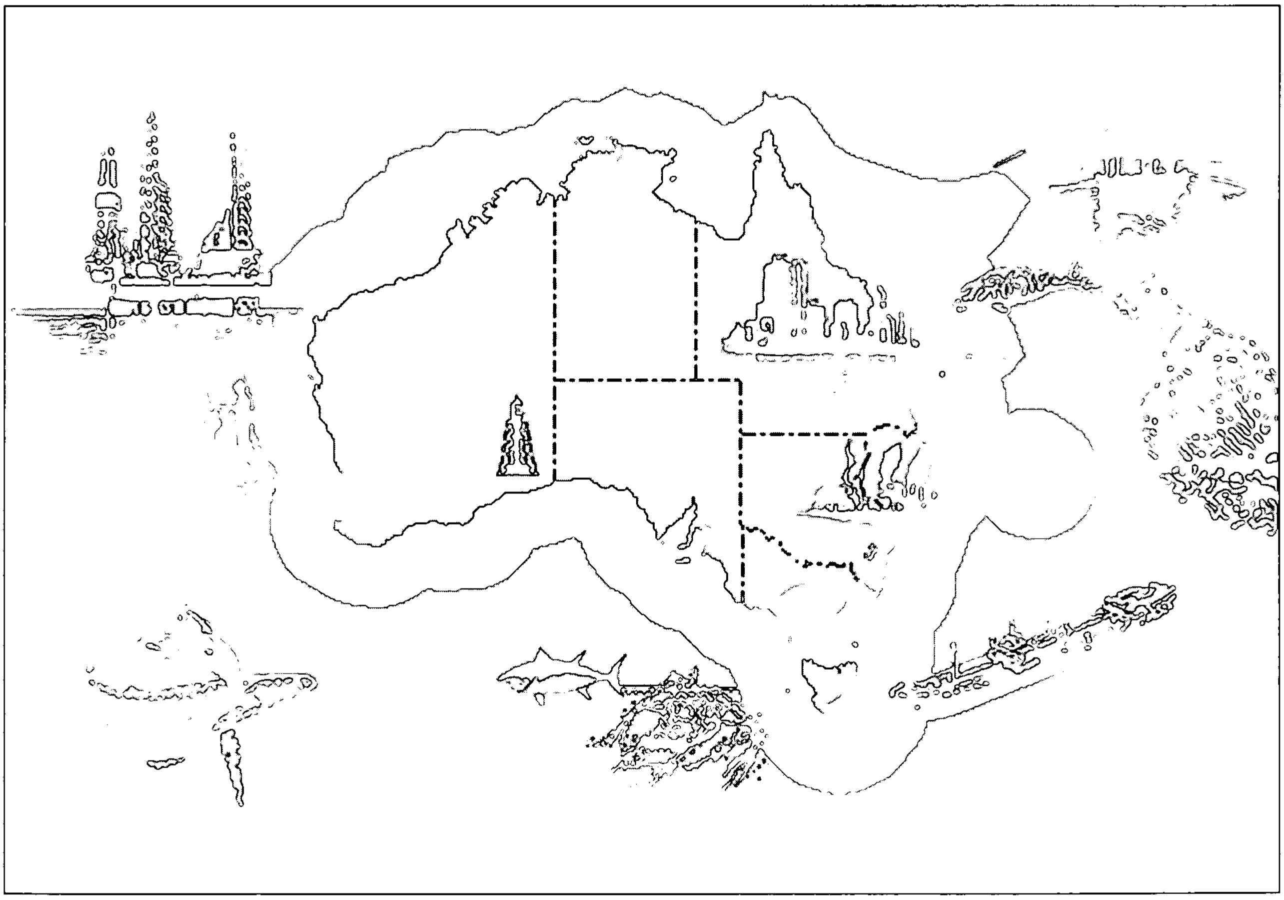
Part 6

Issues in the marine environment around Australia

While Australia has a relative small population, it is highly concentrated in the coastal zone of the south-east, and to a lesser extent, the south-west. Most of the issues in the marine environment tend to be concentrated in these areas.

Previous Parts of this report have assessed the overall status of marine ecosystems and marine biodiversity; discussed general uses and their impacts; and described general issues in Australia's marine environment. This Part takes a more spatial or jurisdictional approach and assesses, as far as it is known, the status of the marine environments in each Australian State and the Northern Territory.

These chapters are again condensed from more detailed papers written by experts from each State or Territory and have been minimally edited. In most cases the authors came from government marine environmental management agencies and reports were critically reviewed within those agencies. Where authors came from outside agencies, they were reviewed by relevant government agencies. The reports and these chapters do not necessarily reflect the official views of any government.



Chapter 51. Issues in Queensland's marine environment[1]

Queensland has the second longest coastline in Australia and a high diversity of subtropical and tropical marine habitats. These range from the exposed coastlines and large, mangrove fringed embayments and estuaries of the south-east, to the protected inshore waters of Cape York and the Gulf of Carpentaria, and the vast complex of coral reefs of the Great Barrier Reef and Torres Strait. Outside the south-east, the coastal population is relatively low. The issues in Queensland primarily result from the impacts of land-based activities, particularly in the south-east.

The issues discussed in this chapter were identified through a literature review, wide consultation and a questionnaire which was distributed to 35 government officers, private sector representatives, consultants and community groups seeking their opinions and sources of further information. They are focused largely on the coastal waters as the issues affecting the Great Barrier Reef are specifically discussed in Chapter 69.

Characteristics of Queensland's marine environment

Queensland has 5,200 kilometres of mainland coastline and 7,400 kilometres including islands, and the 2,000 kilometre long Great Barrier Reef. It includes a number of different geomorphological and biogeographical regions.

The subtropical south-east is characterised by high wave energy ocean beaches and the world's largest sand barrier islands. These enclosed large, protected bays are dominated by tropical and temperate seagrass and mangroves. The south-eastern region is the most densely inhabited.

The Great Barrier Reef, the world's largest coral reef complex, has developed on the shallow, wide, north-eastern continental shelf. The Barrier Reef protects the mainland coastline which is characterised by soft shores and mangroves. The adjacent coast ranges from wet tropical to semi-arid and, apart from a number of provincial towns and cities, is generally sparsely inhabited.

Torres Strait in the north is a shallow, narrow strait between Cape York and Papua New Guinea. It is strewn with islands and reefs, and has very large areas of seagrass. The islands are inhabited by Torres Strait Islanders, a people of Melanesian origin.

To the north-west lie the shallow, protected waters of the Gulf of Carpentaria. Much of this coastline is mangrove dominated and is very sparsely inhabited.

Major issues and threats

The pattern of European settlement in Queensland is similar to elsewhere within Australia, with most major population and industrial centres located along the coast and substantial areas of the coastal catchments dedicated to agriculture activities. The centre of population is in the south-east, in the fast growing Brisbane/Gold Coast/Sunshine Coast region.

Catchment land uses

Grazing is the major land use, averaging 57% of the catchments, and ranging from 96% of the catchment for the Western Gulf, to 8% for the Mulgrave-Russell Rivers. Cropping averages only 6% of catchments and is a major land use in only a few catchments such as the Johnstone and Mulgrave-Russell Rivers. These land uses have increased erosion and the export of sediment and nutrients to the marine environment. Table 5.1 summarises the perceived level of concern for key issues in each of the catchments, and the recreational and commercial fishing values for each catchment area, based on the considered opinion of State departmental officers.

The issues of most concern in these catchments were: construction of river impoundments; erosion from cropping land; stream channel instability; urban expansion; and instream and offstream water use conflict. Catchment areas in the Southern Coastal region rate the highest levels of concern, with some catchments in the Central Coastal and Northern Coastal regions also showing problems. These concerns are generally associated with catchment areas with high and growing populations, and with more intensive land use and high economic productivity. The majority of catchment areas rate highly for recreational and commercial fishing value.

[1] Based on a paper by D. Tarte, M. Hall and K. Stocks, Australian Littoral Society, Mooroka, Queensland.

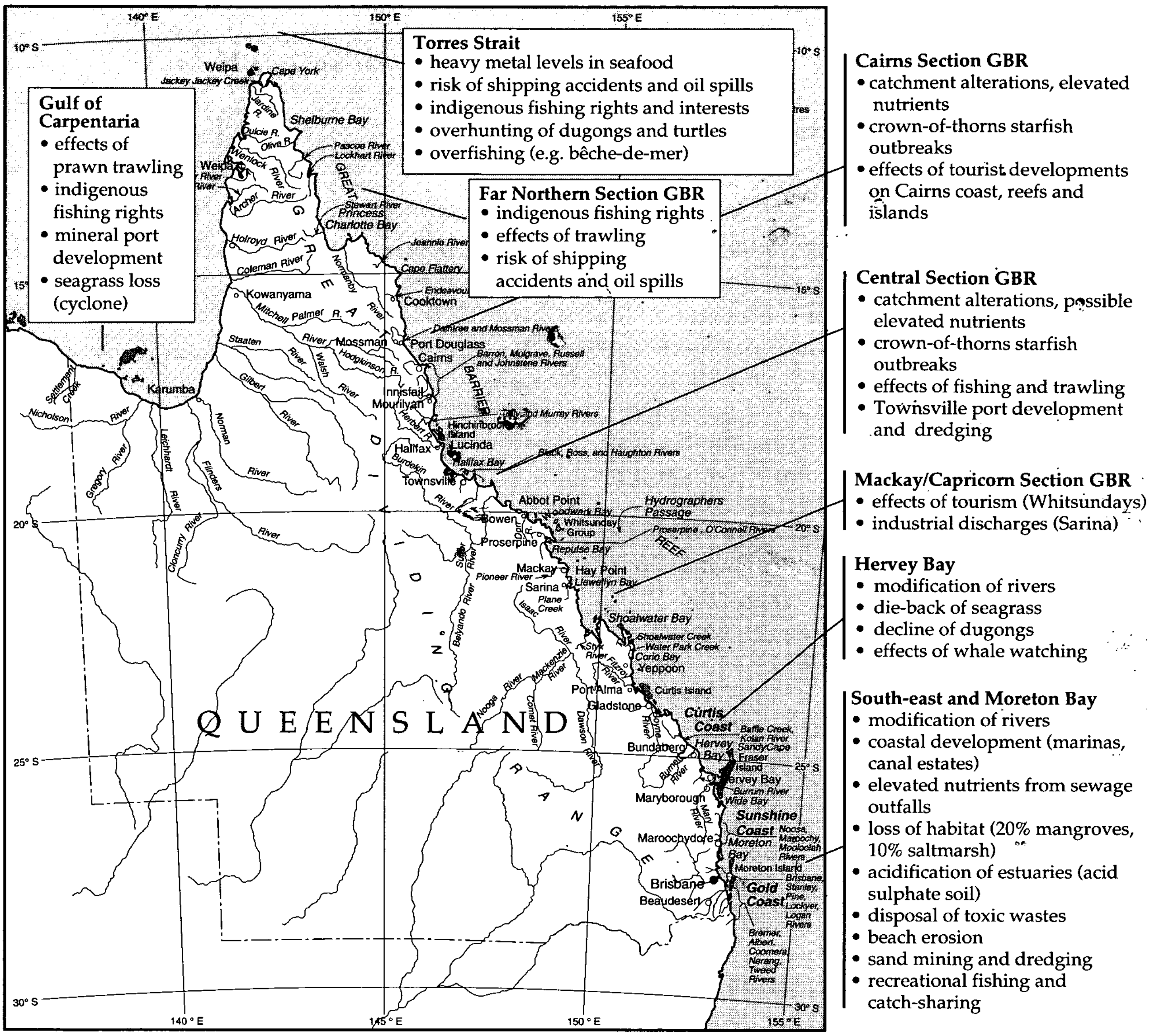


Figure 51.1: Issues in Queensland's marine environment.

Population: 2.98 million (62% in the Brisbane and Moreton divisions). Coastline: 9,800 km long. Major features are south-eastern (SE) open coasts and bays; Great Barrier Reef region; Torres Strait; and Gulf of Carpentaria. Problem areas include Brisbane and Moreton Bay, Gold Coast, and some regional ports.(6-14,42-47,51,69)*

Major State and regional issues include:
- changes in catchment uses
- increase in sediment and nutrient run-off (particularly in GBR lagoon and Moreton Bay)
- coastal strip development in SE (urban, industrial, marinas, agriculture, grazing)
- competing uses of coastal strip
- threats to Great Barrier Reef (water quality, effects of fishing, effects of trawling, tourism developments, crown-of-thorns starfish)
- loss of inshore habitat (mangroves, saltmarsh)
- Aboriginal and Torres Strait Islander fishing rights and lack of involvement in management
- protection and preservation of Aboriginal and Torres Strait Islander sites of significance
- effects of ports (dredging, oil spills, possible introductions)
- shipping risks through Torres Strait and Great Barrier Reef inner route
- effects of tourism (especially Cairns, Whitsundays, Sunshine Coast and Gold Coast)
- destruction of cultural heritage sites
- effects of trawling (Moreton Bay, GBR)
- overfishing of some stocks
- recreational fishing and catch-sharing (especially in SE)
- discharge of toxic liquid wastes (especially in SE)
- die-back of seagrass (Hervey Bay)

(*refer also to these chapters)

River impoundments

Since the 1940s a number of Queensland's river systems have been impounded to supply water for agriculture and potable water for urban populations. Weirs or barrages have been built to reduce the upstream extent of tidal influence and so allow greater access to fresh water in the lower reaches.

The ecological roles of rivers in terms of freshwater flow rates, nutrient cycles and life histories of aquatic species has received scant attention in the placement and management of water storages. Debate about an 'environmental allocation' when determining water release rates from dams has occurred only in recent years. While some impoundments contain fish ladders, the overall impact of these barriers on the migration of fish and other aquatic species for breeding purposes has not been documented.

Catchment discharges

The major impacts of catchment uses on the marine environment is changed water quality of the rivers discharging into coastal waters. The export of sediment from the coastal catchments and indicates contributions from the major land uses of urbanisation, cropping and grazing as well as a comparison between current conditions and the 'pristine' situation prior to European settlement is shown in Figure 42.4.

Change to Queensland's coastal catchments since European settlement have resulted in a three- to five-fold increase in sediments and nutrient levels discharged. The Burdekin-Haughton, North-East Cape York and Fitzroy catchment areas contribute most to the marine environment (45% of the total). A total of 77,000 tonnes of nitrogen and 10,000 tonnes of phosphorus are exported annually. All these estimates are based on mean flow conditions for each catchment area; exports can be at least three times greater during years of major flooding (see also Chapter 42).

The bulk of sediment and nutrient export are derived from grazing lands. Exports from cropping lands are relatively more significant in the wet tropics catchments. Point sources of nitrogen and Phosphorus make up only a minor proportion of total catchment exports except in the heavily populated Gold Coast-Beaudesert and Brisbane catchments.

Coastal strip development

Most of Queensland's population is located in coastal towns and cities. While Queensland's overall population is predicted to grow 1.7% annually till 2021, this growth is likely to be concentrated in the five coastal areas, south-east Queensland, and the coastal centres of Hervey Bay, Whitsundays, Townsville and the Cairns area. Parts of these areas are likely to experience a 28% to 272% increase in population by 2006. Unless carefully planned and managed, effluent disposal, urbanisation, run-off and increased recreational pressures on these coastal areas will increase pressure on the marine environment.

Water quality

Sediments and nutrients

The Great Barrier Reef (GBR) Marine Park Authority has monitored aspects of water quality since the mid-1980s (Chapters 42 and 69). There is general agreement that the major water quality problems for the GBR derive from excessive sediment and nutrient discharges into the near shore waters. These discharges may raise the levels of nutrient and benthic algal and phytoplankton growth in the inner and mid lagoon waters, particularly in specific coastal locations such as the Cairns and Whitsunday regions. Elevated nutrient levels are considered the major factor in a worldwide trend of a general decline in coral reefs (Chapter 12).

There appears to be insufficient evidence to establish a direct causative link between land use patterns in the coastal catchments and the changed water quality conditions in parts of the GBR. However there is strong evidence for the need for improved land management practices. The 1992 massive die-back of seagrasses in Hervey Bay (almost 1,000 sq km in area: Chapter 9) has been linked to an extreme flooding event in the Mary and Burrum Rivers, and provides further circumstantial evidence of impacts of land use.

Contaminants

Levels of most contaminants (heavy metals, polychlorinated biphenyls (PCBs) and other organochlorines and hydrocarbons) within GBR waters proper are generally close to the lower limits of detection. In some adjacent coastal waters (particularly harbours) concentrations indicative of low to moderate pollution levels equivalent to those found elsewhere in Australia and overseas have been recorded.

For areas outside of the GBR Region, adequate water quality data is only available for Moreton Bay in south-east Queensland. Again, nutrient and sediment loadings are cited as the major cause for concern. Toxicants such as metals, pesticides, PCBs and petroleum are at relatively low levels, but much of the data was collected in the late 1970s.

Sewage

Certain areas on the western side of Moreton Bay show signs of nutrient pollution, in particular elevated levels of phosphorus. These areas are generally associated with major sewage treatment plant discharges, in particular the mouth of the Brisbane River and Bramble Bay. This pattern is likely to occur in other coastal estuaries where there is a combination of sewage treatment plant discharges and periods of low flushing.

Queensland has 138 sewage plants discharging into rivers and coasts. Of these, six are tertiary and the remaining are secondary. Point-sources of nutrients are of concern mainly for the major coastal centres of south-east Queensland, Hervey Bay, Fitzroy River, Townsville and Cairns but other areas could experience pollution events given a combination of plant over-load or malfunction and low river flows or limited tidal flushing.

Loss of habitat

Significant intertidal areas have been reclaimed for urban, industrial, tourism, airport and port expansion along the Queensland coast, particularly in the high growth areas of Moreton Bay, the Gold and Sunshine Coasts, Hervey Bay, Gladstone, Whitsundays, Townsville and Cairns. In southern Queensland, canal estate housing developments have proved popular for coastal urban areas. The Moreton Bay area has lost up to 20% of its mangrove forests since European settlement, and around 10.5% of the saltmarsh between 1974 and 1987.

Intertidal lands also have been reclaimed for agricultural purposes such as grazing and sugar cane production. Large tracts in central Queensland have been utilised for ponded pastures. This involves building earth embankments to trap freshwater run-off and in some areas prevent tidal inundation. Environmental effects include: alterations to freshwater flows into tidal wetland areas; loss of tidal marsh habitat; and introduction of invasive exotic grasses and other weeds.

Acid sulphate soils

An associated problem of dredging for canals and marinas has been the exposure of acid sulphate soils. This problem has been identified only recently (Chapter 52) although anecdotal evidence suggests that acid sulphate soil events have occurred in a number of sites in south-east Queensland following excavation for canals.

Ports

A substantial proportion of Queensland's economy is based on agricultural products and the mining of coal and mineral resources, much of which is exported. Queensland has six 'trading' ports for export of primary products (Weipa, Cape Flattery, Mourilyan, Lucinda, Abbott Point, Hay Point). The other major ports (Brisbane, Gladstone, Townsville and Cairns) handle both imports and exports and service regional population centres. These latter ports have major industries sited within relatively close proximity (e.g. Brisbane has oil refineries and a major fertiliser manufacturing plant; Gladstone an aluminium smelter; and Townsville the Yabulu nickel refinery). Handling of hazardous cargoes and bunkering fuel are the main operational areas where pollution incidents can occur. Recently the Queensland Department of Transport released a draft Environment Policy for Queensland Ports as a commitment to ensure responsible environmental management by port authorities. Implementation of this Policy should assist in reducing the risk to the marine environment of port operations.

Maintenance of these ports can require the regular dredging of shipping channels and swing basins. The dredge spoil can be used either for reclamation purposes onshore, or is dumped at specified offshore dumping sites. If the sites are not suitably located and the operation well managed this can cause acute environmental damage through site run-off and sediment plumes. Ports requiring regular dredging operations include Brisbane, Townsville, Cairns and Weipa. Queensland Transport has argued that most of the sediment dredged originates either directly or indirectly from the catchment, and that good management principles by other authorities can minimise the process of erosion and silt transport during periods of run-off, controlling the introduction of sediments and contaminants into waterways.

Shipping traffic

Around 4,500 cargo ships visited Queensland ports during 1991/92. In 1992 there were over 2,000 commercial fishing boats, 600 Class I charter vessels primarily servicing GBR tourism, and 107,827 private pleasure vessels registered in Queensland.

Potential effects on the marine environment include: grounding or major accident by ships carrying hazardous cargo; ballast water introductions; chronic 'small' fuel and oil spillages at ports or while underway; sewage and garbage disposal at sea; and the development of coastal environments for marina and port facilities and associated industrial developments.

Of particular concern is the threat to the Great Barrier Reef by shipping using the Reef's Inner Route shipping lane, the Great North East Channel through Torres Straits, and the various designated passages through the Reef (Chapters 36, 69, 74).

Queensland is presently drafting new Marine Pollution legislation which will give effect to MARPOL 73/78 Annexes I (oil), II (noxious liquid substances), III (harmful substances carried in packaged forms) and V (garbage). This should provide an adequate legislative base to limit the impacts from shipping traffic, provided sufficient resources are made available to the responsible agencies to implement the legislation, and provide adequate navigational aids and enforcement, inspection and monitoring staff.

Operational discharges from ships can be reduced by the provision of adequate waste oil reception facilities in ports. The ports of Cairns, Townsville and Gladstone have such facilities, whereas Cape Flattery, Lucinda, Abbott Point and Hay Point ports do not.

Shipping accidents and spillages

Data from the GBR gives some estimate of the frequency and type of shipping accidents and spills in Queensland waters.

Numerous large-ship incidents with significant pollution potential have occurred. Some 19 collisions and 24 groundings have occurred since 1979. In addition oil pollution from operational discharges from large ships is a common occurrence, with over 30 reports in the REEFPLAN Area since 1990, the largest being estimated at around 10 tonnes. There have also been a number of spills from bunkering and other operations in ports. Discharges from and accidents with small vessels are also a source of oil pollution, with about 350 collisions, sinkings, fires and other incidents having occurred in the Reef Region since 1980 (Raaymakers 1993).

Ballast water introductions

Experience in southern Australia has shown that a combination of frequent visits of vessels from international ports as well as movement between ports within Australia increases the potential for introduction of exotics from ballast water or associated sediments (Chapter 48).

Queensland ports receive 27% of international shipping visits (i.e. 1,284 of a total of 4,779 visits) and 25% of domestic movements (i.e. 677 of a total of 2,681 visits). The ports experiencing most international traffic are Hay Point, Brisbane and Gladstone (75% of total movements). Brisbane, Gladstone and Weipa have the most domestic traffic (70% of total movements). A recent assessment of the risk of ballast water introductions indicates that the Queensland ports most likely to experience problems with ballast water introductions are Brisbane, Hay Point, Gladstone and Weipa.

Tourism

Most of the State's tourism is based in coastal areas many of which provide access to important marine and estuarine habitats (e.g. Great Barrier Reef and Hervey and Moreton Bays). The focus of tourism activity is in the coastal centres already identified as areas of high population growth, in particular the Gold and Sunshine Coasts.

The Queensland Tourist and Travel Corporation (QTTC 1992) estimates that 1.237 million international visitors came to Queensland in 1992, an increase of 16.3% over 1991. It estimates that there will be 4.7 million interstate and 5 million international visitors in the year 2000. This will contribute directly $12 billion annually to the Queensland economy, create 320,000 jobs and require a doubling of hotel/motel rooms and units and flats.

On the Great Barrier Reef itself there are 18 islands with tourist resorts. The majority of tourists access marine areas from mainland centres using either commercial day-trip boats or over-night charters. (Chapter 69). Many of the impacts associated with tourism are the same as those noted earlier for an expanding urban population. However, some developers have established resorts in undeveloped coastal areas that often are environmentally sensitive and of high conservation value. In Queensland this trend has been exacerbated by specific legislation which actively promotes integrated resorts such as Woodwark Bay in the Whitsundays and Corio Bay in central Queensland. Additionally, successive Queensland governments have funded the QTTC to market and develop tourism, and yet have not established a mechanism to develop environmentally sensitive strategic plans for the industry.

Issues associated with managing the high volume, large-group, day-trip tourism industry which operates mainly in the Cairns and Whitsunday regions include: location of mainland departure terminals; access to high quality destination sites; habitat interference and damage at destination sites; location of permanent facilities (e.g. pontoons) in remote areas; localised sewage pollution; interference with important fauna sites; and reduced access opportunities and amenity and aesthetic values for local users.

Fisheries

Queensland's marine and estuarine waters support extensive commercial and recreational fisheries. Major commercial fisheries, landings and their status are summarised in Table 51.2.

Unfortunately, there is a lack of data for recreational catches for most fisheries. It is estimated that approximately one third of angling effort occurs in the Moreton Region with some 300,000 recreational anglers catching approximately 2,000 tonnes of finfish; this compares with a commercial catch of 1,600 tonnes. The Queensland Commercial Fishermen's Organisation notes that if the commercial mullet catch is excluded, as these are not taken by recreational fishers, then the commercial catch is approximately 700 tonnes, substantially less than the recreational catch.

The intensity of the combined commercial and recreational fishing effort in the Moreton Region combined with the high population growth in the region makes this area particularly vulnerable to the impacts of fishing, in particular overfishing.
While a variety of impacts result from fishing activities, the fisheries themselves rely on the maintenance of healthy ecosystems and good water quality.

Important research issues include: the impacts of trawling in the Great Barrier Reef; growth and mortality, stock structure and biomass of the various fishery species; and the recreational fishing effort.

Environmental concerns by fishers include siting of future marina developments and other shore-based facilities so that they are not located in fisheries habitats.

The potential impacts of the growing aquaculture industry require assessment as there are a number of land-based and off-shore projects established along the Queensland coast and many more are proposed. Potential impacts include: reclamation/modification of coastal wetland sites for aquaculture ponds; effluent discharges from ponds; potential introduction of diseases and translocation of species; and use of wild stock to manufacture fish food.

Industrial development and mining

Queensland has a number of major industries sited along the coast. Generally, these either service large population centres such as Brisbane's oil refineries or they process or handle one of the State's agricultural or mineral products such as the alumina refinery plants at Gladstone, coal loading facilities at Mackay, and nickel treatment plant and sugar refineries in the Townsville region. Operations of these industries are controlled by a variety of Queensland legislation, and their environmental performance is overseen by the Queensland Department of Environment and Heritage (QDEH).

While Queensland's industries operate generally within the guidelines established by government, over the years there have been various serious pollution incidents. Prior to the introduction of the *Clean Waters Act* and Regulations in 1975 and other environmental control legislation during the 1970s, most industry operated with little regard to controlling environmentally harmful waste discharges. This was evidenced by various organic and chemical industrial discharges into the Brisbane River and other coastal streams; the 60-year history of high volume organic waste discharges from the Sarina (Australian National) Power Alcohol plant into tidal creeks discharging into Llewellyn Bay; and various mine and tailing site discharges into water bodies in major catchments.

Evidence submitted at the 1994 Criminal Justice Commission's Inquiry into the Improper Disposal of Liquid Waste indicates that while the situation has improved, there are still a number of major problems. Most importantly, Queensland has no legislation that adequately controls the disposal of toxic waste. This has led to some operators dumping untreated, toxic liquid waste into streams and tidal wetlands. The lack of strong legislation and insufficient resources in both the QDEH and local government has meant that this problem is only now being identified. Compounding this problem, the QDEH has been unable to carry out adequate monitoring of receiving waters. Consequently, the extent of contamination is still to be determined.

Probably some of the most contentious development proposals in Queensland have been those associated with the mining and petroleum industry. Various mining leases and exploration permits cover parts of Queensland's marine and estuarine estate. These include heavy mineral sand reserves, oil shale deposits, petroleum exploration permits, sand and gravel extraction, and limestone extraction. The foci for much of this activity include parts of the east and west coasts of Cape York, central Queensland and Moreton Bay. Conflicts arise when reserves coincide with areas of high conservation value such as the proposals to sand mine in the Shelburne and Shoalwater Bay areas, extract oil shale in the coastal wetlands of the Curtis coast and Repulse Bay, explore for petroleum in areas adjacent to the Great Barrier Reef, and mine sub-fossil coral from Moreton Bay's limited areas of reef flat.

The *Queensland Environment Protection Act* 1994 and the *Coastal Protection Act*, now in the process of implementation, will resolve many of the problems of waste management and coastal planning.

Aboriginal and Torres Strait Islander use

The previous sections have discussed the variety of impacts on the marine environment resulting from European settlement of Queensland. Aboriginal and Torres Strait Islander communities have established within their cultures a range of rights and duties to marine areas adjacent to their coastal lands. The Torres Strait Islanders in particular are a sea-faring people, many with wide-ranging sea territories (Chapters 22 and 74).

Coastal Aboriginals and Torres Strait Islanders have strong traditions of harvesting marine resources, hunting dugong and turtles, and collecting bird eggs, and many communities in northern Queensland and the Torres Strait are reliant on the sea as a major source of protein. The issues facing these communities include ensuring that: shore-based pollution such as sewage does not impact on marine areas; efforts to establish economic enterprises such as commercial fisheries and ecotourism are sustainable; modern hunting techniques and intensity do not cause local extermination of particular wildlife species such as dugong, turtle and seabirds; and that they are meaningfully involved in consultation and co-management arrangements for parks, reserves and zoning plans (Chapter 20).

Regional issues

General regional issues are summarised in Figure 51.1. However a detailed listing, either definitive or indicative, of chronically or acutely disturbed sites in Queensland's marine areas is not presented because of the paucity of adequate data for much of the area. However, substantial disturbance, particularly of estuarine and inshore marine areas, has occurred since European settlement with chronically disturbed areas associated with most major population centres. Many of the causative agents have been discussed earlier, and areas of particular concern identified. However, for many disturbances, the extent of the problem is only now being recognised.

Future trends

Present problems are likely to be exacerbated by Queensland's expanding population and tourism and industrial activities. To meet these challenges, Queenslanders will need to become far more aware of, and understand the variety of adverse impacts on the marine environment. Appropriate legislation, integrated planning to manage development, and adequate resources for management agencies, community consultation, and monitoring and research are required.

Potential future issues in Queensland's marine environment include:

- increased tourism demand for access to reefs and islands;
- increased access to presently remote areas because of advances in water transport technology;
- increased population and development in coastal areas of high conservation value;
- shipping in the Great Barrier Reef - potential spills of toxic cargoes and introduction of exotic organisms through ballast water;
- conflicts between wildlife protection and recreational use and tourism (e.g. access to important nesting sights for seabirds and turtles; interference with whale migrations by whale-watching tourism; increased injury to dugong and turtle populations from propeller strikes of faster, more numerous vessels);
- insufficient resources for management by agencies; and
- inadequate legislation for environmental protection.

Monitoring and marine environmental reporting

Most water quality monitoring has occurred in parts of the Great Barrier Reef Region (Chapter 69). Some data is also available for Moreton Bay, but little work has been done in the northern waters of the GBR Region nor the Gulf of Carpentaria. The Baseline Study for Torres Strait is monitoring heavy metals (Chapter 74).

Major resource assessment and monitoring programs in Queensland*

Queensland Government Departments:
Sunfish Project: database of logbook data for commercial fishers catch and effort.
Mapping mangrove and seagrass distributions in areas around Queensland: Hervey Bay, Moreton Bay, Cape York, Burdekin Delta, Trinity Inlet and Daintree (QDPI).
Broad-scale resource assessment of Queensland's biogeographic regions (QDEH).
Monitoring population density and distribution of species of concern including green and loggerhead turtles (QDEH).
Seabird Atlas of the Great Barrier Reef (Griffith Uni./QDEH).
Tidal Wetlands Inventory (Australian Littoral Society/QDEH).
Coastal Observation Program in Engineering - monitors beach, wave and wind conditions at 50 sites; storm surge at 20 sites; multiple-year hydrographic surveys, long-and short-term wave recording stations, meteorological data, and aerial photography (QDEH).
Long-term ambient water quality testing for physical and chemical parameters at 52 coastal and inshore sites in Queensland (QDEH).
Site-specific water quality investigations of a limited duration.
Site-specific monitoring (e.g. Raine Island: green turtle nesting and population dynamics (QDEH); Whitsunday-Mackay coast geology and vegetation surveys (QDEH); Woongarra Marine Park study of the impact of trawling on turtles, and study on the impact of an artificial recreational reef (QDEH/QDPI).
Swain Reefs: Survey biological integrity of and human impact on the reefs.
Cape York: resource assessment and the extent and effects of commercial fishing (CYPLUS).

Non-government:
Use of chemical control of mosquito and biting midge in mangrove and saltmarsh areas (Fisheries Research Consultants).
Keppel Bay and Islands, intertidal organisms (Uni. of CQ Biology Dept).
Fishermans landing (Gladstone) trade waste outfall in relation to the benthic community, (WBM Oceanics, Commissioned by QDEH).
Fisherman Islands Mangrove Monitoring (WBM Oceanics commissioned by the Port of Brisbane Authority).

*other than GBR Marine Park Authority (Chapter 69)

Table 51.1: Perceived level of concern of issues* plus fisheries values for each "coastal" catchment

Region, Catchment Area	Agricultural Land Uses			Water Quality Issues				Water Quantity	Natural Habitat Issues			Fisheries Value [1]	
	Cropping Land	Grazing Land	Urban Expansion	Surface Water Quality			Ground Water Quality	Instream and Offstream Water Use Conflict	Stream Channel Instability	Loss of Coastal Wetlands	Barriers to Fish Migration	Recreational	Commercial
	Erosion	Erosion		Nutrient Enrichment	Pesticides	Impact on Biota							
CARPENTARIA													
West Cape York	VL	L	VL	VL	L	L	L	L	VL	L	VL	H	H
Mitchell (2)	L	M	VL	VL	VL	L	M	L	L	VL	L	H	VH
Eastern Gulf	VL	H	VL	VL	VL	VL	L	L	L	L	L	H	VH
Flinders (4)	VL	M	VL	VL	VL	VL	L	L	L	VL	L	H	VH
Western Gulf	VL	M	VL	VL	VL	L	VL	L	L	VL	L	H	VH
SOUTHERN COASTAL													
Gold Coast	M	L	VH	M	L	M	L	VH	M	H	H	M	M
Brisbane	H	M	H	H	M	M	M	M	M	M	VH	M	VH
Sunshine Coast	VH	L	VH	M	L	M	M	M	M	M	VH	VH	M
Mary (16)	H	M	H	M	M	M	H	M	H	L	H	VH	H
Burnett-Kolan	H	M	H	M	L	M	VH	M	VL	L	VH	VH	VH
Curtis Coast	H	M	L	L	VL	M	L	M	L	L	M	VH	VH
CENTRAL COASTAL													
Fitzroy	M	M	L	M	M	M	M	L	L	M	VH	VH	VH
Shoalwater Bay-Sarina	M	M	L	L	L	L	L	L	VL	L	L	H	VH
Pioneer-O'Connell	H	M	M	L	L	L	M	M	H	L	H	H	H
Proserpine	M	M	L	L	L	L	M	H	L	L	L	H	M
Don	M	M	L	VL	VL	L	H	VL	VH	M	L	L	L
Burdekin-Haughton	M	H	L	M	L	M	H	H	H	L	VH	VH	VH
Ross-Black	VL	L	M	M	L	M	M	M	M	M	L	VH	L
NORTHERN COASTAL													
Herbert	L	L	VL	L	L	M	L	L	H	L	H	VH	M
Tully-Murray	L	L	L	L	M	M	VL	H	H	L	H	VH	H
Johnstone	H	L	M	L	L	M	VL	H	M	L	VL	VH	H
Mulgrave-Russell	M	L	M	L	L	H	VL	L	M	H	VL	VH	M
Barron	M	L	M	M	L	M	VL	L	L	M	L	H	H
Mossman-Daintree	L	L	VL	L	L	L	VL	L	L	L	VL	VH	H
North-East Cape York	L	L	VL	VL	VL	VL	VL	L	VL	VL	VL	H	H

KEY: **Issues:** VL = Very Low; L = Low; M = Moderate; H = High; VH = Very High **Fisheries Values:** L = Low; M = Medium; H = High; VH = Very High

NOTES:
Definition of Issues: *Agricultural Land:* erosion of cropping land (soil loss from cropping land); erosion of grazing land (soil loss from grazing land); urban expansion (urban expansion into suitable agricultural land). *Water Quality:* surface water nutrient enrichment (increased loading of nitrogen and phosphorus from rural, industrial and urban sources); pesticides (contamination of water by pesticides from rural, industrial and urban areas); impact on surface water biota (change in natural water quality sufficient to adversely affect aquatic flora and fauna); ground water quality (overall salinity, nutrient enrichment and pesticide levels in ground water). *Water Quantity:* instream and offstream water use conflicts (competing demands between offstream water use (urban, rural, industrial), instream water use (environmental, recreational)). *Natural Habitat:* stream bed and bank instability (changes to the bed and banks of streams that affect existing property, infrastructure and habitat); coastal wetland habitat loss (loss of natural flora and fauna habitat in estuarine and tidal wetlands); barriers to fish migration (impact on the up or down stream migration of fish resulting from artificial barriers on watercourses) (1) Information supplied by the Fisheries Division, Qld DPI (Source: QDPI 1993).

Table 51.2: Average annual commercial catch in Queensland of finfish/crustaceans (1988-91)[1] and status of the fishery[2]

Species	State Total (tonnes)	Status of the Fishery				Status of Knowledge for	
		Overfished	Fully Fished	Underfished	Uncertain	Management	ESD
Crabs							
Mud crab	379		X			adequate	incomplete
Sand crab	452		X			adequate	incomplete
Spanner crab	533		X			adequate	incomplete
Other crab	16						
Prawns							
Banana prawns	731	X				adequate	incomplete
Tiger prawns	1861		X			adequate	incomplete
Endeavour prawns	1303		X			adequate	incomplete
Bay prawns	400		X			adequate	incomplete
King prawns	2395						
- Eastern (SE Qld)		X					
- Ocean			X			adequate	incomplete
- Redspot			X			adequate	incomplete
- Eastern			X			adequate	incomplete
- Western			X			adequate	incomplete
Other prawns	583						
- Redspot (SE Qld)		X				adequate	incomplete
- Greasy			X			adequate	incomplete
- Leader			X			adequate	incomplete
- School			X			adequate	incomplete
Total prawns	7273						
Fish							
Estuarine Fish							
Mullet	2153		X			adequate	inadequate
Yellowfin bream	220						
Summer whiting	356						
Winter whiting	403						
Tailor	198		X			adequate	inadequate
Flathead	88		X			adequate	inadequate
Gar	92						
Black bream	50						
Barramundi	795		X			adequate	incomplete
Total estuarine	5983						
Reef Fish							
Snapper	90				X	incomplete	inadequate
Coral trout	1310						
- Inshore reef		X				incomplete	incomplete
- Offshore reef			X			incomplete	inadequate
Red throat emperor	630		X			incomplete	inadequate
Others	550						
Total reef fish	2580						
Pelagic Fish							
Mackerel	998						
- Spanish			X			incomplete	inadequate
- Grey			X			adequate	inadequate
Dart	37						
Total pelagic	1236						
Lobster	466						
Scallop	161900 (baskets)			X	adequate	incomplete	
Squid	193						

Sources:
1. Table 8.1 in QCFO (1993)
2. Table B.1 in ESD Working Groups (1991). The table is based on information given by Commonwealth and State government agencies which has been assessed as 'good', 'adequate', 'incomplete' or 'inadequate'.

Summary and conclusions

1. Queensland has a long coastline and diverse subtropical and tropical marine ecosystems, including coral reefs and mangroves.

2. The condition of the marine environment ranges from pristine over large areas of the north-east and north-west, to locally disturbed or threatened in the developed south-east.

3. The major issues in Queensland result from catchment land uses. Elevated sediments and nutrients resulting from grazing and cropping may threaten coral reefs in the inner Great Barrier Reef. Coastal strip development and high volume tourism (particularly in the south-east and parts of the Great Barrier Reef coast) have resulted in loss of habitat and amenity.

4. Other threats include discharges from industrial developments and mining; port dredging; spills of oil and toxic material in ports and from shipping; introductions of exotic species; the effects of fishing (especially the large recreational fishery in the south-east) and effects of trawling on the sea floor.

5. The maintenance of the interests of Aboriginal and Torres Strait Islanders in the coastal zone and their closer involvement in management are important.

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The technical paper by D. Tarte, M. Hall and K. Stocks was reviewed by the Queensland Department of Environment and Heritage.

Chapter 52: Issues in New South Wales' marine environment [1]

European settlement of the New South Wales coastline commenced in 1788 when Captain Arthur Phillip established the penal colony of Sydney. Phillip was conscious for the need for planning to prevent pollution, and issued orders to control domestic animals and the indiscriminate clearing of trees near the Tank Stream, the colony's water supply. However, by 1795 the stream was polluted by domestic sewage and pig sties, and by 1810 pollution from tanneries, breweries, distilleries and slaughterhouses was serious. Expansion of the colony up the Parramatta River was accompanied by clearing of mangroves and bush, infilling of saltmarsh, urbanisation and industrialisation, which polluted its upper reaches. The pattern of settlement had been set: sewage disposal, water quality, changes in coastal land use, and loss of habitat continue to be the major marine environmental problems in New South Wales.

New South Wales is today Australia's most populous State. More than 80% of its population reside in coastal areas, with the bulk living in the industrialised Newcastle/Sydney/Wollongong area. This area also has the most serious marine environmental problems. However other coastal regions have experienced rapid growth in the past 20 years. Between 1971-91, the industrial Hunter and Illawarra regions, and the rural Gosford-Wyong and Richmond-Tweed regions were amongst the top ten growth areas in Australia.

This chapter describes the major marine environmental issues in New South Wales' coastal environment over the past decade: sewage and its disposal, eutrophication, and pollution of Sydney's beaches. Sewage disposal is a particularly sensitive issue along the New South Wales coast because of the widely publicised problems of Sydney.

Characteristics of New South Wales coastal waters

From the Australian context, the marine environment of New South Wales is of particular interest because of the mixed tropical and temperate fauna and flora, the influence of the East Australian Current, and the diversity of unique habitats including temperate coral reefs, coastal lakes and estuaries, and drowned river valleys.

The continental shelf is relatively narrow and the coastal waters are primarily affected by interactions of the southwards-flowing East Australian Current (EAC) from the Coral Sea, and cooler Tasman Sea water intruding from the south. The EAC typically separates from the coast around Sugarloaf Point (ca 300 kilometres north of Sydney) but occasionally may continue to Ulladulla (400 kilometres south of Sydney). These separation zones are often prone to upwelling of cooler shelf/slope water which brings nutrients onto the shelf and increases algal productivity. Sydney's waters are affected by the EAC around 75% of the time. As it leaves the coast the EAC forms turbulent, anticlockwise flowing, warm eddies around 150 kilometres wide, and clockwise, cold eddies around 30 kilometres wide which may intrude on the continental shelf further south.

Coastally trapped waves which originate in Bass Strait and southern New South Wales travel northwards, causing current reversals. The smaller scale upwellings may also bring nutrients to coastal waters and may enhance algal activity. Tides have small effect except where ebb tide jets from bays and large rivers occur. Storm winds, particularly from the south-east, may break up temperature layers offshore. These may bring normally submerged sewage plumes to the surface.

Coastal features and human development

The north coast rivers are broad and slow-flowing with well developed flood plains and extensive, associated coastal wetlands. Towns are situated at their mouths. High rainfalls can lead to flooding and flushing of the estuaries. Pollution problems are largely related to clearing, agriculture and agricultural industries, forestry operations, sand mining, urbanisation, flood mitigation works and

[1] Based on a paper by Dr R. Macdonald, Environment Protection Authority of New South Wales, Sydney, New South Wales.

water supply dams, which may increase erosion, sediment loads, pesticides and nutrient loads and change flow regimes. Development of drainage channels has resulted in 'acid drainage' problems, resulting from oxidation of sulphides in certain soils. Flood mitigation works have caused problems by infilling of wetlands, and may increase the incidence of fish diseases such as 'red spot'.

The catchments of the central and south coast lagoons (e.g. Lake Macquarie, Tuggerah Lakes and Lake Illawarra) have been progressively urbanised, and the lakes have been significantly affected by nutrients and sedimentation.

The south coast rivers are generally shorter with smaller flood plains, and river mouths and lakes are often separated from the sea by permanent or semi-submerged sandbars. They are not well flushed and are less able to tolerate stresses. Urbanisation and tourism are the major developments whilst agriculture, fisheries and woodchip exports are major industries. Water problems tend to be localised and are associated with nutrient enrichment and sedimentation.

Major issues and threats

The major problems in New South Wales coastal waters are sewage and its disposal, and eutrophication. However, increasing competing uses are posing major problems in New South Wales' coastal waters which are widely used for swimming, surfing, diving, sailing, boating, and angling, and for commercial tourism, shipping and fishing. Recreational use has greatly increased because of increased leisure time, better access, more water craft, the popularity of coastal holidays, and for retirement centres of an aging population. Port works, dredging, and industrial development have also caused loss of coastal habitat.

Recent inquiries into the coastal zone have emphasised the problems in New South Wales' coastal environment. Major issues raised by the House of Representatives Standing Committee on Environment and the Arts (1991) include: ocean disposal of sewage and lack of suitable alternatives; impacts of bioaccumulation of toxic substances; and the need for national water quality guidelines and standards for waste discharges.

Major concerns raised by the Resource Assessment Commission include the continuing rapid urbanisation of coastal areas, particularly in northern New South Wales; its effects on fish stocks, natural habitats and wetlands; the further deterioration of water quality in many locations; and loss of amenity of many beaches. A review of New South Wales Coastal Government Policy is being undertaken of non-metropolitan areas by the Coastal Committee of New South Wales, the body responsible for government policy and liaison.

Sewage, eutrophication

Historically, sewerage systems and sewage treatment works were constructed after urbanisation has occurred, leading to the construction of inadequate septic disposal systems and resultant illegal disposal of effluents to local waterways. This has been particularly apparent in the case of Sydney (see Case study 1, below).

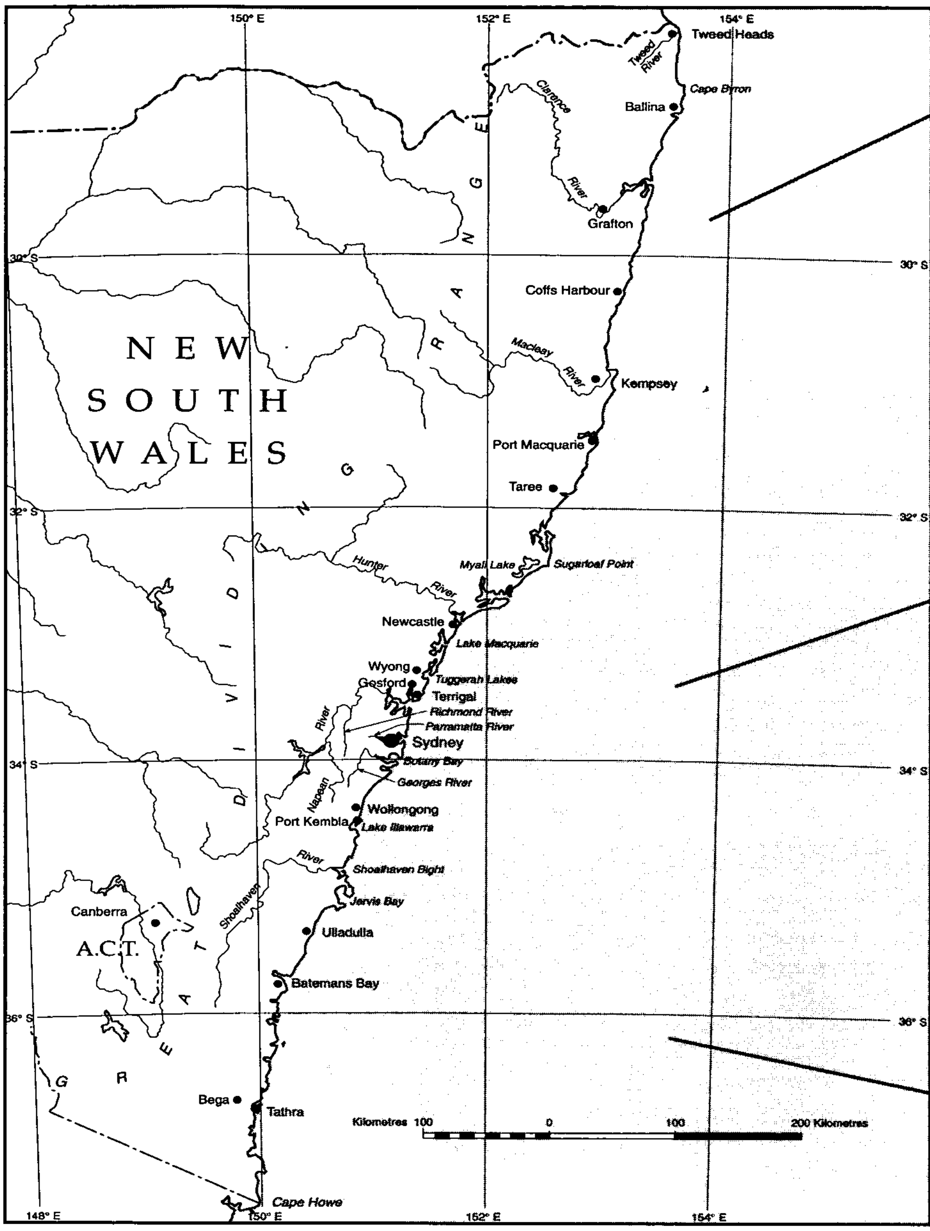
Since the 1970s and '80s most urban communities with populations over 700 have been connected to sewerage. While septic disposal is no longer an issue in most areas, there are continuing problems with some emergency sewer overflows, particularly during and after storms, as they may result in degradation of receiving waters. Illegal connection of stormwater drains to sewers increases the problem; for example, in some older urban areas testing showed that over 50% of connections were illegal.

Sewage in the Newcastle-Sydney-Wollongong region is generally treated to a primary level (i.e. removal of solids) before ocean discharge. At Newcastle all discharges will be treated to a secondary standard by 1996. Sewage in other coastal areas is treated to a secondary standard before discharge, generally from isolated, rocky shoreline locations. Sludge from major treatment plants has traditionally been discharged to sea, but this has been replaced by use as landfill and compost.

Sewage discharges to coastal rivers are treated to secondary or tertiary standards. Localised eutrophication has occurred where flow is low and flushing poor. This occurred in the Georges River in the Sydney area in the late 1970s but the discharges affecting this river have now been diverted to the ocean. Water quality is a continuing issue in the Hawkesbury-Nepean River catchment where the bulk of Sydney's recent population expansion has occurred. Here the river is an important source of potable and agricultural water, and an important site for recreation and commercial fishing.

Studies by the New South Wales State Pollution Control Commission (SPCC) in 1978-83 found that ammonia, total nitrogen and total phosphorus inputs from treatment algal plants were excessive. Since that time, reductions in the loads of phosphorus and ammonia have been achieved and algal plant growth has been reduced. In Lake Macquarie, where an SPCC environmental audit found eutrophication had resulted from discharge of treated effluents, it was decided to reduce nutrients by a combination of reuse options and diversion of effluents through an ocean outfall. This is due for completion in 1996.

Health issues in New South Wales' coastal waters are described in detail in Chapter 47.



Northern
- coastal strip development and competing uses
- degradation of estuaries
- declines in seagrass
- acidification of estuaries (acid sulphate soil)
- sand mining
- eutrophication of coastal lakes

Central
- coastal strip development and competing uses
- ports related infrastructure
- declining water quality
- degradation of estuaries
- eutrophication of coastal lakes
- ocean sewage discharges (especially Sydney)
- state of swimming beaches (pollution, litter)
- localised pollution from sewage and industrial discharges (heavy metal, tributyl tin, organochlorine and petroleum, micro-organisms)
- large recreational fishery and catch-sharing
- shoreline fishing

Southern
- coastal strip development and competing uses
- ports, marinas and tourist developments
- eutrophication of coastal lakes
- overfishing (gemfish, southern bluefin tuna)
- Aboriginal fishing rights

Figure 52.1: Issues in New South Wales' marine environment:

Population: 5.77 million (80% in coastal zone, most in Sydney/Newcastle/Wollongong). Coastline: 1,900 km. Major features are open coastlines, river estuaries, drowned river valleys on central coast, and large coastal lakes. Major issues stem from declining water quality in urban areas and coastal strip development. Problem areas include Sydney ocean sewage outfall sites (relocated 1990), Homebush Bay, Georges River and Lake Illawarra, Lake Macquarie and Tuggerah Lakes. (6-14,42-47,52*)

Major State and regional issues include:
- declining water quality from sewage and run-off; elevated nutrients in estuaries and bays
- coastal strip development, catchment disturbances and loss of habitat
- destruction of cultural heritage sites
- modification of estuaries
- eutrophication of coastal lakes
- acidification of estuaries (acid sulphate soil)
- decline of 50% of seagrass (by eutrophication, habitat alteration)
- localised pollution by heavy metals, tributyl tin, chlorinated compounds and oil (especially in Sydney metropolitan area)
- poor bathing water quality (especially Sydney beaches in 1980s)
- decline in coastal fisheries
- large, unmanaged recreational fisheries and catch-sharing
- protection and preservation of Aboriginal sites of significance
- Aboriginal fishing rights and interests
- shoreline fishing
- effects of prawn trawling on sea floor communities

(*refer also to these chapters)

Bioaccumulation of contaminants

Large numbers of fish have been monitored for contaminants under the Sydney Environmental Monitoring Program (EMP) which assesses the effects of the relocation of the ocean sewage outfalls. Before diversion of the sewage offshore, morwong, blue groper and snapper caught near the outfalls had accumulated the highest concentrations of organochlorines and mercury along this section of coast. Contaminant levels have now been decreased in morwong in the vicinities of the old outfalls. Bans on fishing which had been formerly imposed at the sites of the old sewage outfalls (Bondi, Malabar and North Head) have been removed.

New South Wales Fisheries Branch studies of four species of fish found low levels of organochlorines in fish from most areas, with the highest being in the Parramatta and Georges Rivers.

Bans on fishing because of concerns about the possible presence of contaminants still exist in the upper sections of the Parramatta River, Cooks River, Thorsby Creek to the mouth of the Hunter River (Newcastle), the South Channel of the Hunter, and Port Kembla Inner Harbour and its tributaries.

Other contaminants

Urban run-off may adversely affect water quality. Storm water increases rates of erosion and sedimentation, and it may contain nutrients from domestic sources and faecal matter (from sewer overflows and pet droppings); oil, grease and trace metals from roads; and refuse (plastics, cans etc), but there have been few studies of the problem. A study of five coastal catchments in Sydney found some increases in faecal bacteria, nutrients and suspended solids in drains and adjacent bathing areas during wet weather. In coastal lakes such as Lake Illawarra, Lake Macquarie and Tuggerah Lakes, tributaries may be eroded and sediments may smother bottom habitats, decrease water depths, and increase weed growth. In new urban developments increasing attention is being given to erosion control by measures such as the installation of stormwater detention ponds.

Petroleum spills

Spills have been frequent in New South Wales but have involved small volumes. In 1991-92, 330 spills were reported to Environment Protection Authority (EPA) and the Maritime Services Board. The median size was less than ten litres, and the maximum was 3,000 litres. The smaller spills were generally associated with fuelling of small boats, and the larger with pipeline incidents. While most were of nuisance value rather than of ecological significance, concerns are expressed that they may have long-term cumulative effects in chronically affected areas. Because of the large quantities of oil transported and refined in New South Wales, oil spill response plans have been developed. A series of coastal resource atlases is being produced by the EPA with funding from the Australian Maritime Safety Authority to document environmentally sensitive coastal sites.

Spoil dumping

Around one million tonnes of dredge spoil is dumped in the sea each year, with the bulk from Newcastle, Sydney and Port Kembla harbours. Ocean dumping is generally restricted to cases where other options are impractical, but spoil is analysed for contaminants before permission is granted.

Habitat losses

Drainage, reclamation, sedimentation, changed energy environment and decreased water quality may degrade marine habitats of fish and other biota. Recent mapping of New South Wales wetlands has shown significant losses of wetlands habitats in the northern rivers over the past 40-50 years. (The one exception is the Macleay River which had increased seagrasses following construction of a new river entrance). Data for the whole State are not available. A State Environmental Planning Policy (No. 14. - Coastal Wetlands) gazetted in 1985 restricts developments on these lands, and aims to preserve and protect designated wetlands.

Table 52.1: Changes in seagrass, mangrove and saltmarsh (square kilometres) in three northern rivers

river	year	seagrass	mangroves	saltmarsh
Tweed	1947	1.41	2.89	0.70
	1962	0.87	2.91	0.38
	1981	0.40	3.09	0.20
	1986	0.39	2.76	0.20
Clarence	1942	5.28	5.13	2.41
	1966	2.76	5.07	2.34
	1971	1.58	5.20	2.41
	1981	1.54	4.89	2.14
	1986	0.83	4.79	2.05
Macleay	1956	0.88	5.38	6.09
	1976	1.32	5.42	4.17
	1981	1.29	5.70	3.97
	1986	1.31	5.70	3.97

Fish stocks

The particular problems of management of New South Wales' coastal fisheries are described in detail in Chapter 31. Stock sizes, and effects of commercial and recreational harvesting and environmental stresses are not known for most fished species. In 1991 the Ecological Sustainable Development (ESD) Working Group on Fisheries listed 41 marine and estuarine species in New South Wales as overfished or fully fished. There was inadequate knowledge for any species to satisfy either management or ESD purposes. Until recently the size of the recreational fisheries were not fully appreciated (Chapters 31 and 33).

State of estuaries and coastal lagoons

Large parts of the coastline and most estuaries have suffered through indiscriminate or ill-planned development. A survey of all of the estuaries and coastal lagoons in New South Wales (Bell and Edwards 1980) indicated that only four of the total of 137 still had relatively pristine waters and catchments at that time. Sixty-six of these water bodies were notable in having less than 50% of their shoreline remaining in a natural condition.

Regional issues in New South Wales

A selection of regional issues are summarised here in the form of case studies.

Case study 1

Sydney's sewage problem[2]

Sydney's first supply of water, the Tank Stream was already polluted by domestic wastes by 1795, and was worsened by discharges from small industries in the early 1800s. As Sydney's population grew along the Parramatta River, and then south to Botany Bay and the Georges River, so did the waste water problem, and by the late 1800s the harbour had grown foul. Between 1888 and 1916 sewers had to be built to divert untreated sewage to the open sea, at Bondi, Malabar, and North Head. By the 1920s bathers were complaining of sewage on ocean beaches.

While Sydney's first sewers were laid in the 1850s, the urban sprawl westwards in the 1950s and 1960s occurred so rapidly that no sewerage was installed. Only after a major outbreak of hepatitis in the western suburbs (population 778,000) in the mid-1960s, was inland sewage treatment commenced. This in turn, created problems in the rivers. Because of acute beach pollution, three primary treatment plants were built at Bondi (1960s), Malabar (1974) and North Head (1984). These solved the problem for a time, but by the 1980s the city's famous ocean beaches were again so severely polluted by sewage that many were unsafe for bathing.

Public opinion again demanded action. A major program, costing $290 million, was undertaken to carry primary treated effluent 3-4 kilometres out to sea to diffuser heads for dispersal into deepwater ocean currents. The three plants were commissioned in 1990-91, since which there has been a marked improvement in water quality off ocean beaches.

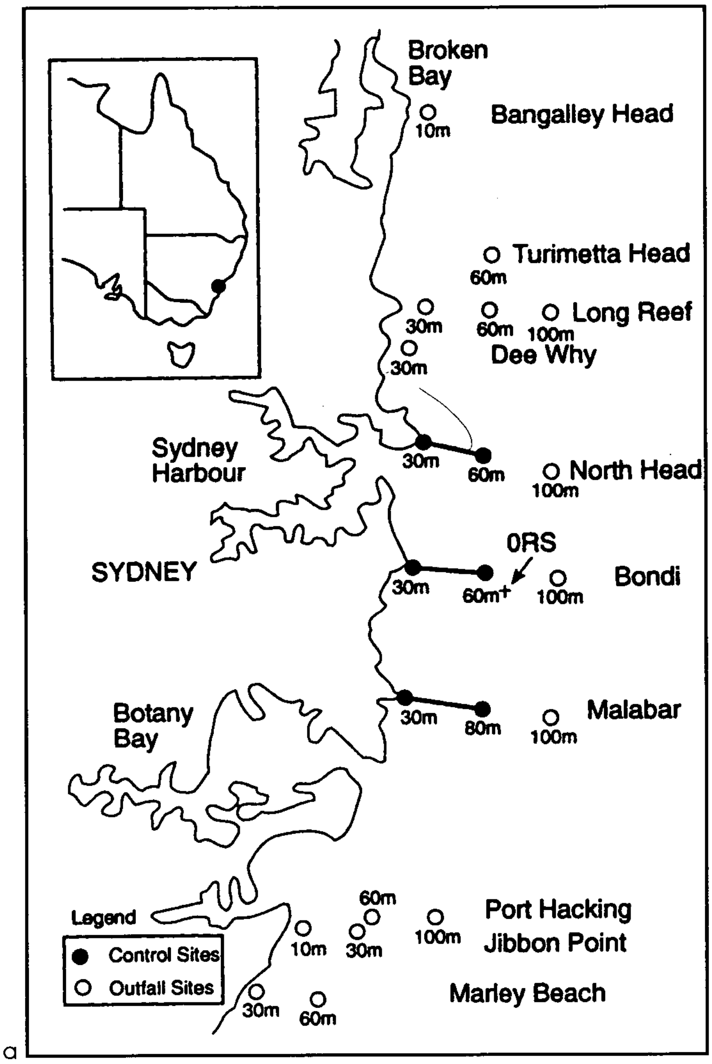
The sewers and treatment plants which collect and treat effluent from domestic and commercial/ industrial sources are owned and operated by the Sydney Water Board. The quality of the industrial effluent produced is controlled by the Board under trade waste agreements. The quality of treatment discharges is controlled by legislation administered by the New South Wales Environment Protection Authority (EPA). Approvals and licences may require monitoring of effluents.

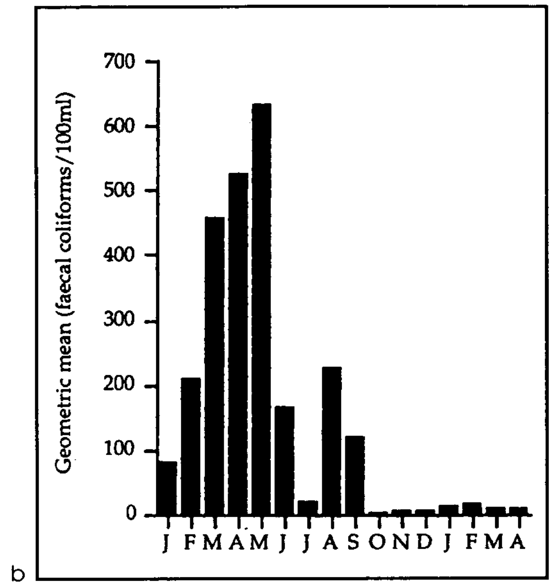
Coastal water quality prior to 1990:
Prior to 1990, monitoring of water quality and biota showed that beaches were adversely affected by sewage from treatment plants along 40 kilometres of Sydney's coastline. The sea water at many surfing beaches was often visibly discoloured and contained particles of grease. Bacterial levels frequently did not reach Health Department guideline for bathing. Famous Sydney beaches such as Manly and Bondi failed Health Department guidelines for coliform bacteria more often than they passed, while beaches at greater distances from outfalls were less polluted. Flesh of some species of fish taken near the major discharge points also contained contaminants at levels above residue levels set by the National Health and Medical Research Council.

Coastal water quality after 1990:
The commissioning of the new submarine outfalls have significantly improved water quality, although the full extent is not yet apparent. Bacterial levels have improved at all beaches and now pass bathing water quality guidelines 90% of the time. Bacterial levels have been reduced by 100-fold at Maroubra. Levels of technical chlordane in oysters and in both chlordane and dieldrin in fish have declined from significant, to below detection levels. No trends are yet apparent in diversity and abundance of fish and benthic species. Beaches further away have not shown any adverse effects from the re-located outfalls.

Offshore water quality:
To what extent has the relocation of outfalls simply exported a pollution problem? Monitoring at the outfall sites indicates that the discharged sewage plumes are normally trapped in deeper, stratified waters. Bacterial levels in these deeper waters (>30 m) are high (>several hundred cfu/100ml), while those in the upper half are low (<10 cfu/100ml). Of a range of organochlorine compounds being investigated in deepwater sediments offshore, only hexachlorobenzene has so far been detected. Trace metal levels varied, but lay within the 'low contaminant status'. Monitoring is continuing at inshore and offshore locations.

[2] [illegible] Environment Protection Authority of New South Wales, Sydney, New South Wales.





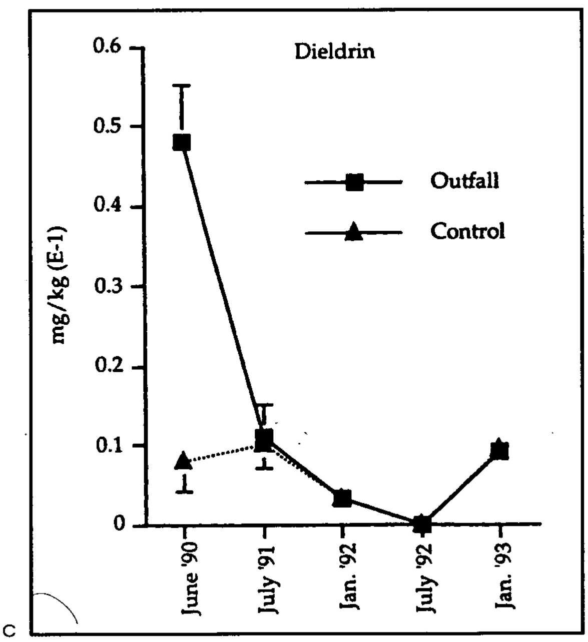


Figure 52.2: Sydney sewage outfalls. (a) Sydney's urban coastline showing deep water outfalls. (b) Faecal coliform densities at Maroubra beach showing reduction following relocation of outfalls in 1990. (c) Reduction in dieldrin levels in red morwong fish off Sydney after relocation of ocean outfalls.

Case study 2

Changes in Botany Bay since 1770

Botany Bay has changed greatly since Captain James Cook anchored there in 1770. At first it was a source of timber, oysters and fish for the infant colony. In 1815 it was settled and the first industry, a textile mill was built on Cooks River. However, by 1870 natural oysters were almost extinct, clearing of vegetation had created mobile sand dunes (a problem ever since), and Cooks River was badly polluted by sewage. Major changes to the Bay continued with the construction of oil refineries, Mascot airport and the 'second port', all of which involved extensive dredging and reclamations. Disturbances to the Bay's environment has been the subject of many commissions of inquiry, from one on declines of oysters in 1867, to the industrial development of Kurnell Peninsula in recent times.

Environmental information on Botany Bay has been recently synthesised by the University of Sydney's

Institute of Marine Ecology. The Bay contains diverse marine habitats such as saltmarshes, mangrove forests, sandy beaches, mudflats, rocky shores, submerged soft bottoms, seagrass beds, and rocky reefs, with high species diversity (e.g. 290 plant species in the saltmarsh, 230 species of fish in the Bay, 225 invertebrates in the sand and mud, and 170 species of birds).

Major environmental problems are thought to be urban run-off, loss of habitat from reclamation, and dredging. Saltmarsh has been almost entirely lost by reclamations and urban run-off (1,000 ha was lost to 1950, and 4-7 ha per annum since then). Some mangrove forest has been lost (1-3% of original) from reclamations and possibly oil pollution, but this is now protected. Seagrass beds have been declining because of dredging, oil spills, sea urchin 'plagues' and erosion. Rocky and soft shores have been affected by urban run-off, bait collecting, and oil pollution.

The challenge for the future is to understand better the ecology of the Bay and our effects on it, and to better manage these. As the Port Botany Inquiry concluded: 'Unrestrained and uncontrolled, the development (of the port) would no doubt have very far-reaching and adverse impacts. However, this Inquiry does not accept that the existence of the port must destroy all the amenities and values of the Bay. There will be some diminution of total potential, but careful planning and control can produce an acceptable co-existence of amenity and industry.'(McGuiness 1988)

Case study 3

Eutrophication of Tuggerah Lakes

Situated between Sydney and Newcastle on the New South Wales Central Coast, the Tuggerah Lakes are a large (80 sq. km in area, 121 km of shore), shallow (aver. depth 1.9 m) lake system, with a constricted ocean entrance. Increasing sediments and nutrients from catchment clearing, rural and urban run-off and sewage have resulted in serious shallowing and eutrophication, and poor water quality. The New South Wales Department of Public Works has begun a major restoration program to revive the lakes' environment and restore their amenity value.

The program involves the reduction of sediment and nutrient inputs (by soil conservation programs, sediment traps and nutrient filters on all streams and drains discharging into the lakes); removal of sediments and nutrients (by removing ooze, silt and aquatic plants from the lake bed and beaches); and improving tidal exchange (by deepening channels and by deepening the channel at the Entrance). Foreshores are being revegetated and wetlands are used as biological filters. Artificial sand islands have been made from dredge spoil for bird breeding. (NSW Public Works n.d.)

Case study 4

Acid soils and fish kills in coastal rivers of northern New South Wales

Fish kills occur worldwide and result from natural and human induced factors such as infectious and non-infectious diseases, climatic change, flow stoppages and chemical pollution. In northern New South Wales there is a seasonal pattern of fish kills that has recently been attributed to estuary acidification from acid sulphate soils.

Acid sulphate soils are formed when iron pyrite (FeS_2) sediments of coastal lowlands oxidises to sulphuric acid. In developed or agricultural soils, the acid sulphate oxidises if the water table is lowered either through naturally occurring droughts, or artificially through land drainage practices. Dredging and excavation may also expose the pyrite to air and allow oxidation. The acid produced reacts with clay minerals in the soil and increases levels of dissolved aluminium and iron. These in turn form compounds very toxic to fish and promote further acidification.

The aluminium compounds in acidified water affect fish gills by taking out calcium, and interfere with respiration and osmoregulation. Pathological effects include inflammation and necrosis of gills and skins, causing the widely reported red-spot disease.

Floodgates may release pulses of abnormally clear or green coloured acid water which may cause large, catastrophic fish kills downstream. Sea mullet, yellowfin bream, eels and catfish are particularly affected. Similar fish kills may be widespread in northern Australia at the beginning of wet seasons when the first flush of acidified water is carried into billabongs. (Sammut et al. n.d.)

Monitoring and marine environmental reporting

As in most other States, information on the ecological structure and function, and environmental status of the biotic marine environment in New South Wales is not well collated. Much of the information is unpublished and scattered, and has generally not been adequately synthesised. One of the few syntheses, a description of the ecology of, and anthropogenic impacts on, Botany Bay, found information was scattered, and was of varying quality.

New South Wales Fisheries is currently examining biogeographic trends in the context of the Ocean Rescue 2000 program which will provide an ecological framework for a network of marine protected areas.

Monitoring

All waste water discharges into the marine environment are required to meet licence conditions set by the EPA on an annual basis. Pollution reduction programs may be required where discharge quality needs improvement. The EPA and the Sydney Water Board have been active in monitoring of water quality in the Sydney metropolitan area.

At the Sydney ocean outfalls a comprehensive environmental monitoring program includes oceanographic, water quality and community structure and abundance studies. For contaminant studies, fish are sampled near the old and new outfall sites, and at control sites from Terrigal (50 kilometres north) to Jervis Bay (140 kilometres south). This is providing important information on Sydney's marine environment. New South Wales Fisheries has monitored contaminants in four species of fish in various estuaries. In the Newcastle region the EPA is monitoring contaminants in coastal waters and sediments for the Hunter Water Corporation and Hunter Port Authority. The Sydney Water Board is monitoring areas in the Sydney and Illawarra regions for future planning purposes for its shoreline outfalls and stormwater discharges.

Summary and conclusions

1. The major marine environmental issues in New South Wales are water quality (possible contamination of beaches by sewage, and eutrophication and sedimentation of estuaries and coastal lakes), and loss of coastal habitat (by strip development, sedimentation from changes in land use, flood mitigation works etc). Other problems include conflicting usage and loss of amenity, and declines in fish stocks.

2. The most densely populated and most industrialised region, Newcastle/Sydney/Wollongong, has had the most serious water quality problems in New South Wales. However, there is evidence that some aspects of water quality has improved.

3. Sydney's coastal sewage discharge problems have been alleviated by the recent installation of deepwater ocean outfalls but this may not provide a long-term solution.

4. The effects of primary treated sewage on Sydney bathing beaches may have overly focused concerns on ocean discharge, and on Sydney as a particular area for concern.

5. Systematic water quality monitoring has occurred around the Newcastle/Sydney/Wollongong region, but has been limited in non-metropolitan areas.

6. Coastal strip development outside the metropolitan area is a major threat to coastal habitats in the rapid growth areas in northern and southern New South Wales and requires planning to minimise adverse environmental impacts.

7. Point-source discharges are now better controlled and located to minimise impacts, but controls of diffuse sources have still to be adequately addressed.

8. Sustainable management of fisheries resources has still to be adequately addressed.

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Acknowledgments:
The technical papers by Dr R. Macdonald and N. Philip were reviewed within the Environmental Protection Authority of New South Wales.

Chapter 53. Issues in Victoria's marine environment[1]

With an area of 227,600 square kilometres, a 2,000 kilometres coastline and a population of 3.7 million, Victoria has the highest population density and population to coastline ratio of any State and Territory. The major features of Victoria's coast are that it has only two large embayments, Port Phillip Bay and Western Port and it has the largest lakes system in the southern hemisphere, the Gippsland Lakes. The embayments are also the epicentres of urban and industrial development and the restricted circulation of water within these bays makes them particularly prone to pollution.

This chapter describes some of the major marine environmental issues in Victoria, including the eutrophication, heavy metal pollution from past practises, loss of seagrass beds and intermittent algal blooms.

Characteristics of Victoria's marine environment

Victoria's coast forms the northern boundary of Bass Strait, a shallow basin influenced by the Tasman Sea and East Australian Current in the east, and colder and more fertile waters of the subantarctic Southern Ocean to the south and west. The water temperature ranges from 12°C to 18°C. No major rivers drain to its coast, and while seasonal upwellings occur off the east and west, Victoria's waters are characterised by low nutrient concentrations and relatively low productivity.

About 70% of Victoria's population and industry are concentrated around Port Phillip Bay in Melbourne and Geelong. Commercial activities include shipping, oil and natural gas fields, fishing and aquaculture. Ports, wharves, refineries, chemical storages, fertiliser plants, aluminium smelters, fish processors and other industries lie along the coast. Recreational fishing, boating, sightseeing and related tourism are of great significance to coastal economies. The major problems arise from the concentration of population and industry around Victoria's two major bays, extensive land use within the coastal catchments, and the consequent discharges of nutrients, toxicants, silt and debris which cause short-term and long-term environmental problems.

Major issues and threats

Nutrients

Point-source and diffuse inputs of nutrients are the major marine pollution factors in Victoria. Eutrophication has increased the frequency of toxic algae blooms, and contributed to the loss of seagrass beds through epiphyte growth. The major sources of the nutrients which enter Port Phillip Bay are the rivers and creeks which drain into it and the Werribee Sewage Treatment Complex where 65% of Melbourne's domestic sewage and 80% of its industrial wastes are treated with passage through an extensive lagoon and land filtration system.

Treated waste water containing nutrients and trace levels of toxicants is discharged into the western end of the Bay, and has resulted in a prolific growth of some algae and decline in seagrass within four kilometres of the outfalls. The commissioning of the South-Eastern Purification Plant at Carrum, south east of Melbourne, has reduced nitrogen input into the Bay and reduced bacterial levels at beaches. Nutrient enrichment from catchments is also implicated in severe algal blooms which can sometimes occur in the Gippsland Lakes.

Toxicants

Heavy metals (particularly mercury and cadmium) have at times been found in high levels in shellfish, fish and sediments in Port Phillip Bay. Such occurrences reflect the types of industries and the waste disposal practices which were common some 30-50 years ago with these metals remaining in the Bay sediments. High levels of mercury in many shark and dogfish species off Victoria lead to the banning of consumption of most species.

Licensing of direct discharges of effluents into the sea by the Victoria Environment Protection Authority (EPA) and diverting most industrial discharges to the sewerage system has significantly reduced inputs of toxicants into Port Phillip Bay and mean concentrations in the environment have been falling since the 1960s. This positive trend is reflected in limited residue studies carried out on fish. For

[1] Based on a paper by R. Winstanley, Acting Director, Victorian Fisheries Research Institute, Queenscliff, Victoria.

example monitoring of mercury levels in sequential samples of sand flathead has shown that while levels were at the National Health and Medical Research Council recommended limit (0.5 PPM) in the period 1975-80, they had declined to 0.24 PPM by 1990.

Levels of tributyl tin (TBT) from antifouling paint are high in localised waters and sediments in Port Phillip Bay and the use of these paints has been banned on vessels less than 25 metres in length since 1989.

Chlorinated pesticides such as DDT and dieldrin, and PCBs have been detected in the Bay, but in most cases at levels lower than the maximum permitted. Use of these compounds in Victoria is now severely restricted.

Storm water, silt and debris

Urban run-off into Victorian bays and inlets remains a significant problem. In Western Port, accelerated sedimentation due to erosion of catchments and stream channelling are believed to have contributed to the loss of around 70% of seagrass beds during the 1980s by increasing turbidity and reducing light penetration.

Over 300 drains enter Port Phillip Bay, carrying untreated storm water, oils, grease, wastes, pet excrement and litter from roads and gutters. Plastic litter from storm water, fishers and recreational boaters is a problem for marine life and reduces the aesthetic values of Victoria's waters and shores. Domestic litter is particularly evident after sudden and severe storm events and over the past two years a strong media and education campaign has been running in Melbourne to raise community awareness about the connection between the major drains and Port Phillip Bay.

Algal blooms and marine biotoxins

Algal blooms (Chapter 14) have increased in frequency and effect in Victoria because of increased nutrients and altered stream flows. In recent times they have been most serious in the Gippsland Lakes, where they have caused fish kills, affected water conditions and impacted upon tourism. Port Phillip Bay has been periodically affected, by the 'red tide' dinoflagellate *Gymnodinium mikimotoi* in the 1950s, the diatom *Rhizosolenia chunii* in 1987, and the toxic dinoflagellate *Alexandrium catenella* in January 1988, April 1991, and January 1992, and the diatom *Nitzschia pseudodelicatissima* in November 1991.

During 1993/94 large blooms of a non-toxic dinoflagellate *Noctibica scintillons* occurred in Port Phillip Bay. An algal bloom warning procedure is in place and harvesting of shellfish is suspended until regular monitoring indicates that a bloom is over.

Hydrocarbons

By far the most significant source of hydrocarbons into the marine environment is from land-based industrial discharge and urban run-off via stormwater drains, then rivers and creeks.

The eastern Bass Strait oilfield off Victoria contains 12 platforms, a number of well heads, and a system of pipes on the sea floor carrying oil and gas to shore facilities on Ninety Mile Beach. Minor spills have occurred but there is no evidence of adverse impacts. However, fishing operations are affected by exclusion zones around the fixtures to minimise risk of collision with platforms and damage to fishing gear as well as for security reasons.

Spillages associated with loading and unloading at the refineries in Port Phillip Bay, Corio Bay and Western Port have resulted in some localised and minor contamination by hydrocarbons.

Minor spills regularly occur in Victorian bays. In Port Phillip Bay spills of less than five litres occur daily, and over 100 litres occur less than once a month. Combat of spills in Victorian waters are covered by the Victorian supplement to the National Plan for Combating Oil Pollution at Sea (Chapter 39).

Habitat modification or loss

The coastal habitat has been modified by a number of factors. In some estuaries and inlets, the clearance of the catchment, altered freshwater flows and nutrient inputs have increased turbidity and altered the salinity and temperature regimes thus modifying the habitat. In situations where extensive tree clearing in the catchment has occurred these issues are being addressed by Landcare programs. The larger bays and inlets have also been impacted by catchment dynamics, urban development and the introduction of exotic marine species.

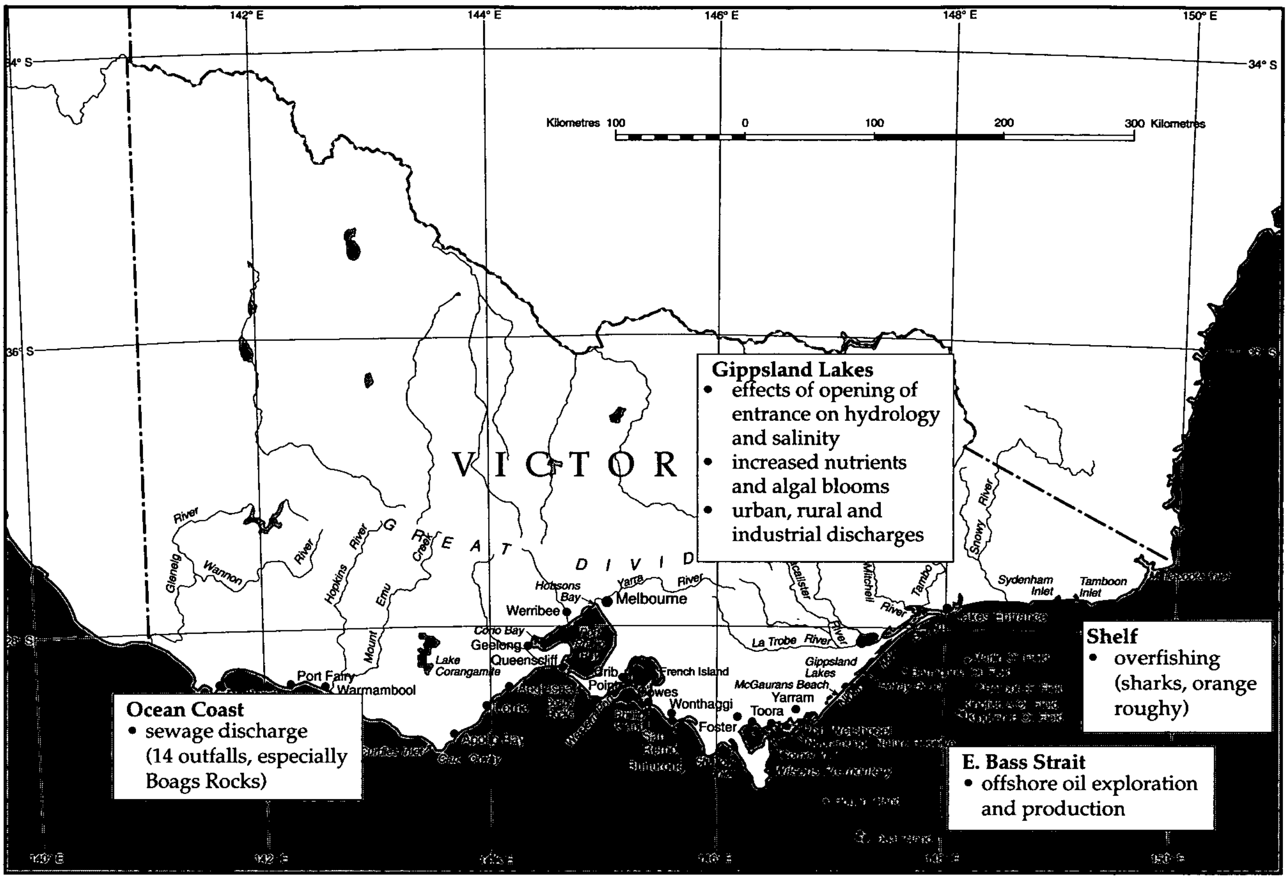
Ballast waters and exotic species

The increase in toxic algal blooms has increased fears of introductions of exotic pests through ships' ballast waters. In 1986-87 around two million tonnes of ballast waters were discharged in the ports of Melbourne and Geelong, and 0.5 million in Western Port. Sixteen exotic species have so far been identified in Victoria, the majority from the main ports like Hobsons Bay and Corio Bay which suggests that shipping is the main factor.

The toxic alga *Gymnodinium catenatum*, the kelp *Undaria pinnatifida* and the predatory starfish *Asteria amurensis* which were introduced into Tasmania have the potential to cause severe damage to Victoria's environment and fisheries if they become established along the mainland coast. The introduction of exotic pests into Victorian marine waters was formally listed in the *Flora and Fauna Guarantee* Act 1988, as a 'Potentially Threatening Process' in 1993.

Pathogens, public health

In 1956 typhoid fever was traced to shellfish from Hobsons Bay. Because of persisting high levels of



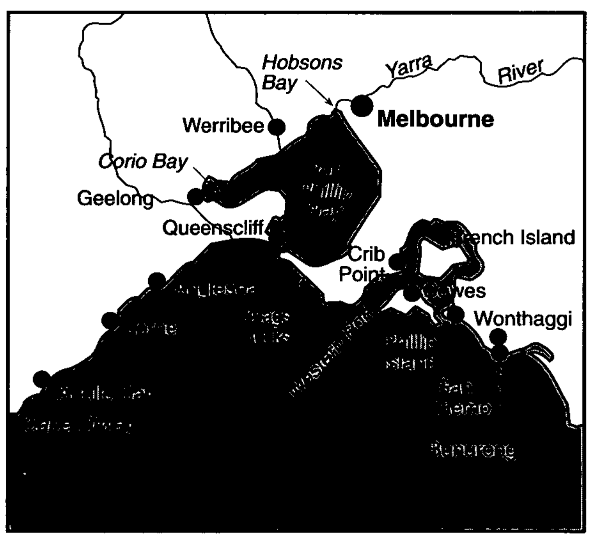


Figure 53.1: Issues in Victoria's marine environment:

Population: 3.7 million (70% in Melbourne & Geelong). Coastline: 2,000 km long. Highest coastal population density and industrial development in Australia. Major features: open coasts and lakes in east; large bays in centre; cliffed coast in west. Major issues stem from declining water quality in bays, inlets, estuaries and lakes. Problem areas include: Port Phillip Bay (especially Corio Bay, Hobsons Bay, Geelong Arm), and Western Port and Gippsland Lakes.(6-14,42-47,53)*

Major State and regional issues include:
- below standard water quality of some coastal waters, particularly from nutrients in sewage effluent and stream discharges
- coastal strip development, catchment disturbances, silt from rivers, loss of habitat areas
- degradation of areas of estuaries and inlets
- die-off of seagrass
- localised pollution of sediments near boat harbours (e.g. Corio Bay)
- algal blooms
- impacts from offshore oil exploration and extraction
- localised oil spills (especially Port Phillip Bay)
- protection and preservation of Aboriginal sites of significance
- Aboriginal fishing rights and interests
- competing coastal uses (urban, industrial and tourism development, fisheries, oil and conservation)
- alteration of hydrological cycles in some estuaries
- introduction of exotic species (algae, seastars)
- overfishing (sharks, rock lobsters)
- effects of trawling and dredging on sea floor
- dredging and spoil disposal

(*refer also to these chapters)

Some exotic marine pests In Victoria

Toxic phytoplankton, *Alexandrium catenella*, a cause of paralytic shellfish poisoning, was first seen in 1986, and has caused blooms in 1988, 1991 and 1992.

Rice grass, *Spartina townsendii*, deliberately introduced to stabilise shores, has significantly altered many areas.

The Pacific oyster, *Crassostrea gigas*, deliberately introduced, has displaced native species in south-eastern Australia.

The exotic colonial polychaete worm, *Sabella spallanzanii*, has become the dominant species in the Geelong Arm of Port Phillip Bay.

faecal bacteria a ban has been placed on harvesting shellfish from this bay, Corio Bay, and off Werribee. The Victorian EPA regularly monitors Port Phillip Bay waters to ensure bathers and others are not exposed to risk from pathogens, and aquacultured shellfish have been monitored for *E. coli* and toxic algae over the past five years.

The new Beachwatch program was introduced as an initiative of the Government in December 1992. The Beachwatch information service operates between December and March and provides a 24 hour, seven day a week 'hotline' information on water quality and beach conditions around Port Phillip Bay.

The program is divided into two operational components. The first establishes the suitability of water quality for swimming at bayside beaches. This involves the sampling and laboratory analysis of water samples from about 30 popular locations around the Bay for the presence of *E. coli*, an indicator bacteria used to detect faecal contamination.

Overfishing

Whales and seals were overexploited during the early settlement of Victoria, resulting in the elimination of the New Zealand fur seal, the Australian sea lion and the southern right whale from the region, and the Australian fur seal from some Bass Strait islands. Stocks of the native oyster *(Crassostrea angasi)*, first harvested in 1843, were exhausted by the 1920s.

The biomass of school sharks *(Galeorhinus australis)* has now been reduced to around 15-25% of the original biomass, and that of gummy sharks *(Mustelus antarcticus)* to around 40-50%. Limited entry, gear restrictions and licence consolidations have reduced fishing effort to two thirds of the peak level in 1987 and the biomass has apparently stabilised.

The catch rate of rock lobsters *(Jasus edwardsii)* has also declined, from 2.5 kilogram/pot lift in 1950 to 0.5 kilogram/pot lift, and an assessment program is in place to make recommendations about future management. A noticeable increase, during the past decade, in the gathering of shellfish and crustaceans from the intertidal and shallow subtidal areas of the central Victorian coast has had a significant impact on some species. In response to this situation, Shellfish Protection Regulations are now in place in Victoria.

Ecological impacts of fishing

Public concern about the ecological effects of scallop dredging increased in the 1980s, leading to its ban in 1984 in depths of less than 10 mtres in Port Phillip Bay to protect seagrass, shallow reefs and shellfish beds. Increasing public concerns following a resurgence of scallop dredging prompted the first detailed studies in 1991 of effects on benthic communities. Early findings suggest that changes to communities in the sediments do occur, but their extent and persistence are still under investigation.

Mussel dredging in Port Phillip Bay was banned in 1986 because of concerns of its environmental impacts, and because the emerging mussel aquaculture industry provided an alternative source of mussels.

The little penguins *(Eudyptula minor)* living at Phillip Island constitute a major Victorian tourist attraction. The penguins feed in Port Phillip Bay and elsewhere and pilchards are an important component of the diet. The impact of the escalation of pilchard catches in Port Phillip Bay, from 200 tonnes per annum in the late 1970s to 2058 tonnes in 1992/93, on penguin mortality and breeding success needs to be monitored.

Effects of dredging and mining

Dredging of shipping channels and port facilities, and the subsequent dumping of spoil, are important environmental issues, particularly in Port Phillip Bay and Western Port. In 1992, the EPA introduced a dredge protocol which sets out procedures for ensuring the effects of dredging on the environment are minimised. At Lakes Entrance 500,000 tonnes of sand is dredged each year to keep the port open.

Sand mining of the shoreline for beach renourishment occurs to a limited extent, with localised effects. At Queenscliff sand is taken for beach renourishment in Geelong and on the Bellarine Peninsula. Larger scale dredging occurs to renourish Port Phillip Bay's beaches; since 1975 a total of 20 kilometres of beaches have been enhanced.

Lack of integrated coastal zone management

Nearly 96% of Victoria's coastline is in public ownership. Despite this the institutional arrangements for management of the coast have been confusing and lacking in coordination for some time. Up to the present Victoria's coast has been managed by 160 separate committees and agencies, operating under 29 Acts of Parliament.

This maze of responsibilities has at times led to poor planning decisions characterised by inappropriate subdivisions on sensitive coastal land, intrusive foreshore developments and the virtual exclusion of the public from coastal management.

The Victorian government has initiated a major reform process to correct this situation. It is proposed to establish a Coastal and Bay Management Council which will be set up under new legislation. This new Council will be responsible for effective coordination of coastal planning and management. Three Regional Coastal Boards are to be established and each will provide a forum for strategic planning and policy implementation at the regional level.

Community involvement in the management of the coast is now being improved through Victoria's new Coast Action program. This program was launched in May, 1994 and aims to increase community awareness and understanding of coastal issues as well as participation by local community groups, interest groups and land holders in projects which are focused upon improving the protection of coastal areas.

Competing uses and conflicting interests in the coastal zone

Competing uses include commercial harvesting and extraction (e.g. fisheries, aquaculture, sand extraction) and recreational harvesting (e.g. angling, spearfishing, intertidal food gathering), non-exploitive uses (e.g. conservation, recreation, education and scientific); and waste disposal (e.g. urban, industrial and effluents).

Conflicts exist between commercial and recreational fishers (e.g. snapper in Port Phillip, abalone), and between conservationists and fishers (e.g. the siting of marine protected areas); between developers and both fishing and conservation groups. These conflicts were particularly evident in the development of the South Gippsland Marine Parks and in submissions to the Natural Resources and Environment Committee of the Victorian parliament when it reviewed Victoria's Bay and Inlet fisheries in 1991.

Regional issues

Port Phillip Bay

The catchment of Port Phillip Bay contains around 3.2 million people, and one third of Australia's manufacturing industry. The Bay is shallow (max. 24 metres), and has limited tidal exchange with Bass Strait; 4% of its volume (25 cubic kilometres) is exchanged per day. Each year it receives around one cubic kilometre of fresh water from its catchment, 0.2 cubic kilometre of sewage, and 40,000 tonnes of sediment from the Yarra River. Around 1,000 tonnes of nitrogen and 30 tonnes of lead enter via dustfall and rainfall each year.

Nutrients are highest in Hobsons Bay, off Werribee, and in Corio Bay. Phytoplankton biomass has increased, particularly in Hobsons Bay, and dissolved oxygen in bottom waters may become reduced during spring and summer. Cadmium, lead, mercury and PCBs were high in Corio Bay in the 1960s but are decreasing. At the present time Port Phillip Bay is the subject of a major environmental study which is being carried out by the CSIRO with significant input by Melbourne Water, the Victorian Department of Conservation and Natural Resources, the Victorian Environment Protection Agency and the Port of Melbourne Authority.

This study is due to be completed in 1996 and will result in an up to date and integrated picture of the chemical, biological and physical status of Port Phillip Bay together with a state of the art computer model which describes how the Bay, as a biophysical and environmental system, will respond to changes in climate, inputs etc. The model for the Bay will be predictive and thus will be able to be used in making future management decisions which could have impact upon Port Phillip Bay.

Western Port

Major human impacts began with the commencement of large-scale drainage of the surrounding swamplands in the 1890s. Around 70% of the 260 square kilometres of intertidal seagrass beds has disappeared over the past two decades. Increased sedimentation from catchment erosion and swamp drainage, port development, shipping and boating and associated pollution are suggested causes. The impacts on stocks of seagrass-dependent fish such as whiting have been significant.

Steel and petroleum industries around the Bay are currently licensed to release phosphorus compounds, zinc, surfactants, ammonia, phenol and other pollutants, but the biological and chemical thresholds set can on occasions be exceeded.

Gippsland Lakes

Since the construction of a permanent opening into the ocean in 1889, the Lakes have undergone a number of major ecological changes. The increased salinity lead to the die-back of seagrass beds, which have been reduced to around 12% of the original area, and changed the fringing shoreline vegetation.

Lake Wellington suffers from high turbidity and extreme variability in salinity, and the diversity and abundance of its biota has been reduced in comparison with the biota of the eastern lakes. Blooms of the blue-green alga *Nodularia spumigena* occurred in 1971, 1974 and 1987-88, and have been attributed to increased nutrients and high oxygen demands of organic material, and higher salinity. A contingency plan for algal blooms has been prepared.

Nutrient inputs have been significantly reduced through the commissioning of the Delray Beach ocean outfall in 1992 for APM's pulp and paper waste waters which formerly discharged into Lake Coleman, and the sewering of the towns of Lakes Entrance, Metung and Paynesville.

These new discharge arrangements have resulted in a noticeable improvement to Lake Coleman as an ecosystem with improvements in vegetation, aquatic life and the return of large numbers of water fowl and other water-dependent birdlife. It is expected that these positive improvements will continue.

Coastal waters - general

The major point-source discharges to coastal waters are from 17 sewage treatment plants, nine of which are treated to secondary level. The largest is the Boags Rock outfall which discharges 35% of Melbourne's secondary treated sewage. The second largest is the Black Rock outfall which discharges acutely toxic industrial and domestic waste from the Geelong region into Bass Strait at a point 1.2 kilometres offshore.

Victoria's open coast periodically experiences minor oil spills. In 1990 a spill from a passing vessel killed hundreds of little penguins on the Otway Peninsula.

Estuaries - general

In virtually every inlet and estuary from Mallacoota to the Glenelg River, siltation from upstream land use practices associated with farming and forestry, plus reduced flows resulting from water management, have resulted in significant shallowing and alteration of aquatic habitats. Catchment land degradation has caused siltation in the Glenelg River, Hopkins River, Curdies Inlet, Lake Connewarre and Barwon River, Werribee River, Anderson Inlet, Shallow Inlet, Corner Inlet and Nooramunga, Sydenham Inlet, Snowy River and Mallacoota Inlet. Elevated nutrient levels occur in the Hopkins, Curdies, Barwon, Little, Yarra, Bunyip and Thompson Rivers.

Future trends, management challenges and concerns

The major challenges lie with protecting and restoring marine environments in the face of further population growth, water usage and intensification of urbanisation and land use. By the year 2015 the population of Melbourne is expected to be 3.6 million (a rise of 0.58 million), and that of Victoria 5.7 million (a rise of 1.3 million).

Victoria's commitment to integrated planning and management of public waters and their catchments is fundamental and, movement towards integrated management of catchments will be accelerated as a consequence of the significant reforms which are being introduced through the *Catchment and Land Protection Act* 1994.

Monitoring of contaminants in water, sediments and biota has proven the effectiveness of EPA's discharge licensing and alternative waste treatment and disposal programs (and the value of environmental monitoring). However, the current 'Environment Effects Statements' (EES, Victoria's environmental impact assessment) being produced for works, developments and discharges generally provide only a snapshot of the environment and most do not provide a sound basis for ongoing decision making.

With Victoria's endorsement of the principles of Ecological Sustainable Development (ESD) in fisheries, fisheries management plans are now being prepared on an ESD framework which emphasises the importance of habitat protection and water quality.

Possible future concerns include:

- declining water quality in some estuaries and specific points along the coast
- loss of seagrasses
- alteration/impacts on benthic habitats
- reducing the impact of urban stormwater run-off in Port Phillip Bay, Western Port and the coastal lakes
- better management of upper catchment areas
- minimising the introduction of exotic species via ballast waters
- maintenance of fisheries.

Reduced domestic water consumption rates, improved sewage treatment, effective wastewater management and other measures will be necessary in order to maintain (and in some locations to improve) the quality of the marine environment while at the same time accommodating for expected increases in the size of urban and semi-urban populations.

Monitoring and marine environmental reporting

Victoria's integrated studies of its major embayments, monitoring of known problem areas, and regional planning strategies are models for the collection of information required for marine environmental management.

The nature of Victoria's fisheries resources is moderately well known and data and models exist which provide insights into the physical systems of Bass Strait and Port Phillip Bay. Marine habitats and communities have been intensively studied in Port Phillip Bay and Western Port and at some locations along the coastline. There has not however been a systematic survey of marine habitats and communities along the whole Victorian coastline.

The Land Conservation Council is currently investigating marine, coastal and estuarine resources, their status and use, and developing strategic planning advice on the protection of significant values and the sustainable use of these resources. The report 'Marine and Coastal Special Investigation', released in 1993 is the first descriptive report of a State's marine environment, and is an important baseline for management. The most recent report relating to Victoria was the report to the Commissioner for the Environment on assessment of indicators, data and environmental monitoring programs for coastal and marine environments which was released in 1991.

A major study was undertaken of Western Port in the 1970s although this has not been repeated to assess recent changes. A major environmental study of Port Phillip Bay is being undertaken at present and this has already been described.

Monitoring and environmental reporting

The Victoria EPA and Department of Conservation and Natural Resources monitor:

1. salinity, temperature, nutrient levels in Port Phillip Bay (6 sites) each fortnight;
2. water quality (nutrients, chlorophyll, suspended solids, trace metals, hydrocarbons, etc) in water and sediments and harvested resources
3.fish and shellfish in Port Phillip Bay (6 sites), Western Port (3 sites) and the Gippsland Lakes (5 sites); fish communities with annual trawls;
4. marine biotoxins in aquacultured shellfish ('Shellfish Quality Assurance Program'); and
5. stormwater, litter traps, solid waste agreements and bacteria levels (during summer).

Future marine environmental monitoring in Victoria

Conditions and trends in the marine environment have been reviewed in the 'State of the Environment Report: Victoria's Coastal and Marine Environment'. The initial study has focused on key indicators to detect long-term changes in the marine environment. It found that very little of the existing environmental data was adequate to do this as monitoring programs were designed for other purposes, and emphasised the necessity of statistically designed programs to detect long-term trends.

Key indicators were identified for:

- water quality in specific areas (e.g. dissolved oxygen for central Port Phillip Bay), and wider areas (eg nutrients and chlorophyll a in Bass Strait);
- marine biota (eg extent and health of seagrass beds);
- sediments (nutrients, carbon and toxicants);
- estuaries (salinity regimes, community structure).

Summary and conclusions

1. Victoria has the greatest population density and population per unit coastline in Australia. It has distinctive, large shallow embayments, and the largest coastal lakes in the southern hemisphere.

2. Overall, Victoria's marine environment is in reasonably good condition, supporting significant fisheries, water-based recreation and tourism.

3. Since European settlement the marine environment of the major bays (Port Phillip Bay and Western Port) and lakes (Gippsland Lakes) has changed significantly because of changes in land use, urbanisation (principally the expansion of Melbourne) and industrialisation, as well as the enclosed nature of these bays which restricts flushing.

4. Major problems include declining water quality (generally nutrients, locally heavy metals, organochlorines, litter); algal blooms, including toxic marine algae; loss of seagrasses; and the introduction of exotic species via ballast waters.

5. Victoria has adopted an integrated approach to planning and management of catchments, and coastal and marine environments. It has emphasised the importance of monitoring in management and the Victorian government is in the process of introducing major reform by setting up a Coastal and Bay Management Council which will be responsible for effective coordination of coastal planning and management.

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Acknowledgments:
This chapter was reviewed by the Victorian Department of Conservation and Natural Resources.

Chapter 54: Issues in Tasmania's marine environment[1]

The marine environment is particularly important to Tasmania, Australia's island State. Tasmania has a coastline of 3,200 kilometres, and a large number of small to medium sized islands. It has a temperate maritime environment and its coastline is characterised by several large estuaries, and productive seagrass and kelp communities. Although Tasmania has a relatively low level of development, the coastal ecology has been significantly altered since European settlement. Issues in the marine environment stem largely from water pollution, particularly from toxicants from mining, mineral processing and other industries, and from nutrients from sewage, agriculture and industrial sources. In the 1970s parts of the Derwent Estuary were so seriously contaminated by mercury that they were exceeded only by notorious Minimata in Japan. However, water quality is being improved in many places, and large areas in the southern and western coasts are still amongst the most pristine in the nation.

This chapter briefly describes Tasmania's marine environment, some of the major issues and threats facing it, and some of the most seriously affected areas. While it specifically focuses on the problems of pollution, it is important to acknowledge important efforts being made towards ecologically sustainable development in this State.

Characteristics of Tasmania's marine environment

Because of differences in prevailing winds, currents, catchment rainfalls, tides and temperatures there are significant differences in the marine environments of various regions of Tasmania.

Annual ocean temperatures range from 12-18°C in the south, to 13-19°C in the north. Prevailing winds are north-westerly and are strongest in winter and spring. Tidal ranges are around 0.8 metres in the south, to 3.3 metres in parts of Bass Strait. Salinities are lowered in west coastal waters by high rainfalls (average 3,700 mm, compared to 500 mm in the east).

Major coastal features include: headlands interspersed with sand beaches and lagoons in the north-east; cliffed coasts, sheltered bays and drowned river valleys in the south-east; cliffed coasts and sand beaches in the south; sand beaches, headlands, river estuaries and harbours in the west; and open coast and river estuaries with numerous islands in the north.

Major issues and threats

Many of the Tasmania's estuaries have urban and industrial developments, and associated water quality problems. The main areas affected on the north coast are the Burnie area and Tamar River; on the west coast are Macquarie Harbour and the Pieman River; and on the south-east is the Derwent Estuary.

Heavy metal pollution

In the west coast most mining is concentrated in the Pieman catchment (e.g. Renison (tin); Rosebery (tin, lead, zinc); Savage River (iron ore); Que River (tin, lead, zinc: now closed)) and the King River which drains into Macquarie Harbour (Mt Lyell (copper)). In addition, some west coast mines mine sulphide ore bodies and dumps and exposed faces continue to produce 'acid mine drainage' (AMD) which is a serious, persistent environmental problem.

The lowered pH of AMD leaches heavy metals from the ore and sediments and they are carried into catchments and the sea. Heavy metal levels in fish from the Pieman remain within National Health and Medical Research Council (NHMRC) guidelines.

Three major mineral processing plants in Tasmania are situated in estuarine and coastal areas. On the Derwent River, a zinc ore processor discharged most wastes into the river between 1916 and 1973. Much of this still lies in estuary sediments.

Off Tasman Island, jarosite (a mixture of iron, ammonia and various anions) have been dumped into the sea since 1973 under a Commonwealth permit. As this area is in the vicinity of important fishing grounds, a program for the extraction of metals and land disposal of wastes is now underway.

[1]Based on a paper by C. Rees for the Parks and Wildlife Service, Department of Environment and Land Management, Tasmania.

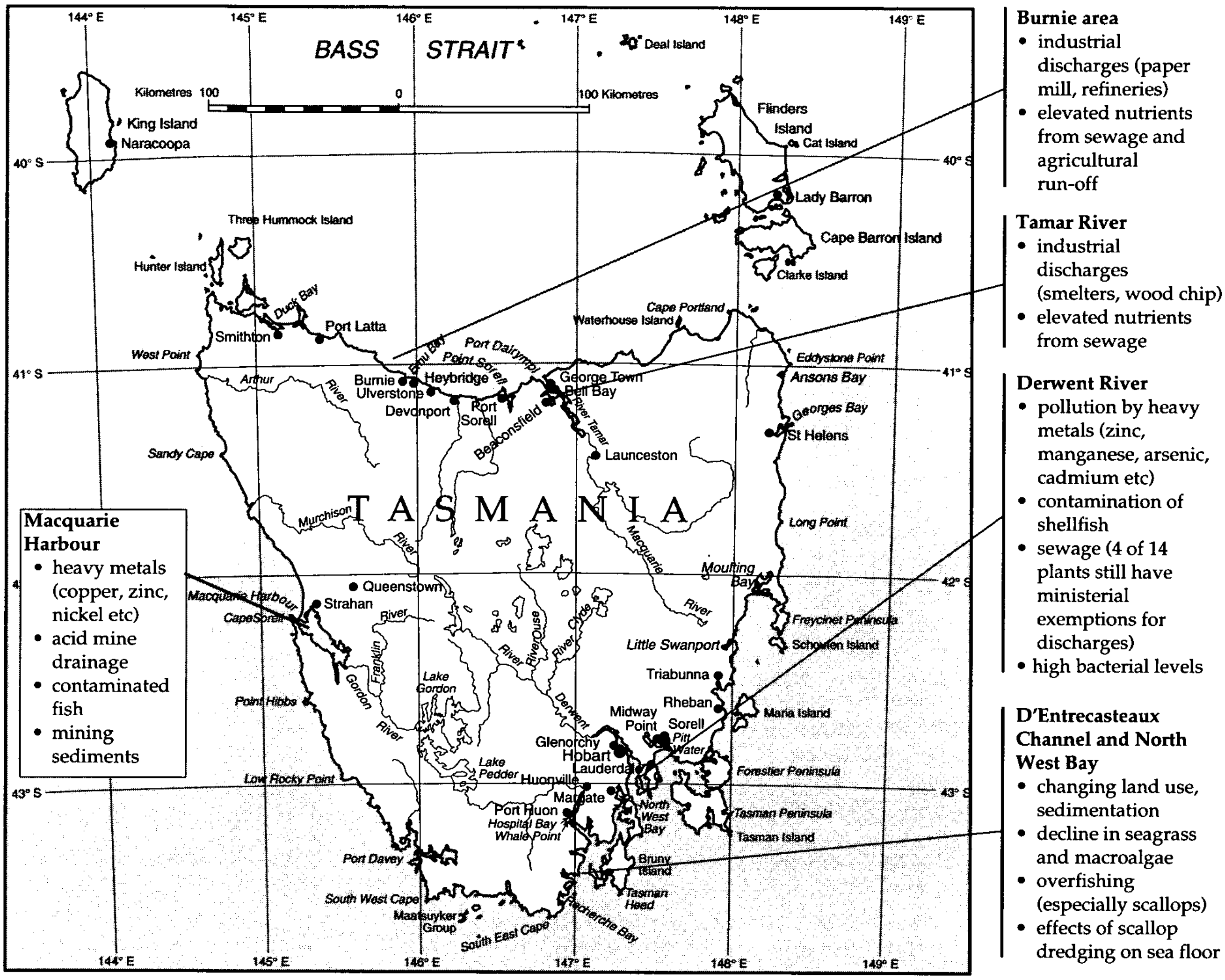

Figure 54.1: Issues in Tasmania's marine environment:

Population: 450,000 (180,000 in Hobart). Coastline: 3,200 km long. Australia's only island State. Major features: headlands interspersed with sand beaches and lagoons in north-east; cliffed coasts, sheltered bays and drowned river valleys in south-east; cliffed coasts and sand beaches in south; sand beaches, headlands, river estuaries and harbours in west; and open coast and river estuaries with numerous islands in the north. Major issues stem from poor water quality (heavy metals, nutrients), introductions of exotic species and fisheries (declining catches, catch-sharing). Problem areas include: Derwent River, Macquarie Harbour, Burnie area, D'Entrecasteaux Channel and North West Bay, Orielton Lagoon and Tamar River.(6-14,42-47, 54)*

Major State and regional issues include:

- poor water quality in major estuaries from heavy metals from mining and refineries, and elevated nutrients from sewage, urban and agricultural run-off
- coastal catchment development from agricultural, urban and industrial development
- introductions of toxic dinoflagellate *(Gymnodinium catenatum)*, Japanese kelp *(Undaria pinnatifida)*, the Northern Pacific seastar *(Asterias amurensis)*, Pacific oyster *(Crassostrea gigas)*
- decline in fisheries (scallops, lobsters)
- lack of recreational gillnetting controls
- effects of dredging and trawling on the sea floor
- alteration of hydrological cycle of major estuaries
- protection and preservation of Aboriginal sites of significance
- Aboriginal fishing rights and interests

(*refer also to these chapters)

Near Burnie, a refinery discharges iron ore wastes into Bass Strait where sedimentation has increased turbidity and affected benthic life. A Ministerial exemption on discharges is in force until 1994.

In Bell Bay in the Tamar River , metal processors treat waste waters but there may be potential for heavy metal contamination from diffuse emissions.

Pulp and paper processing may affect water quality in parts of Tasmania. A pulp mill which operated at Port Huon until 1987 increased nutrients and particulates in the lower Huon River. A newsprint mill at Boyer on the Derwent discharged woodfibre and chemicals (including mercury) until 1988, but has since improved effluent quality. A paper plant at Burnie currently discharges organochlorines and other wastes into Emu Bay under a ministerial exemption.

Nutrients

Urban and agricultural run-off carry nutrients and other pollutants into the Derwent Estuary, Tamar River, North West Bay, Duck Bay, Georges Bay, Pittwater and other estuaries and embayments.

Forty-five sewage treatment plants currently discharge directly into coastal, estuarine or bay waters. Of these, 13 have ministerial exemptions covering effluent levels. These are due to cease in 1994 but compliance with regulations may not be achieved in time.

Hydrocarbons

Tasmania has a relatively light oil tanker traffic and oil pollution has not been a significant problem. Although a low risk, a major marine oil spill is always a possibility. Under the Tasmanian Supplement to the National Plan to Combat Pollution of the Sea by Oil (NATPLAN: Chapter 39), coastal features at risk have been identified and contigency plans have been prepared. However, Tasmania does not have the facilities to cope with even a minor spill and would rely on other States.

Tasmania currently has no offshore oil exploration or production. A production well for oil and gas is likely to be installed in the Yolla field, 140 kilometres north of Burnie, and there is the possibility of drilling off the west coast near Strahan in the future.

Fisheries

Some of Tasmania's fisheries are either in decline (e.g. shark, scallop, rock lobster, barracouta) and require a reduction in fishing effort. Most others are being fished at levels that present knowledge cannot guarantee as ecologically sustainable. Reasons for declines include overexploitation, loss of breeding and nursery grounds, loss of habitat, pollution and natural fluctuations of stocks. Direct and indirect effects on the marine ecosystem are poorly understood. Despite considerable research, it has not been possible to predict sustainable yields of most of Tasmania's fisheries.

Major issues in fisheries include:

- serious declines in school and gummy sharks which have led to restrictions of fisheries and increased protection of nursery areas;
- the collapse of the scallop fishery because of overexploitation (closed since 1987 and so far showing little sign of recovery);
- declines in catch rates of rock lobsters, leading to reductions in the fishing season;
- possible ecological effects of a jack mackerel fishery (an important food for marine mammals, seabirds and other fish);
- management of the South-East Trawl Fishery (16 species are now subject to catch limits); and
- effects of demersal trawling on benthic communities (e.g. damage to 'corals' on pinnacles trawled for orange roughy).

Effects of scallop dredging

Anecdotal information suggests that commercial scallop dredging in D'Entrecasteaux Channel has severely degraded the environment by exposing anoxic muds, and has affected scallop recruitment.

Recreational gillnetting

The level of recreational fishing, which is very popular in Tasmania, is also of concern. Recreational gillnetting in particular is little regulated compared with other States. No licence is required, a maximum of three nets are allowed per person, and there are no controls on set times and attendance of nets. The Division of Sea Fisheries estimates that there are between 15,000 and 45,000 recreational nets of up to 50 metres in length.

Effects of aquaculture

Salmonid farming began in Tasmania in 1984 and has grown rapidly since then. This has created localised environmental problems, many of which have been resolved. Some 35 finfish aquaculture leases have been granted, although not all are currently active.

Environmental impacts and threats have included:

- shooting of wildlife predators such as seals and seabirds (now rare following improvements in netting and cages);
- locally elevated nutrients because of wastes (reduced by rotation of cages);
- visual pollution, noise and loss of amenity; and
- feral fish (research suggests escapees are more likely to starve).

Coastal catchment development

In the post-war decades there has been considerable alteration of the coastal zone from agricultural, urban and industrial developments, wetland drainage, forest clearing, road construction and subdivision of water front lands and dunes for holiday properties.

Hydrological cycles have been affected by the damming of most of the major rivers for hydro-electricity, irrigation and domestic or industrial water supply. Natural seasonal flows have been altered, total discharges reduced and saline penetration has occurred. The ecological impacts are little known but may include loss of habitat, and disruption of natural breeding and migratory patterns.

Shores have been altered in some areas through port constructions, aquaculture developments and recreational facilities. While individual impacts may be small, cumulative effects are significant.

Declines in seagrasses

Five species of seagrass occur in Tasmanian waters. *Posidonia australis* dominates the Furneaux Group and other islands in the north and *Heterozostera tasmanica* dominates sheltered bays and estuaries in the east and south-east.

There have been significant losses of seagrass beds in the Hobart and D'Entrecasteaux region, Triabunna and St Helens on the east coast, and the Tamar, Port Sorell, and Duck Bay near Smithton on the north-west. In many cases these water bodies receive wastes from urban, agricultural and industrial sources increasing nutrient levels and sediments. There is a strong relationship between seagrass decline and the abundance of algal epiphytes on the seagrass beds.

Declines in string kelp

The string kelp *Macrocystis pyrifera*, which may reach 30 metres in length, forms dense stands along some rocky coasts. The kelp is highly productive and provides important habitat for fish and invertebrates. The kelp was commercially harvested for a period in the 1960s and 1970s with up to 9,000 tonnes harvested each year. The biomass declined and the enterprise became uneconomic and closed in 1972. However, the kelp has continued a dramatic decline since then.

The cause of the decline is not known. Factors suggested include a rise in mean sea temperatures; increased run-off and siltation from forestry activities which may affect recruitment; silting from past scallop dredging; frond damage from boat traffic; and overfishing of the rock lobster, a predator of the sea urchins which graze on kelps.

Introduced species

The introductions of harmful exotic marine species via ships' ballast waters is of great concern in Australia (Chapter 48). Tasmania has been particularly affected by the introduction of marine pests.

It is thought that bulk woodchip carriers introduced the toxic dinoflagellate *Gymnodinium catenatum* into Tasmanian waters. Toxic blooms of this species are now regular, threatening shellfish farms in the Huon (Chapter 14).

The Japanese kelp *Undaria pinnatifida* was first seen at Rheban on the east coast in 1988 but it is thought that it may have been introduced via ships' ballast waters around 1982. This kelp grows to about two metres in height and outcompetes some native species important to abalone and urchin fisheries. So far it has affected a 25 kilometre length of coast at Triabunna on the southern tip of Maria Island. Its temperature tolerances indicate it has the potential of growing along the entire southern coast of the mainland, from Wollongong (NSW) to Cape Leeuwin (WA). *Undaria* cannot be eradicated but may be controlled through harvesting as it is an important maricultured crop plant in Japan.

The Northern Pacific seastar *Asterias amurensis* is a serious ballast water introduction into Tasmania. A predator of scallops, mussels, oysters, crabs, barnacles and some gastropods, the seastar is a pest on shellfish farms and fishing grounds in Japan. It has no known predators and has the potential to spread over considerable areas of southern Australia (Chapter 48). The large predatory starfish *Astrostole scabra*, which was first recorded in the 1960s, may have been introduced from New Zealand where it is abundant. It is now common on exposed reefs on the eastern, southern and western coasts.

The Pacific oyster *Crassostrea gigas*, was first introduced into Tasmania in the 1950s and is now widely cultivated throughout the State. It has become established in the wild, and encrusts shores in the south-east and in the Tamar region. Its impacts on intertidal communities are unknown.

Gunn's screw shell *Maoricolpus gunnii* is believed to have been introduced from New Zealand with oysters in the 1920s. It has significantly altered the benthos in many areas and has now reached southern New South Wales. The New Zealand crabs *Cancer novaezelandiae* and *Petrolistes elongatus*, the chiton *Amaurochiton glaucus* and the seastar *Patiriella regularis* were probably introduced around the same time. Effects on local biota are not known.

Status of marine wildlife

Tasmania's coasts are increasingly polluted by debris from shipping and fishing boats which may be ingested by or entangle wildlife. Around 1.5% of Australian fur seals are entangled in human debris at any period of time. A survey of 88 sites around Tasmania in 1990-91 found 65% of all litter was plastic, of which 40% was related to fishing or aquaculture. Special educational programs have been directed at commercial and recreational fishers and the boating community. The development and marketing of a strapless bait box has helped to reduce this type of litter (Chapter 46).

Ten species of seals inhabit or visit Tasmania's coasts. These are protected by law, but may be threatened by illegal shooting, entanglements and ingestion of marine litter, reductions of prey food by fishing, conflicts with aquaculture, and disturbances of haulout sites by tourists.

Some seabird populations have declined because of predation by feral animals, disturbance of breeding sites, ingestion of marine debris, pollution and from interactions with fisheries. Gannets were formerly a favourite bait for crayfishermen and the population breeding at Cat Island in Bass Strait fell from around 10,000 pairs to only 10. There has been a high mortality of albatrosses and gannets from offshore longlines. Little penguins have also declined because of their use as crayfish bait, loss of habitat and competition with fisheries for food.

Climate change

During the past 30 years, the mean seawater temperature in the Tasmanian region has increased by around 1.5°C. Because of the retraction of the subtropical convergence to higher latitudes, nutrient levels and plant productivity has declined. This may have caused declines in jack mackerel, loss of *Macrocystis* beds (above) and perhaps the extinction of other algal species which have not been recorded for several decades. An increase in water temperatures through global warming would presumably have a greater effect on Tasmania than other States because of a further decline in productivity and the lack of refuges further south into which cool water species could move.

Regional issues

The marine environment has been chronically disturbed in areas around Tasmania where human populations and industries have been concentrated.

D'Entrecasteaux Channel and North West Bay

The population in this area increased by 33% between 1971 and 1991 and increased pressures on the marine environment. Major issues include overfishing (particularly the collapse of scallops); increased sedimentation resulting from changes in land use; urban and industrial effluents which have caused a decline in seagrass and macroalgae; and degradation of wetlands through reclamation or illegal waste disposal.

Derwent River

The Derwent, around which the capital Hobart (population 172,000) is situated, was described in 1973 as one of the most polluted rivers in Australia. Studies indicate that shellfish throughout the estuary are still unfit for human consumption. Finfish are within standards but must be treated with caution because of heavy metal contamination. Contaminants include treated and untreated sewage, nutrients, food wastes, chlorinated compounds and heavy metals (zinc, manganese, arsenic, cadmium, mercury, copper and lead). Bacterial levels are often high, and most popular swimming beaches have been closed from time to time. While the Derwent has been monitored for many years, surveys have been narrowly based and the ecology of the Derwent remains poorly understood.

Water quality has markedly improved in recent years. Major industries on the river have reduced discharges in compliance with the lifting of ministerial exemptions in 1994. Four of the 14 sewage treatment plants still have exemptions but are required to have full secondary treatment by 1994. While discharges have been reduced to within 'acceptable' limits, some community groups are calling for zero discharges of pollutants into the Derwent.

Macquarie Harbour

The Mount Lyell mine in Queenstown has been releasing tailings into the Queen River since 1922. The mine was granted a pollution exemption with no specified limits in 1974. Each year 1.5 million tonnes of tailings containing manganese, cadmium, nickel, copper and zinc, and undocumented amounts of acid mine drainage enter the Queen River. Much of this flows into the King River and then into Macquarie Harbour where it has formed a 250 hectare delta of sediments.

Heavy metals have been irregularly monitored since 1974. Oysters contain five times the NHMRC standard of copper, and brown trout and dogfish contain two or three times the standard for mercury. A Department of Health warning in 1993 advised the public not to eat some species of fish from the harbour more than once a fortnight. A CSIRO report in 1991 found that concentrations of dissolved heavy metals in the harbour were 100 times that in coastal sea water. A study is currently under way on sediment and metal dispersion in the harbour, on status of sediments, possible impacts future changes in the King River catchment, and broader environmental management issues.

North-west coast

The marine environment between Table Cape and Point Sorell in the Burnie area is affected by effluent from a paper mill, acid-iron waste from refineries, partially treated sewage, urban and agricultural run-off, and spills from ports and shipping. Some impacts on marine communities have been documented but investigations on the synergistic effects of effluents in the Burnie area and Bass Strait are required.

Orielton Lagoon

Orielton Lagoon, an internationally recognised wetland for migratory wading birds, was created in 1953 through the construction of a causeway at Pittwater. Bcause tidal exchange is limited, the lagoon became eutrophic, causing the disappearance of seagrass. The lake is now subject to periodic blooms of macroalgae, and in 1993 there was a bloom of toxic blue-green algae. A study has recommended the land disposal of effluents, increased tidal exchange and a range of catchment management measures.

Tamar River

The Tamar catchment is the site of major urban, industrial and agricultural developments. Effluents enter from the city of Launceston, 13 sewage treatment plants, and industries including aluminium and ferrous smelters, wood chip mills and a power station. Information on the environmental status is limited; an environmental baseline study is being coordinated by the Department of the Environment and Land Management.

Monitoring and marine environmental reporting

The Department of the Environment and Land Management, Parks and Wildlife Service has databases on recreational facilities and flora and fauna and is establishing a geographic information system. Specific marine programs include shearwater and seal monitoring, marine debris and pollution, marine reserves, introduced marine invertebrates, and whale sightings and strandings.

The Department's Environmental Management Division, which is responsible for licencing polluting industries, has a number of aquatic and marine monitoring programs. These include the West Coast Monitoring Program (for heavy metals), Derwent River Monitoring Program (repeating 1975 surveys), Derwent River Nutrient Study, and the Macquarie Harbour Study.

The Department of Primary Industry, Division of Sea Fisheries monitors information for fisheries management, including collection and analysis of catch statistics, baseline research and monitoring in Marine Reserves, and mariculture.

CSIRO does not conduct monitoring programs as such, but does undertake research on specific environmental issues such as the Wesley Vale pulp mill project, the Derwent and Storm Bay pollution studies, offshore jarosite dumping, the east coast trawl fishery, and Macquarie Harbour heavy metal study.

Summary and conclusions

1. The major issues in Tasmania's marine environment stem from water quality. The main estuaries has been affected by heavy metals, elevated nutrients and other pollutants as a result of mining, mineral processing and other industries, and agricultural and urban run-off.

2. Introductions of exotic species in ships' ballast waters are of particular concern. Introduced toxic dinoflagellate *(Gymnodinium catenatum)*, Japanese kelp *(Undaria pinnatifida)*, and Northern Pacific seastar *(Asterias amurensis)* are potentially very serious pests and potentially threaten the southern mainland.

3. Catches in a number of Tasmania's fisheries have not been sustained. Concerns include decline in scallops, sharks and rock lobsters; ecological effects of jack mackerel fisheries; and the effects of recreational gillnetting.

4. The most affected areas include: D'Entrecasteaux Channel and North West Bay (changing land use; sedimentation; decline in seagrass and macroalgae; overfishing, especially scallops); Derwent River (heavy metals; contamination of shellfish; sewage and high bacterial levels); Macquarie Harbour (heavy metals; acid mine drainage; contaminated fish); Burnie area (industrial discharges; elevated nutrients from sewage and agricultural run-off); and Tamar River (industrial discharges; elevated nutrients from sewage).

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Chapter 55: Issues in South Australia's marine environment[1]

South Australia possesses a large range of coastal habitats and marine ecosystems, from the rough rocky coasts of the south-east and west, to the calm-water seagrass and mangrove habitats of the gulf regions. Threats to these environments and their fauna and flora result primarily from land-based pollution, habitat loss through urbanisation and coastal development, the effects of fishing, and conflicts between user groups.

Most of South Australia's population of 1.4 million is concentrated in the major coastal towns and cities on the Fleurieu Peninsula (Adelaide) and northern Spencer Gulf (Whyalla, Port Pirie and Port Augusta). Economically important activities in the coastal zone include commercial and recreational fishing, aquaculture, tourism, shipping, and mineral and petroleum exploration. In South Australia human activities, and environmental impacts and conflict and competition issues, are very concentrated.

Characteristics of South Australia's marine environment

South Australia has over 3,700 kilometres of coastline (including Kangaroo Island, but excluding the offshore islands), and some of the most biologically diverse marine communities of Australia's temperate coast. This diversity is largely the result of the array of different coastal landforms and habitats, and the variability in sea temperatures, particularly in the gulfs region.

Oceanography

South Australia's marine environment extends from the cool-temperate waters of the south-east (where annual temperatures range from 12-14°C), to sheltered Spencer Gulf and Gulf St Vincent (range 14-25°C), to the transitional warm temperate Bight Region in the west (range 14-25°C). A summer upwelling in the south-east brings nutrient-rich cool waters to the surface, increasing productivity and providing the basis for the State's major fisheries.

Marine habitats

South Australia's coastline is characterised by an array of different habitats, from rough-water rocky areas of the south-east and west, to the extensive calm-water seagrass and mangrove habitats of the gulf regions, one of the largest, sheltered coastal ecosystems in Australia.

Seagrasses

The seagrasses of South and Western Australia comprise one of the largest temperate seagrass ecosystems in the world. Gulf St Vincent and Spencer Gulf have the largest areas in South Australia and these provide the basis for many of the State's fisheries.

Mangroves, saltmarsh

The sole mangrove, the grey mangrove *Avicennia marina* var. *resinifera* covers about 230 square kilometres. The most significant stands are near Ceduna on the West Coast, Franklin Harbour near Cowell, and around the northern ends of Gulf St Vincent and Spencer Gulf near Port Pirie and between Port Adelaide and Port Gawler. Large areas of saltmarsh, of high species diversity, are present.

Seaweeds

The oceanic waters of South Australia have one of the richest seaweed floras in the world; around 1,200 species have been recorded, the great majority being endemic to southern Australia (e.g. over 75% of the red seaweeds are endemic).

Invertebrates

It is estimated that there are around 6,440 species of marine invertebrates of which only a third have been described. Diversity is also very high. Over 500 species of nudibranchs (sea slugs) and 200 species of ascidians (sea squirts) have been recorded, the latter being the richest assemblage in the world.

Vertebrates

Thirty-one species of marine mammals, 75 of seabirds, six of penguins, three species of sea turtles and 370 species of fish have been recorded from State waters. The endangered southern right whale *(Eubalaena australis)* calves along the coast, and major populations of the rare Australian sea lion *(Neophoca cinerea)* breed on offshore islands. It also has significant populations of the unique, rare leafy sea dragon *(Phycodurus eques)*, and the notorious great white shark *(Carcharodon carcharius)*.

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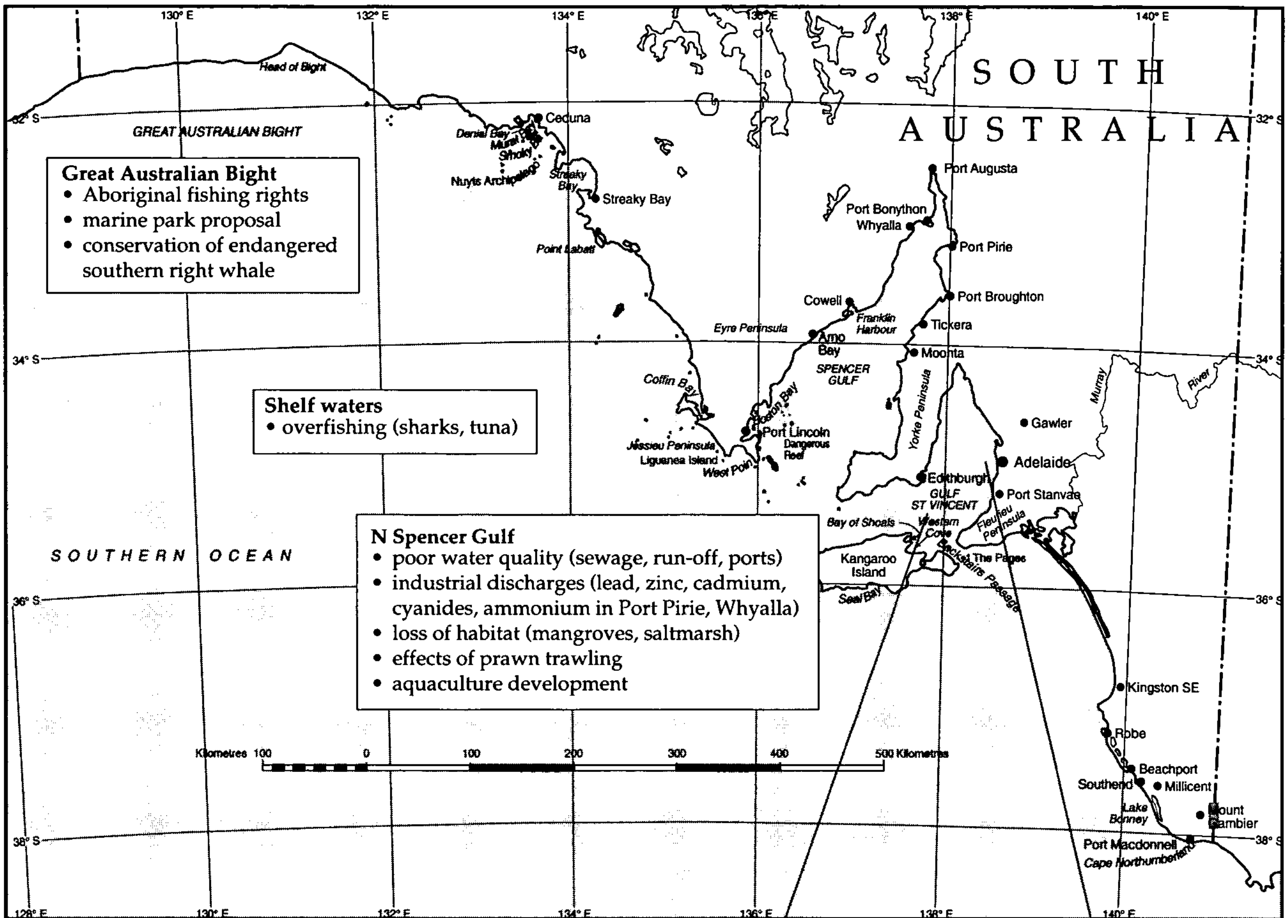
[1]Based on a paper by Dr K. Edyvane, South Australian Research and Development Institute (Aquatic Sciences), Adelaide, South Australia.



Gulf St Vincent
- overfishing of prawns, snapper
- effects of prawn trawling

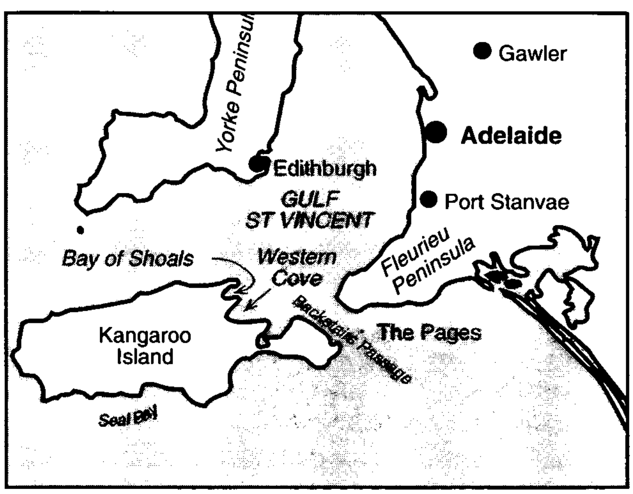
Adelaide area
- declining water quality (especially elevated nutrients)
- declining seagrass (22% decline)
- algal blooms (inc. red tides)
- industrial discharges, oil spills
- loss of mangroves and saltmarsh

Figure 55.1: Issues in South Australia's marine environment:

Population: 1.4 million (most in Adelaide and Fleurieu Peninsula). Coastline: 3,700 km and dry (fewest estuaries in Australia). Major features: mouth of the River Murray via Lake Alexandrina; large gulfs (Gulf St Vincent and Spencer Gulf) with cliffed coasts east and west. Major issues stem from declining water quality in gulfs and estuaries. Problem areas include: Port Adelaide, Whyalla, Port Augusta, Port Pirie and Port Lincoln. (6-14,42-47,55)*

Major State and regional issues include:
- declining water quality: elevated nutrients from sewage and run-off
- degradation of estuaries (5 of 8 threatened)
- loss of habitat (especially mangroves, saltmarsh)
- die-back of seagrass in gulfs
- competing uses of coastal strip
- protection and preservation of Aboriginal sites of significance
- Aboriginal fishing rights and interests
- declining fish stocks (especially southern bluefin tuna, school sharks)
- industrial discharges, toxicants
- threatened species (Australian and New Zealand fur seals, Australian sea lions, southern right whales)
- development of aquaculture

(*refer also to these chapters)



(Source: Environment Protection Council of South Australia)

Pollutant	Human impact	Ecological impact	Source	Areas most affected	Probable spread or increase	Scope to prevent or ameliorate	Action priority
nutrients and other organic wastes	boost algal growth; create 'nuisance' Special cases is red tides - combination of nutrient build-up and pest species	algal growth reduces light penetration, killing seagrasses. Change in nutrient ratios can alter make up of plant and animal communities; organic wastes deplete oxygen	point - sewers diffuse - drains, stormwater	metropolitan Adelaide Port Lincoln	moderate - through fish farming	moderate	high
	red tides restrict recreation and consumption of seafoods	red tides deplete oxygen during and after ' bloom' and introduce toxins		red tides also off metropolitan Adelaide and Port Lincoln	red tides likely to increase with development of fish farming	moderate - but expensive	
faecal wastes	restricts recreation and consumption of seafoods	may promote filter feeders	point - sewage diffuse - other human and animal sources	Adelaide - west Lakes/Port R. River Torrens Patawalonga Onkaparinga R. Port Lincoln	low for human, high for other animals (pets)	moderate - but expensive	high
particulates and turbidity	aesthetic, swimming accidents	smothers substrate and changes species mix - (e.g. Aldinga)	stormwater; industrial discharge; dredging	all larger towns and ports	high - with further residential demands	good, but lies with local Government	high
exotic pests and diseases	foul hulls free living algae may 'bloom'	compete directly, or reduce advantages of local species	point - ships and boats fish farming	statewide and continuous	high	high to exclude, nil to eradicate	high
heavy metals	contaminates seafoods reduce numbers of fish that may be taken or consumed by humans	reduce diversity of marine organisms	point (municipal and industrial process) diffuse (agriculture and cars)	Upper Spencer Gulf Adelaide - Port River/West Lakes, Patawalonga	low falling	Pirie - good Whyalla - fair diffuse - poor	medium
litter	restricts recreation - accidents (needles stick)	kills birds, mammals	diffuse (drains, stormwater, boating)	statewide	moderate	high	medium
other chemicals **(pesticides, consumer and household products)**	contaminate seafoods	kill marine organisms	household and agriculture	statewide	low - many problem chemicals no longer registered (hence unavailable)	moderate	medium
process waste	perceived effects often aesthetic; contaminate seafoods; recreational exposure	may affect behaviour of organisms	industry	Adelaide regional centres Lake Bonney (SE)	low	high	
chemical spill/overspray (from past control)	kill fish that may be taken/consumed by humans	kill marine organisms	point	statewide sporadic	low	high	low
hydrocarbons **(oil)**	foul structures and beaches may taint seafoods	probable metabolic effects on organisms; kill birds	point - tankers and pipelines, industrial (solvents etc) diffuse - road runoff	statewide but sporadic regular at Adelaide and Port Augusta	low	high for point sources, moderate for diffuse	low
bitterns (salt fields)	aesthetic	probably affects organisms	point (salt fields)	Adelaide Price (at intervals)	low	moderate	low
thermal	restricts recreation (but boosts fish growth)	excludes some organisms - facilitates exotic species	point - power stations	metropolitan and Upper Spencer Gulf	low	low	low

Table 55.1: Estuarine and marine pollutants in South Australia: Action priorities

Major issues and threats

Marine pollution, strongly linked to land-based activities, is largely concentrated in the Adelaide metropolitan area and the northern Spencer Gulf region. A study of land-based marine pollution identified 49 nutrient, 17 chemical and 15 thermal point-sources of pollution, the major ones being sewage effluent and stormwater discharges. Issues, and areas affected, are summarised in Table 55.1.

Elevated nutrients

Nutrient enrichment or coastal eutrophication is the major marine pollution issue in South Australia. The main effects of this are seagrass loss or degradation because of smothering by epiphytic algae, increased frequency of algal blooms (including 'red tides'), and the loss of mangroves.

The main point-sources of nutrients are sewage outlets at Bolivar, Port Adelaide, Glenelg and Christies Beach in metropolitan Adelaide, and at Whyalla, Port Augusta, Port Pirie, Finger Point (Mt Gambier) and Port Lincoln. Nutrients are also discharged by the steelworks at Whyalla, food processing plants at Port Lincoln, and fish processing plants at Port MacDonnell, Cape Northumberland, Carpenter Rocks, Southend, Beachport and Robe in the south-east, Edithburgh and Moonta on the Yorke Peninsula, and at Port Lincoln and Streaky Bay on Eyre Peninsula.

Seagrass loss

Seagrass degradation was first linked to increased nutrients from sewage effluents at Glenelg outfall in 1970. Since 1935 some 4,000 hectares or 22% of the total seagrass area off the metropolitan coast of Adelaide has been lost because of nutrients and suspended material from sewage effluent and sludge and storm water. Of particular concern is the cycle of instability following loss of seagrass. Sediments previously bound by the roots are released, increasing light attenuation and causing the loss of larger areas of seagrass.

Between Glenelg and Semaphore, inshore losses of seagrass were gradual until about 1961, when they increased rapidly as beds fragmented. While the inshore seagrass boundary has now stabilised, regression is still occurring within the beds. Within existing beds off the metropolitan coast, seagrass cover has declined from 80% in 1949 to 28% in 1993. If the poor water quality and the present rate of loss continues, it is estimated that there will be no seagrass left off metropolitan Adelaide by the year 2014.

Outside the metropolitan Adelaide region, large-scale loss has continued to occur in the poorly-flushed northern Spencer Gulf region, from Tickera to Port Pirie. The latest episode of loss followed an extensive algal bloom in February 1993, and affected an area extending along 80 kilometres of coast. The causes have not been determined but elevated nutrients and sediments from agricultural run-off and/or a pathogen have been suggested.

Algal blooms and 'red tides'

High levels of nutrients also result in excessive growth of seaweeds and planktonic algae. In the upper reaches of the Port River, high levels of nutrients (largely from effluent from the Port Adelaide sewage treatment works) cause blooms of several species of opportunistic phytoplankton, including the toxic dinoflagellates which cause 'red tides'. As shellfish which feed on these bioaccumulate toxins which may cause the potentially fatal paralytic shellfish poisoning in human consumers, the taking of shellfish from the Port River-Barker Inlet system is regularly prohibited during spring algal blooms.

Elevated nutrient levels also result in the nuisance growth of the seaweeds, *Ulva* and *Gracilaria*. Blooms occur in the northern Adelaide metropolitan area, and in the Barker Inlet estuary where the major source of nutrient enrichment is from the Bolivar sewage treatment works. Under the prevailing winds, drift *Ulva* can accumulate in mangrove and beach areas such as St Kilda where it forms large, decomposing masses.

Mangrove losses

Elevated nutrients also indirectly affect mangroves adjacent to sewage outfalls. Stranded *Ulva* masses prevent or retard the establishment and growth of mangrove seedlings, and choke established trees by smothering the aerial roots or pneumatophores. The major area of 'nutrient-induced' mangrove die-back is between St Kilda and Port Gawler, adjacent to the Bolivar sewage outfall. Die-back, which began six years after the outfall was commissioned, has affected approximately 250 hectares of mangroves adjacent to the outfall since 1956. The full extent of mangrove loss in the Adelaide metropolitan region has not been estimated.

By contrast, in areas not influenced by the effluent mangroves have been advancing. For example, in the Light River there was a seaward advance of mangroves averaging 18 metres/year between 1935-79.

Toxicants

The main source of chemical discharges are the industrial plants at Whyalla and Port Pirie, the Playford power station at Port Augusta (in northern Spencer Gulf), the various sewage outlets, chemical works at Port Adelaide, and a pulp mill at Lake Bonney. These are summarised in Table 55.1 and are described in some detail under regional issues (below).

Oil pollution

Between January 1988 and June 1992 there were 14 oil spills, totalling 8,610 litres, in South Australian waters. Two spills occurred in Port Adelaide and 10 occurred in Port Stanvac. In 1982, a spill at Port Stanvac released 234,325 litres of oil, and in August 1992 an accident in Port Bonython released around 300,000 litres (296 tonnes) of heavy bunker oil - Australia's largest coastal oil spill to date. Considerable environmental damage occurred in sensitive mangrove and seagrass communities of upper Spencer Gulf. All clean-up operations in South Australia are coordinated under the National Oil Spill Contingency Plan.

The effects of chronic oil spills on the marine environment have generally received little attention. Long-term, chronic effects of the frequent, minor spills at the oil-handling facilities at Port Stanvac and in the Port River are unknown. The impacts of spillages and ballast water discharges at Port Bonython have been monitored as a condition of licencing. No effects have been detected there to date.

Thermal pollution

The most significant thermal discharges are from power stations at Torrens Island (Port Adelaide) and Port Augusta, although most major industries discharge some cooling water. Monitoring at Torrens Island indicates changes in composition of benthic intertidal communities and seagrass adjacent to the cooling water outfall. Heavy metal contamination near the Port Augusta power station is thought to be from fly ash in the station's effluent. Following mangrove die-back, fly ash ponds at the Playford station were relocated. The cause of a continuing die-back of mangroves adjacent to Hospital Creek is unknown.

Exotic species and ballast water discharges

The exotic toxic dinoflagellate *Alexandrium minutum* (Chapter 14) is thought to have been introduced into South Australia via ships' ballast waters. Blooms of this species are now responsible for regular toxic 'red tides' in the Port River. A recent survey has shown *A. minutum* cysts in the sediments of other major ports and bays in the State, including Port Lincoln, Ceduna (Thevenard), Kangaroo Island (American River, Penneshaw, Ballast Head, Kingscote), Coffin Bay, Franklin Harbour and Streaky Bay. The introduction is of major concern to the oyster industry in many of these areas.

Tributyl tin antifoulants

Antifouling paints containing organotin compounds such as tributyl tin (TBT) have been used extensively on vessels in ports and marinas. Because of adverse environmental effects on marine life at very low levels (i.e. in parts per trillion), controls on usage have been effected in most States, but have not yet been introduced into South Australia. In this State a recent survey of the neogastropod imposex index, the bio-indicator of TBT, found 100% incidence in specimens collected from Barker Inlet, Port Lincoln and Coffin Bay. These areas all have major boat moorings.

Diffuse source pollution

Urban run-off is of concern in metropolitan Adelaide. Storm water is a major source of faecal bacteria in Lake Patawalonga at Glenelg, the Onkaparinga Estuary and West Lake. Control is difficult. For example, Lake Patawalonga receives storm water from the Sturt River which has a catchment of creeks and drains which are under control of 11 different local government councils. Flushing in the lake is limited and bacteriological standards for recreation are exceeded most of the time. The Patawalonga also has a high sediment and nutrient loading, and a large quantity of floating debris and rubbish accumulates. Seagrasses have declined in the vicinity of the ocean outlet, and local beaches are affected by debris.

Fisheries

Fish, crustaceans and molluscs have long been important sources of food and other products for humans in South Australia. Aboriginal communities prior to Europeans had well developed fisheries using stone fish traps and weirs in some areas. Early whalers and sealers established bases on Kangaroo Island.

Today, commercial and recreational fishing are now the main uses of the marine resources, and ensuring their sustainable and equitable use presents a major challenge to managers. Commercial landings are around 20,000-25,000 tonnes per year.

Several important commercial fisheries are overexploited, the most serious being the southern bluefin tuna. Western king prawns in Gulf St Vincent are considered overfished. Ten other marine fisheries are considered 'fully fished': blacklip abalone, greenlip abalone, garfish, mulloway, western king prawn (Spencer Gulf and West Coast), southern rock lobster, snapper, King George whiting, and yellowfin whiting. Four fisheries are of 'uncertain status': bream, cockles, snook, and blue eyed trevalla. Five fisheries are considered 'underfished': blue crab, ocean jackets, yellow eyed mullet, Tommy ruff, and Australian salmon.

The status of knowledge is considered adequate for the management of only five of the State's 27 fisheries: blacklip and greenlip abalone, southern rock lobster, King George whiting and Australian salmon. The effects of trawling on the seafloor benthos, on by-catch, and on the marine environment in general are not known.

Aquaculture

Mariculture is relatively new in the State and involves only three industries: cage and barrel culture of abalone *(Haliotis rubra, H. laevigata)*; cage culture of southern bluefin tuna *(Thunnus macoyii)*; and rack culture of Pacific oysters *(Crassostrea gigas)*. Land-based pond culture includes the microalga *Dunaliella salina*, yabbies and barramundi. In 1993 there were 88 approved mariculture sites: 76 oyster leases, 11 tuna farm leases, and one abalone lease.

The tuna farms, a recent development, involve the 'growing out' or fattening of wild-caught juvenile southern bluefin tuna in cages in the Boston Bay area. Leases are 20 hectares in area, and there is the potential for a total of 98 cages with 40 metre diameters. The Port Lincoln Aquaculture Management Plan has recommended a total of 17 sites, comprising 158 cages, by 1995.

Aquaculture is particularly prone to land-based pollution as farms require high water quality. Adverse environmental impacts may include habitat modification, the introduction of exotic species and diseases, and local effects on water quality, wildlife, aesthetics, and other users. Sea-based fish farming of tunas in South Australia may also result in increased pressure on pilchard stocks used for food. The major impact of South Australian aquaculture has been the spread of the introduced Pacific oyster, thought not to be able to reproduce in the high saline water of South Australia, over wide areas of Australia where they have displaced native species. Department of Environment and Land Management and Department of Primary Industries lease and licence conditions require environmental monitoring.

Competing uses and conflicting interests

The multiple and generally conflicting uses of the coastal and marine environment can often result in habitat degradation or loss. Uses such as tourism, recreation, scientific research, education and conservation require the maintenance of the natural state, whereas urban and industrial development, fishing, aquaculture and mining are exploitative or extractive. Inevitably, without integrated and coordinated management of these activities, the range of different activities and uses will continue to conflict with each other and create discord amongst user groups.

Major conflicts in South Australia are between urban and industrial development, and fishing interests. Concerns exist over the impact of sewage and stormwater pollution on seagrass habitats, particularly in Gulf St Vincent; on the loss of mangrove and saltmarsh habitats; and on the contamination of fish from oil spills and industrial discharges.

Even in more remote areas such as Smoky Bay, sewage pollution from septic tanks from shack developments are of concern to fishers. Of particular concern is the proposed freeholding of all coastal shack developments which could exacerbate existing environmental problems such as septic tank seepage, destruction of coastal habitats, rubbish, coastal erosion and storm risk.

As aquaculture is particularly prone to land-based pollution it is generally incompatible with land developments. Unsightly oyster racks and fish cages may, in turn, reduce aesthetic for tourists and access for anglers. The incremental development of oyster leases in many scenic areas in the State (e.g. Coffin Bay) is causing local conflict with community, fishing and tourist interests.

Uncontrolled tourism may lead to the destruction of the natural features which initially made an area attractive. Visitors to remote and wild coastal areas require parking, marinas and accommodation. Uncontrolled beach shack development, off-road vehicles and camping are causing considerable coastal erosion to some of the State's most scenic coastal regions, such as the West Coast, Eyre and York Peninsulas.

Regional issues

In addition to the general pollution and eutrophication in the Adelaide metropolitan area described above, several industrial areas in the Spencer Gulf are also polluted.

Port Pirie

Located at Port Pirie on the eastern shore of upper Spencer Gulf is the Broken Hill Associated Smelters, the largest lead and zinc smelter in the world. The smelter, which has operated since 1890, discharges aerial and liquid wastes into the surrounding environment. Despite efforts to reduce pollution, each year around 250 tonnes of zinc and 100 tonnes of lead are discharged into Spencer Gulf, via First Creek.

A CSIRO study between 1979-83 found that around 600 square kilometres of sediments has been contaminated by particulate cadmium, lead and zinc, and lesser areas by copper, arsenic and manganese. Most biota also showed elevated levels of these metals. Although muscle component of edible species did not exceed the human health standards, three species approached the limit. Species richness and composition of adjacent seagrass beds has also been affected.

Whyalla

The largest chemical discharge in South Australia occurs on the western side of Spencer Gulf where the Broken Hill Proprietary steelworks at Whyalla discharges solids, metals, cyanides, ammonia compounds and phenols into an area open to the sea. Levels of zinc, cadmium, chromium, copper and lead are elevated on the adjacent soft shores and it is feared that the marine food chain may become contaminated. While the effects of these effluents on marine life have not been studied, they are considered to be similar to those of Port Pirie.

Lake Bonney pulp mill

Lake Bonney, a permanent, shallow coastal lake near Millicent, is polluted by effluent from two pulp mills. The fate of the contaminants in the lake and sea are not known but their potential long-term effects remain a cause of concern. For example, while over 35 tonnes of adsorbable organic halogen (AOX) was released into the sea between September and November 1989 and created a visual plume covering 55 square kilometres, no contaminants were detected in the sediments and biota tested.

Conservation status of communities and special species

Estuaries

Many estuaries in South Australia are seriously threatened by human activities. The State has the least number of estuaries in Australia (only 15 of the nation's 738: Chapter 6), but these are especially important because of the State's generally arid nature. Most of the rivers flow only after local rains and the estuaries receive little fresh water input. Many are 'reverse estuaries' because they are often most saline in the upper reaches rather than at the mouth.

State of estuaries

Bucher and Saenger (1989) considered that five of the State's estuaries were under threat to fisheries and conservation values:

Coorong: moderately affected; increasing salinity in the lower reaches of the Murray; reduced flow and lower flood frequency.

Port Adelaide River: considerably affected; poor water quality because of pollution; adjacent urban and industrial development.

Second Creek, Port Pirie: sewage pollution.

Port Pirie: moderately affected; residential and industrial development; run-off and shipping discharge.

northern Spencer Gulf: poor water quality from port, sewage treatment works, power station and urban run-off from Port Augusta.

Seagrass

Eutrophication is the major threat to seagrass beds in South Australia and significant areas have already been lost as a result of excessive nutrients in sewage and storm water discharges (above). Prawn trawling may also affect beds in the gulfs but this has not yet been investigated.

Mangroves

The removal of mangroves is controlled under the *Fisheries Act* 1971-82, and the *Harbours Act* 1936-81. However, mangroves are under threat from the small, incremental losses arising from urban and industrial developments and reclamations in the Port River estuary; from changes in terrigenous sediment flows in the northern metropolitan area; from smothering by stranded seaweed and seagrass; from trampling of seedlings and pneumatophores by fishers in the Barker Inlet-Port River estuary and Port Gawler region; and from the oil spill in the upper Spencer Gulf.

Eight other areas of mangroves are subject to physical disturbances: Arno Bay, Cowell, Whyalla South and North, Port Augusta South, Port Pirie, Port Broughton, and St Kilda. Mangroves may be affected by possible leaching of contaminants at Port Augusta, Port Pirie South and Whyalla.

Saltmarshes

The importance of supratidal saltmarshes to the functioning of estuarine ecosystems and to coastal fisheries has been only relatively recently recognised. In South Australia saltmarshes are under considerable threat from agricultural, urban and industrial developments. For example, in the Adelaide area it is estimated that around 80% of the original area has been lost.

Unlike mangroves, saltmarshes are not afforded legislative protection in the State. Although known to be highly diverse in South Australia, there has been no inventory to determine their nature and status.

Status of marine wildlife

With the exception of marine reptiles, birds and mammals, the status of most marine species is poorly known. For terrestrial species, the offshore islands are particularly important as they often contain relic species once common on the mainland.

Marine mammals

South Australia has globally significant populations of the endangered southern right whale *(Eubalaena australis)*, the New Zealand fur seal *(Arctocephalus forsteri)*, and the rare Australian sea lion *(Neophoca cinerea)*.

The global population of the southern right whale is estimated to be around 3,000, of which the Australian population numbers 400-800. The most significant calving and breeding areas in Australia are at the Head of the Bight, and to a lesser extent, at the Merdayerrah sand patch in the Nullarbor Cliffs region of South Australia.

While the Australian sea lion occurred along the entire southern coastline prior to sealing last century, it is now restricted to limited areas of South and Western Australia. The South Australian population is estimated to be around 6,900, or 70% of the global population. Sea lions have been recorded on 69 offshore islands and reefs, and three mainland sites. They breed on 18 offshore islands, the major sites being the Pages, Dangerous Reef and Seal Bay on Kangaroo Island.

The South Australian population of New Zealand fur seals is around 22,600, or 83% of the Australian population. There are 11 breeding sites in the State, the major being the Neptune Islands, southern Kangaroo Island and Liguanea Island. Smaller breeding colonies and haul-out sites are found on the Sir Joseph Bank Group, Nuyts Archipelago and islands off the Jussieu Peninsula.

These species are completely protected under the *Whale Protection Act* 1980, but there is a need to protect key feeding grounds and breeding areas. As the fur seal population increases, the interactions with fishers has increased. Injuries from boats and entanglements in nets and marine litter, and competition for common prey species is increasing. As breeding populations of both seal species are highly sensitive to disturbance by humans, it is considered that breeding sites should be designated as prohibited areas.

Seabirds

South Australia's seabirds are relatively well known because of the interests of amateur ornithologists, but population trends are not well established.

The little penguin *(Eudyptula minor)* breeds in 21 sites, 14% of the Australia total. It is thought two birds of prey, the osprey *(Pandion haliaetus)* and white-breasted sea eagle *(Haliaetus leucogaster)* may have become locally extinct in the upper Spencer Gulf because of heavy metal pollution from the Port Pirie smelter. Significant populations of the Cape Barren Goose *(Cereopsis novaehollandiae)* breed and overwinter in the Sir Joseph Banks Group.

Fish

Knowledge of South Australia's fish and their status is limited. Of the 370 species recorded in State waters, 77 are utilised commercially, of which 20 species contribute the majority of the annual catch. The status of the southern bluefin tuna is of particular concern (Chapter 30). Gummy and school sharks have been seriously overexploited, and there are concerns for the great white shark. Snapper have been locally depleted in Gulf St Vincent by overfishing, while mulloway have declined because reduced freshwater flow from the Murray River has affected their life history.

Following heavy collection by fish collectors, the leafy sea dragon *(Phycodurus eques)* is completely protected. The blue groper *(Achoerodus gouldii)* which has been depleted by spearfishermen is protected within the gulfs.

Monitoring and marine environmental reporting

The *Marine Environment Protection Act* 1990 requires the Minister to protect the marine environment and review its condition. Virtually all 115 point-sources of pollution are now licensed, and discharges are monitored. These must comply with guidelines by the year 2001, or face closure. Diffuse source pollution is not monitored.

Ambient marine monitoring is coordinated by the Marine Environment Protection Committee. Monitoring is planned for nutrients, faecal contamination, suspended particles, exotic species and heavy metals in areas of known contamination.

A preliminary state of the environment report for South Australia was issued in 1985, and was followed by more comprehensive reports (including the marine environment) in 1988 and 1993.

Summary and conclusions

1. South Australia has a large range of coastal habitats and ecosystems, from rough water rocky shores to sheltered gulfs, and support some of the largest temperate seagrass beds in the world. South Australia has few estuaries (and consequently, a naturally low input of terrestrial sediments and nutrients), and large, sheltered, and often hypersaline gulfs.

2. While the overall marine environment of South Australia is unpolluted, significant areas of the more heavily populated coast have been adversely affected by urban and industrial discharges, oil spills and other factors.

3. The major issue is elevated nutrients from sewage, storm water and other terrestrial sources which has caused the eutrophication of some areas. Algal blooms are frequent and significant areas of seagrass and mangroves have been lost, adversely affecting the marine environment and fisheries.

4. Other issues include degradation of estuaries (one third are either considerably altered or under threat); overfishing by commercial and recreational fishers (particularly commercial fishing of southern bluefin tuna); loss of habitat (particularly mangrove, saltmarsh) through coastal development; and conflicts amongst users of the coastal zone.

5. South Australia has Australia's most significant breeding and calving areas for the endangered southern right whale. It has globally significant breeding populations of the threatened Australian sea lion, and the New Zealand fur seal. While these species are protected and populations are increasing, their breeding and calving habitats in particular require protection.

6. The knowledge of the status of most groups of organisms, of the key ecosystems, and of the fished species is not well known. Monitoring programs are very limited and generally outfall-based.

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Chapter 56: Issues in Western Australia's marine environment[1]

The Western Australian coastline contains the greatest diversity of marine and estuarine ecosystems of any Australian State. It stretches over 12,000 km, through some 20 degrees of latitude, from wave battered cold/temperate kelp beds in the south, to low energy, mangrove-fringed mudflats in the north.

Despite its great size, Western Australia is amongst the most urban of the Australian states. Around 72% of the population of 1.7 million live within the Perth metropolitan area, and 80% between Geraldton and Esperance in the south-west. Outside the metropolitan area, the coast supports an average of less than 30 people/kilometre, and most of its ecosystems are regarded as virtually pristine. By contrast, around the metropolitan areas human influence has severely degraded some marine ecosystems.

Characteristics of Western Australia's marine environment

The long Western Australian coastline can be divided into several distinct geographical regions, from north to south.

The tropical Kimberley Coast (from the Northern Territory border to Broome) experiences very large tides and consists principally of tidal flats and mangroves, rocky coasts, and relatively few sandy beaches. Most is inaccessible from a landward direction and difficult to reach by sea. The main towns and ports are Wyndham, Derby and Broome.

The arid Pilbara Coast (from Broome to Exmouth) experiences large tides in the north and consists of low lying sandy or rocky shores with small to medium stands of mangroves (particularly in the Exmouth Gulf), and some fringing coral reefs. It includes the towns and ports of Port Headland, Dampier, Karratha and Onslow.

The tropical/subtropical Gascoyne Coast (from Exmouth to Kalbarri) is characterised by clear, oceanic waters because of the narrow continental shelf and low rainfall, and rugged coasts which make access difficult. It includes the towns of Exmouth, Carnarvon and Kalbarri.

The temperate West Coast (from Kalbarri to Cape Naturaliste) is characterised by sandy beaches and dunes, often protected by limestone reefs. It houses the bulk of the State's population and industry in Geraldton, Perth, Fremantle, Mandurah and Bunbury, and as a consequence, experiences the major marine environmental problems.

The temperate South Coast (from Cape Naturaliste to the South Australian border) is characterised by rugged, rocky outcrops which support extensive temperate kelp ecosystems, and high wave energy. The main towns are Albany and Esperance.

Major issues and threats

It is not surprising that the great majority of the State's environmental problems are adjacent to the populated regions of Perth and a few coastal centres. Eutrophication of embayments and estuaries presents the major threat. Other issues include loss of habitat (especially seagrass), modification of estuarine flow, heavy metal contamination, conflicts in usage, and declines in fish catches. Outside these populated areas, a variety of issues such as recreational use, oil drilling, fishing, mining, and impacts on mangroves and coral reefs are of potential significance.

While the following description dwells on the problems of metropolitan areas, these must be placed in context geographically. These areas comprise only a tiny part of this huge State. Outside of these areas, population densities are extremely low and appear to have placed minimal stresses on the marine environment.

Nutrients and eutrophication

Catchments in the south-west have been extensively cleared for agriculture. Nutrient levels in water courses have been largely elevated by run-off of agricultural fertilisers and animal wastes, and estuaries have become eutrophic.

Of 22 estuaries assessed in Western Australia's 'State of the Environment Report', nine are listed as in 'poor' condition: Peel Inlet, Harvey Estuary, Princess Royal Harbour, Oyster Harbour, Beaufort Inlet, Vasse

[1]Based on a paper by Dr J. A. Stoddart, Kinhill Engineers P/L, Victoria Park, Western Australia and Dr C. J. Simpson, Environment Protection Authority, Perth, Western Australia.

Kimberley
- Aboriginal custodianship issues
- possible impacts of trawling
- localised sedimentation of estuaries

Pilbara
- Aboriginal custodianship issues
- effects of pair-trawling on benthos
- oil and gas extraction on NW shelf
- local impacts of ports and salt fields

Gascoyne
- coral-eating snails in Ningaloo
- inshore fisheries (catch-sharing)
- management of whale shark tourism

South-west
- declining water quality (especially elevated nutrients)
- localised heavy metals and oil pollution
- degradation of estuaries
- loss of habitat
- modification of hydrological cycle
- decline of seagrass
- coastal strip development, marinas
- competing uses
- declining coastal fisheries

South
- declining water quality in estuaries and bays (SW)
- localised elevated nutrients, heavy metals (Albany)

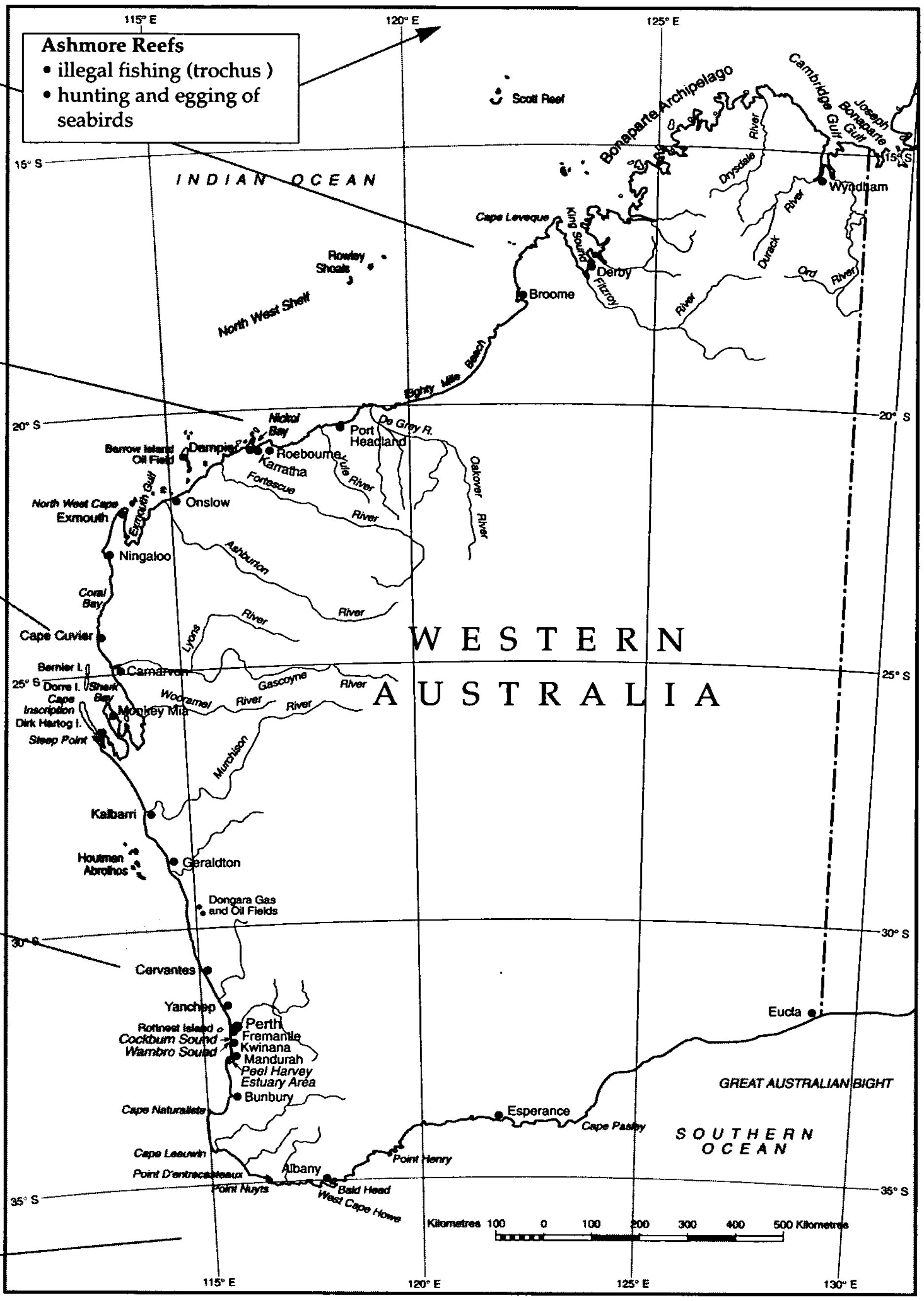

Figure 56.1: Issues in Western Australia's marine environment:

Population: 1.7 million (72% in the Perth metropolitan area). Coastline: 12,000 km. Major coastal regions are temperate south and south-west, and tropical Gascoyne, Pilbara and Kimberley coasts. Most of the State's vast coastline is arid and uninhabited. Marine issues are largely confined to the more populous and industrialised south-west (SW). Major issues stem from declining water quality, particularly elevated nutrients. Problem areas include: Cockburn Sound, Princess Royal Harbour, and Peel-Harvey system. (6-14,42-47,56)*

Major State and regional issues include:
- water quality in south-western estuaries (especially nutrients, eutrophication)
- competing uses of coastal zone (SW)
- localised pollution in bays by heavy metals (SW)
- loss of seagrass (SW)
- catchment alteration
- Aboriginal sea rights and fisheries
- protection and preservation of Aboriginal sites of significance
- declining inshore fisheries (SW)
- catch-sharing (conflicts in commercial/recreational fisheries)
- effects of trawling on sea floor
- environmental risk of petroleum exploration and extraction
- outbreaks of *Drupella* snails on coral reefs
- general lack of scientific knowledge of marine environment

(*refer also to these chapters)

Lagoon, Wonnerup Lagoon, Party Inlet, and Torbay Inlet. For eight of these, agricultural sources are shown as the primary cause of eutrophication. The most extreme case, the Peel-Harvey estuary, has become severely eutrophic from agricultural run-off and now suffers regular blooms of blue-green and other algae (below).

In Princess Royal and Oyster Harbours near Albany, agricultural run-off and urban and industrial waste waters have elevated nutrient levels, leading to increased algal growth, and subsequent loss of seagrass. Wilson Inlet near Denmark also shows increasing nutrient levels, both in sediments and the standing crop of macrophytes, and although no signs of severe eutrophication have yet appeared, it is thought that the system may be about to change its state. A decline in nearshore seagrass in Geographe Bay may be an early sign of similar problems there.

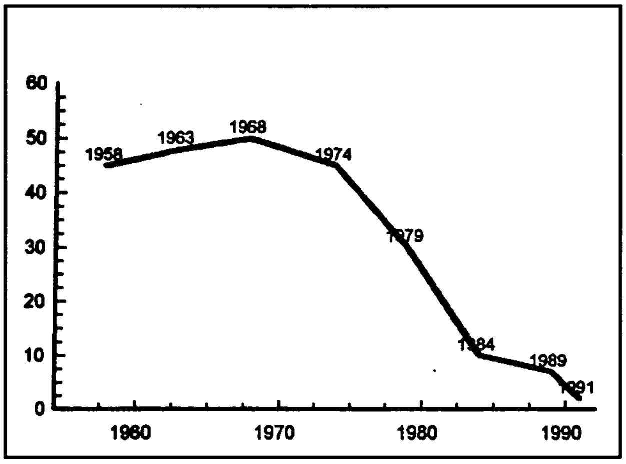

Figure 56.2: Decline of seagrass cover (%) in Geographe Bay, 1958-91.

Nutrients, primarily nitrogen from urban sewage and industrial wastes, have been responsible for the loss of over 75% of Cockburn Sound's seagrasses (*Posidonia* and *Amphibolis*), originally estimated to be 4,000 ha in area. Despite the reduction of nutrients through stringent discharge guidelines, the original beds are unlikely to return because of the poor colonising ability of *Posidonia*. This extensive modification of the benthic habitat has resulted in major shifts in community composition.

The ocean discharge of Perth's treated sewage does not appear to have had a widespread impact on the marine environment but an expected doubling of this over the next 30 years may exceed the nearshore ecosystem's assimilative capacity. A comprehensive study is now underway to assess impacts of existing and future discharges. The Western Australia Environment Protection Authority (WAEPA) and the Water Authority of Western Australia are to examine the cumulative impacts of nitrogenous discharges between Yanchep and Mandurah.

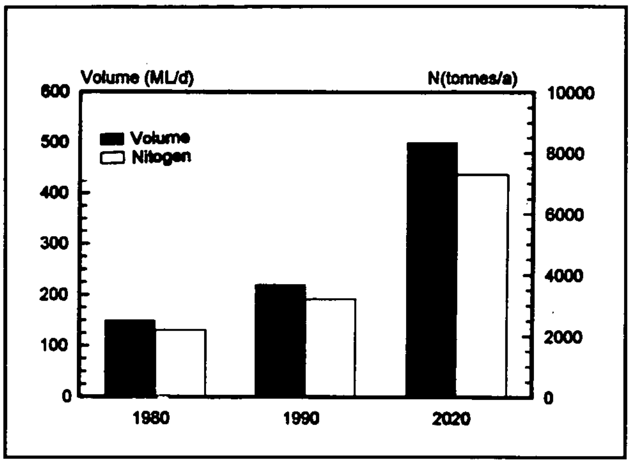

Figure 56.3: Discharge of treated waste water to Perth's coastal waters, and projection to 2020.

Toxicants

Heavy metals from industrial discharges have been problems in Cockburn Sound and in Princess Royal Harbour near Albany. Better waste management in both areas has significantly reduced levels and recent WAEPA surveys have shown a dramatic decline of all toxicants in sediments and biota in recent years. A ban on the harvesting of fish and shellfish in parts of Princess Royal Harbour has recently been revised.

Tributyl tin (TBT) from antifouling paints has also been detected in Cockburn Sound and it is likely that other areas have been affected. A recent investigation shows widespread biological impacts on molluscs around Perth metropolitan waters. Use of TBT has been banned on vessels below 25 metres in length.

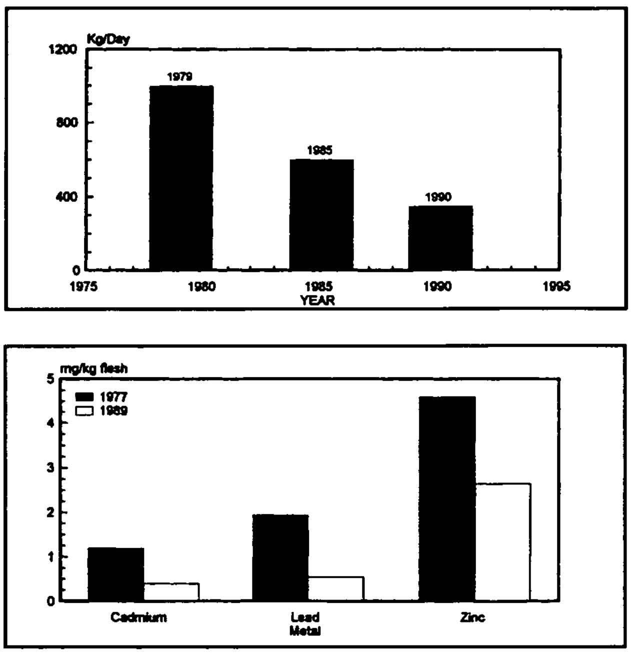

Figure 56.4: Oil input (above) and heavy metal levels in Cockburn Sound mussels (bottom).

Petroleum hydrocarbons, oil drilling and spills

Chronic oil spills and discharges occur in industrial and port areas, and in marinas. Levels of petroleum hydrocarbons were high in Cockburn Sound, but have been reduced by better waste water management by WAEPA. Inputs have been reduced by 70% since 1979.

The development of major offshore oil and gas reserves on the North West Shelf and other areas off Western Australia has occurred over the past decade. Damage to marine communities by drilling muds and other discharges has been localised. To date there is no record of any oil spill having a significant effect on the area's marine ecosystems. While conservationists are concerned about the potential risks involved and oil rig blowouts, the Australian offshore oil industry has had an excellent safety and environmental record.

Two major oil spills occurred in Western Australia in 1991. The sinking of the *Sanko Harvest* off Esperance resulted in the loss of 570 tonnes of fuel oil, and some fouling of beaches and wildlife occurred. The tanker *Kirki*, carrying 70,000 tonnes of crude oil, lost its bow in heavy seas off the Cervantes area. While around 18,000 tonnes of oil was lost, fortunately this did not reach the coastline.

Changing land use, coastal development, and loss of habitat

The effects of land clearing and catchment alteration on the marine environment are limited in the areas of arid coast because of the low river and stream discharges. However there are concerns that the extensive pastoral industry in the wetter Kimberley area has increased sedimentation in coastal and estuarine waters through erosion of top soil.

In the south-west, agricultural clearing has caused extensive modification of the catchments, and, together with fertilisers and animal wastes, has had a severe impact on estuaries. Developments and urbanisation have also disturbed fragile dune systems in this area.

Construction of ports at Port Hedland and Dampier for the loading of minerals, oil and gas have substantially modified the immediate areas and created localised pollution hazards. On a tonnage basis, the port of Dampier, which handles iron ore, salt and liquid gas products, is now the largest in Australia. Construction of solar salt fields around Dampier has resulted in loss of mangroves, but is not otherwise regarded as a problem.

Effects of fishing

The pot fishery for rock lobsters is Western Australia's, and the nation's, most valuable single species fishery. Catches have been sustained through tight controls on fishing licences, gear and seasons. Environmental impacts of the fishery are considered minor. Occurrences of sea lions and turtles becoming entangled in fishing gear are isolated, and some damage to corals by pots has occurred. A management plan for fishing and conservation is being developed.

Trawling for fish and prawns has had significant environmental effects in some areas. Pair-trawling for demersal fish on the North West Shelf by foreign vessels has been shown to have damaged bottom communities and affected fish community structures. While operations have been discontinued, it appears that recovery of these communities has been slow. Gillnetting in the Shark Bay area has been banned because of entanglements of dugongs and turtles.

Pearl culture is Western Australia's largest and oldest aquaculture industry, and is worth around $90 million per year. Environmental concerns centre on effects of prawn trawling on wild stocks of pearl oysters, on high mortality of oysters due to disease, and on localised environmental damage caused by farms.

Recreational fishing is popular in Western Australia. Catches have been declining in more populous areas and there are conflicts in catch-sharing with the commercial sector (Chapter 33).

Degradation of coral reefs

Outbreaks of the coral-eating *Drupella* snails have caused extensive mortality of corals in the Ningaloo Marine Park and elsewhere. The causes of the outbreaks are unknown, but overfishing of natural predators has been suggested (Chapter 50). Crown-of-thorns starfish outbreaks have caused localised damage on the Dampier Archipelago (Chapter 49).

Tourism and recreation

Ecotourism on the Western Australian coast has increased greatly over the past decade, creating localised pressures on facilities and the immediate environment. These include Monkey Mia where the regular visits of dolphins has become a well known attraction, and Hamelin Pool which is famous for its ancient stromatolites. The incorporation of sensitive sites into marine protected areas may provide the management necessary to mitigate these impacts.

On the temperate west coast, 23 marinas have been constructed as foci for tourism, housing and fishing harbours. Apart from localised impacts, they are not regarded as serious environmental problems.

Natural impacts

Natural disturbances to the marine environment may be great, and may exacerbate stresses which result from human activities. Much of the western coast is prone to cyclones which may cause extreme physical damage to the built and natural environment. The strongly seasonal river flows in the Kimberley Coast may cause disturbances through extreme sediment loads.

Coral reefs have been affected by coral bleaching off the Pilbara, and at Ningaloo fish and invertebrate kills have occurred as a result of oxygen starvation caused by the decomposition of coral spawn. Whether outbreaks of *Drupella* snails and crown-of-thorns starfish are natural, or human-induced remains unknown.

Administrational responsibilities

As in other States, the large number of different agencies with responsibilities in coastal management has hindered a strategic approach to coastal planning in Western Australia.

Regional issues

Cockburn Sound

The major concentration of industry on the west coast occurs in Kwinana, 10 kilometres south of Fremantle. A primary consideration for its siting was its location adjacent to the sheltered waters of Cockburn Sound, which provided suitable areas (in engineering terms) for constructing port facilities, wastewater outfalls and raw materials. The well documented decline of the ecosystems of the Sound during the 1960s and 1970s is largely attributable to this sheltered nature which results in low flushing of waters. Environmental impacts included eutrophication, dredging and heavy metal pollution. As described, pollution in the Sound has been reduced through wastewater management.

Case study

Management of the coastal zone in Geographe Bay

The Resource Assessment Commission's Coastal Zone Inquiry has identified the issues in the management of Geographe Bay near Bunbury, as:

- increasing population pressure and associated urban growth;
- loss of amenity due to development;
- threat to the built environment from coastal processes and rising sea level;
- pollution of marine, wetland and estuarine environments, including eutrophication;
- rising demand for recreational facilities on the shore;
- impact of commercial and recreational fisheries on stocks and nurseries; and
- conservation of habitats.

In examining these issues, the Inquiry found that management of Western Australia's coastal zone around Geographe Bay is covered by a large range of legislation and rests with many different agencies: four international agreements, 16 Commonwealth agencies, and 12 key State agencies.

Coastal development in the State is directed by plans that guide the use of coastal land for conservation, recreation and development. Each plan requires input from 10 State agencies: Department of Planning and Urban Development; Department of Agriculture; Environmental Protection Authority (EPA); Department of Marine and Harbours; Department of Conservation and Land Management (CALM); Department of Local Government; Department of Land Administration; WA Tourism Commission and WA Municipal Association; Fisheries Department and Waterways Commission. Coordination is undertaken by the Coastal Management Co-ordinating Committee which comprises representatives of all but the last two agencies.

(Source: RAC 1993)

Princess Royal Harbour and Oyster Harbour

Adjacent to the town of Albany, Princess Royal Harbour is a moderate sized embayment with a narrow opening to the sea. Nutrient discharges from industrial and domestic wastes have led to the loss of most of the bay's lush seagrass meadows and contamination of biota by heavy metals, particularly mercury. Oyster Harbour, an adjacent estuary, shows similar seagrass loss because of eutrophication.

Peel-Hervey Inlet

The Peel-Harvey, a shallow coastal lagoon 70 kilometres south of Perth, is one of the most eutrophic estuaries in Australia (Chapter 42). The system's natural productivity and restricted flushing predispose it to eutrophication.

Increasing phosphorus from agricultural fertilisers which are poorly bound in the catchment's sandy soils, induced extensive growth of the alga *Cladophora* in the 1960s. Severe blooms of the alga *Nodularia* began in 1973 and are now regular features in late spring and early summer. A major management program is underway to reduce the problem by harvesting the algae, by reducing inputs of nutrients, and by enhancing flushing through the construction of a new channel into the sea.

Issues in other areas

Kimberley Coast

Environmental issues include effects of trawling on the sea floor in Joseph Bonaparte Gulf and off Broome; effects of trawling on pearl oyster stocks; and sedimentation of estuaries because of soil erosion.

Pilbara Coast
Environmental issues include effects of pair-trawling on the sea floor; localised effects of oil and natural gas extraction on North West Shelf; and localised disturbance in ports and salt fields.

Gascoyne Coast
Environmental issues include the management of Shark Bay and Ningaloo Marine Parks; management of recreational uses; and predation of corals by *Drupella* snails.

Monitoring and marine environmental reporting

The WAEPA is currently undertaking a major multi-disciplinary study into the cumulative long-term impacts of waste inputs to the southern metropolitan coastal waters, the Southern Metropolitan Coastal Waters Study. This will provide the basis for regulating existing industries and for evaluating cumulative environmental impacts of proposed developments that have potential to affect these waters. The Water Authority of Western Australia is also undertaking a study, the Perth Coastal waters Study, to assess the local and regional cumulative impacts of sewage discharge to metropolitan coastal waters. These studies will provide the basis for long-term management of Perth's coastal waters.

Discharges to the marine environment of Western Australia are licensed and audited under the *Environmental Protection Act* and companies are required to monitor discharge rates and report to the WAEPA on a regular basis. Non-compliance with license conditions can lead to prosecutions.

Petroleum exploration and development in the State is concentrated on the North West Shelf. The area of most concern are the shallow waters surrounding the reefs and islands in the west Pilbara. Petroleum development is routinely assessed by WAEPA. Approval is usually conditional on the companies having adequate Environmental Management Plans, which include monitoring and remedial management components for routine operations, and oil spill contigency plans for accidental spills.

The Government of Western Australia, under the State Conservation Strategy, is obligated to produce a State of the Environment Report every five years. The last report was in 1992.

Summary and conclusions

1. Western Australia's marine environment ranges from almost pristine in the sparsely inhabited majority of the coast, to seriously disturbed in localised metropolitan areas in the south-west.

2. The major issue is elevated nutrients in embayments and estuaries in the south-west, resulting from agricultural and urban inputs.

3. Contamination by toxicants is of local significance in several south-west embayments and estuaries but levels are declining as waste water management is taking effect.

4. Other issues include effects of coastal development and catchment alteration; effects of fishing, including declining inshore catches around more populous areas and effects of trawling on bottom communities; oil and gas extraction; mortality of corals by *Drupella* snails; and competing uses in the coastal zone.

5. The Western Australian marine environment is generally not well known because of its vast area. The status of the metropolitan area is well known, and is well monitored.

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Chapter 57. Issues in the Northern Territory's marine environment[1]

The Northern Territory's population is small. Its marine environment is largely pristine and problems are insignificant compared with the more populous south-east of the continent. Unlike other parts of Australia, most of the coastline (84%) is under Aboriginal control. The major issues centre on the threats to mangroves in the Darwin area, and the need for the closer involvement of the Aboriginal peoples in coastal management.

The Northern Territory has an area of 1,347,519 square kilometres and a mainland coastline of about 7,200 kilometres. It lies entirely within the monsoon tropics. The population of the Northern Territory is about 157,000. Around 85,000 live on the coast, the majority in Darwin (73,000). Most of the coastline is largely unpopulated, and remains remote and often inaccessible during the wet season.

Characteristics of the Northern Territory's marine environment

The Northern Territory is subject to strong south-easterly winds during the dry season between May and October and north-westerly winds during the wet season between November and April. Rainfall varies with latitude and is generally reliable, although considerable variation in onset and duration of rainfall occurs between years.

Sea temperatures are high, ranging from 23 to 33°C. The coastline is largely mesotidal (mean spring range 2-4 metres) while the western coast (from the Western Australian border to Cobourg Peninsula) is macrotidal (>4 metres mean spring tidal range). The maximum range of about 8 metres occurs in the west and gradually diminishing eastwards to less than 1 metre in parts of the Gulf of Carpentaria.

Much of the coastline consists of gently sloping muddy shorelines, lined by mangroves and washed by shallow, warm, turbid waters. Some rocky reef and sandy foreshores are present, usually on shorelines exposed to strong seasonal winds, and reef coral development is generally poor.

The coast features several large drowned river valley systems, notably Darwin and Bynoe Harbours, and large embayments such as Arnhem, Buckingham and Melville Bays. Most of the large tidal rivers and their flood plains show signs of recent ecological change.

The coastal settlements are Darwin (73,300), Nhulunbuy (4,000), Elcho Island (1,200-1,500), Yirrkala (700), Maningrida (1,000) and Ngulu (over 1,000). The remaining coastal settlements are small (200-300) and isolated, and the populations are mainly Aboriginal people. Access to the coast is further restricted by the designation of 84% of the coastline as Aboriginal land (Figure 57.2). Access to Aboriginal land is controlled through permits issued through the Lands Councils.

Major issues and threats

Darwin Harbour

Darwin Harbour (or Port Darwin) is a large drowned river valley system of about 1,000 square kilometres formed by postglacial marine flooding of a dissected plateau. The shoreline of the outer, northern section of the Harbour is predominantly coarse sands and rocky cliffs, and the estuarine shoreline of the inner, southern section of the Harbour is dominated by fine silts and mangroves. Much of the Harbour is shallow, under 10 metres deep, and exposed at spring low tides. The three arms of the Harbour are 10-20 metres deep and the main channel where it passes through the constriction between East and West Points reaches 36 metres in depth.

The city of Darwin lies on the north-eastern side of the Harbour. The majority of environmental impacts on the Harbour are concentrated near the city and the East Arm of the Harbour. Although Darwin is a capital city, it does not have any heavy industry. There is some light industrial development such as slipways, chemical and explosives operations, cement works, fuel storage and a tannery.

Within the Darwin region, the major impacts on coastal and marine habitats are the clearing of mangroves and reclamation of intertidal land. Vehicular and pedestrian traffic on stretches of beach in the northern section of the Harbour has also caused coastal dune and vegetation erosion.

[1]Based on a paper by Dr R. Hanley, Northern Territory Museum, Darwin, Northern Territory.

Timor Sea
- offshore petroleum exploration and extraction

Darwin
- reclamation of mangroves for harbour development
- discharge of sewage
- localised high heavy metals (chromium, zinc, arsenic) from discharges, port spills

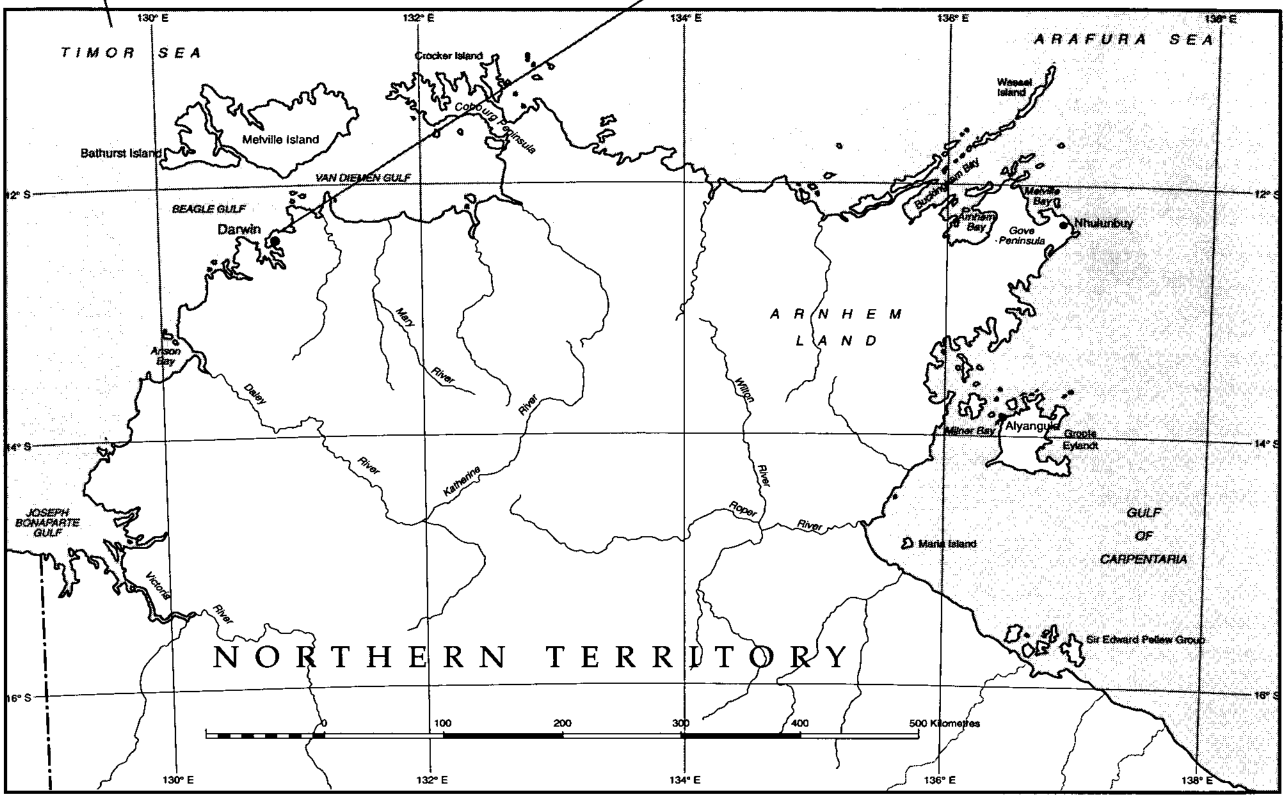

Figure 57.1: Issues in the Northern Territory's marine environment.

Population: 157,000 (85,000 on coast, 73,000 in Darwin). Coastline: 7,200 km. Coastal areas are generally sparsely inhabited and much of the coastline is designated as Aboriginal land. The marine environment is generally pristine. Problems are largely confined to the Darwin area and are insignificant compared with southern States.

Major Territory and regional issues include:
- localised issues in Darwin
- protection and preservation of Aboriginal sites of significance
- Aboriginal fishing rights (84% of coast is Aboriginal land)
- recreational fishing, conflicts in catch-sharing
- offshore petroleum exploration and production

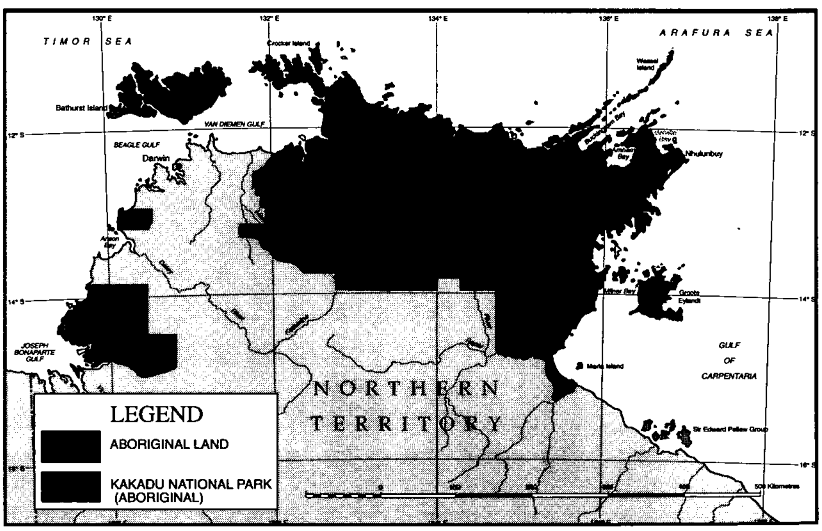

Figure 57.2: Aboriginal controlled coastline of Northern Territory.

Other potential problems are the discharge of sewage effluent and stormwater run-off into harbour waters.

Reclamation of intertidal land

The mangroves of Darwin Harbour, about 20,000 hectares in area, are one of the largest single stands of mangroves in the country and as such are nationally important. The coastline in the Darwin region is almost entirely inaccessible as it is made up of broad intertidal mudflats, dense mangroves and saltpans. The large tidal range, the presence of biting midges and mosquitos, and deep, unstable muds are significant barriers to coastal development. However, development is proceeding and areas of mangrove are being cleared, with landfill in the intertidal zone encouraged for a variety of land use proposals such as port facilities, mooring basins, shipyards and slipways, marinas, housing estates, oil and gas refineries, aquaculture farms and industrial estates. Guidelines which suggest that no housing construction should take place within 1.6 kilometres of mangroves are consistently ignored. No mangrove management plan currently exists, although a management plan is to be developed for Darwin Harbour, and this may address the issue of maintenance of ecosystem productivity.

Sewage and stormwater effluent

The majority of sewage from Darwin is treated in oxidation ponds but there is ocean outfall of untreated sewage at Larrakeyah. All the oxidation ponds are sited adjacent to mangroves and effluent is released from secondary treatment ponds straight into mangroves.

The impact of sewage effluent on mangrove fauna has been poorly studied in the Darwin region, although the large tidal range and strong tidal currents are thought to have an ameliorating effect, through rapid dilution. Studies indicate that inputs of heavy metals, nutrients and pesticides will not be harmful to mangroves themselves, and that mangroves can act very effectively as sinks, trapping nutrients, heavy metals and pesticides that would otherwise be released into estuarine waters. Evidence from ambient water quality studies show the harbour waters are high in dissolved oxygen with low nutrient and chlorophyll 'a' concentrations, indicating little nutrient enrichment.

Heavy metals, hydrocarbons and pesticides

The relatively low levels of industrial infrastructure and maritime activity and the large, semidiurnal tidal range suggest that the low levels of anthropogenic contaminants entering the waters of the harbour are subjected to a rapid and substantial dilution. Ambient water quality surveys of Darwin Harbour have consistently reported low levels of heavy metals, pesticides, PCBs and hydrocarbons and the harbour waters are considered pristine.

Analysis of marine sediments in the harbour for concentrations of various heavy metals and other contaminants has never been undertaken in a comprehensive fashion. Studies around Darwin Harbour found the highest levels of copper, lead and zinc in sediments around the Darwin wharf precinct.

In 1990 the Conservation Commission of the Northern Territory (CCNT) analysed sediments from three wharves in the Darwin Port area (Fort Hill, Stokes Hill and the Iron Ore Wharf) and found high levels of trace metals below the Iron Ore Wharf. Levels of copper, lead, zinc, cadmium and arsenic exceeded the National Health and Medical Research Council (NHMRC) limits. Levels were generally much higher in the upper layers of sediment. The elevated metal levels were all found near a conveyor belt used to load metal ores onto cargo vessels.

Within Darwin Harbour, levels of some metals such as chromium, zinc and arsenic in some sediments appear consistently high. This might be the result of leachate from old dump sites, or the result of recent mining of ore containing high concentrations of zinc in the catchment of the Elizabeth River. High background levels of some heavy metals in sediments may also be due to natural fluvial input from weathered ore bodies in Northern Territory coastal waters.

Very few organisms have been examined for heavy metal and other contaminant levels in Northern Territory waters. The records are patchy, and there is little consistency in the range of contaminants tested. Most of the data are heavy metal concentrations, and these results show that in general, all metals examined were found to be below NHMRC limits.

Much of the research on heavy metal levels in organisms has concentrated on mangrove associated molluscs. The mud whelks *Telescopium telescopium*, *Terebralia palustris* and *T. sulcata* are widely eaten by local Aboriginal people, and there is evidence to suggest that some of these organisms may not be fit for consumption. Urban run-off and sewage effluent discharge in populated areas are potential sources of heavy metals.

High cadmium concentrations in *T. telescopium* were also detected at Elizabeth River but the sources is unknown. High concentrations of cadmium were found in oysters from the Arnhem Land coast, which is sparsely populated and has no anthropogenic source of cadmium. Naturally high concentrations of cadmium have also been reported in some other parts of Australia, for example Shark Bay in Western Australia and in Torres Strait. These studies underline the need for caution in interpreting the results of localised surveys.

Tributyl tin (TBT)

Very little data on TBT levels is available. Spot monitoring of the muds in front of the slipways has revealed TBT contamination but analysis of nearby sediments from Sadgroves Creek shows no contamination, suggesting the area of impact is small. As in most parts of Australia, the use of TBT-based antifouling paints on small boats is illegal under the *Poisons and Dangerous Drugs* Act.

Effects of offshore oil exploration and production

Petroleum exploration and production is a developing industry in the Territory. The major developments are located in the Ashmore/Cartier Adjacent Area, with other interests in the Northern Territory Adjacent Area. The possibility of marine pollution from oil exploration, production and transport could increase in this decade.

The Northern Territory Government has drafted an oil spill contingency plan for Darwin Harbour and proposes to have plans in place for the rest of the coastline by 1998. All proposals for exploratory and production wells have contingency plans prepared by industry, as do mining companies with port facilities such as NABALCO at Nhulunbuy and GEMCO at Groote Eylandt. The National Plan to Combat pollution of the Sea by Oil is implemented in the Territory by a Territory-based committee of government and industry representatives, as in other parts of Australia.

Effects of fishing

Commercial, recreational and subsistence fishing are important activities in the Northern Territory.

The commercial sector is based on prawns, barramundi, mud crabs, pearl culture and demersal and pelagic fish. The Northern Prawn Fishery, which extends from Cape York (Qld) to Cape Londonderry (WA) and includes the entire Northern Territory coast, is managed by the Commonwealth under the provisions of the Offshore Constitutional Settlement. The fishery is valued at around $100 to 150 million per annum but most of the economic benefits are exported to the home ports in other States. Although the grounds lie offshore, prawn stocks are dependent on seagrass beds, mangroves and estuaries during their life histories. These critical areas are protected by permanent and seasonal closures.

With the exception of pearl culture, aquaculture is not well developed, although there is considerable interest in barramundi and prawn farming.

Recreational fishing is of considerable importance to local fishers and the tourism industry. There are around 10,000 recreational boats up to seven metres in length. Subsistence fishing by Aboriginal people occurs along almost the entire Territory coastline.

Regional issues

Although most of the marine environmental issues are centred in the Darwin area, there are localised water quality issues in the mineral ports on Melville Bay and Milner Bay.

Melville Bay

Melville Bay, approximately 170 square kilometres in area, is fringed by mangroves, several coarse sandy beaches and some rocky shores and headlands in the north. The substrate over most of the Bay is fine muds and silts, typically anoxic. Seagrasses (largely *Halophila* spp.) are present, but patchy in distribution. The Nabalco bauxite mine at Nhulunbuy lies inland, and the ore is transported by conveyor to the alumina refinery on Gove peninsula.

A number of studies have examined Nabalco's operations and potential environmental impacts on the region. Possible sources of concerns include the level of sulphur emissions from the Steam Power Station stacks; the discharge of heated sea water into the Bay; occasional spills of caustic soda; and heavy metal contamination.

A barge-landing facility, a fuel depot for prawn trawlers and a recreational yacht club in Inverell Bay are responsible for regular small spills and leakages of diesel fuel, paints, and petroleum based products almost daily.

The scale of these problems must be kept in perspective. The population is small, and therefore the volumes of effluent and spillages are also small. At present, there are no contaminants in concentrations high enough to be of immediate concern.

Milner Bay

The township of Alyangula on Groote Eylandt is on the shores of Milner Bay, where manganese ore mined further south at Angurugu is loaded onto bulk carriers. The manganese mine has been operated by Gemco since 1965.

A study of manganese and other heavy metal levels in marine sediments, sea water, and in oysters and fish found levels were within the range of background levels recorded elsewhere in the Northern Territory. The exception was manganese in marine sediments, which was reported at higher than typical levels at several locations. The current manganese extraction and shipment operations appear to have had little impact on the marine environment in Milner Bay.

Management challenges and concerns

While there are no major threats to the marine environment of the Northern Territory at this time, the challenges concern the maintenance of the relatively undisturbed coastal environment, while undertaking needed economic development. The Northern Territory's major industries of fishing and tourism depend heavily on the maintenance of the coastal and marine environments.

A further challenge facing the Northern Territory is to address and resolve Aboriginal interests in coastal management. Under the *Aboriginal Land Rights (NT)* Act, Aboriginal people own land to the low water mark over much of the coastline. They also have the capacity to apply for closure of seas to two kilometres offshore, under complementary Territory legislation, and can declare marine sacred sites under the *Northern Territory Sacred Sites* Act. Native title rights may extend well out to sea. Appropriate mechanisms are needed to allow full Aboriginal participation in coastal management in the Northern Territory.

Summary and conclusions

1. The Northern Territory has a largely pristine marine environment. No large-scale chronic or acute pollution stresses have been identified. However, for much of the coastline no baseline data exist.

2. Significant industrial development and population growth is expected in at least the Darwin region during the next few decades. As there will be impacts on the marine environment, it is imperative that a coordinated program of baseline data collection is implemented to allow the development of sound management plans.

3. Coastal management in the Northern Territory incorporates a diversity of community interests. Aboriginal aspirations are highly significant, given Aboriginal ownership of most of the coastline, their extensive subsistence usage and their interests in achieving full participation in the management of marine environments.

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Part 7

Marine environmental management and conservation

Management of aquatic environments must consider the very high degree of connection within them and with land-based activities. In the sea, water masses (including the adults and larvae of many marine species, nutrients and pollutants) may be carried great distances in ocean currents. Many human activities also span land and sea, for example, recreation, fishing, transport, resource developments and defence. Catchment uses may affect streams, rivers, estuaries and therefore distant coastal waters. Actions and events on land may therefore have far-reaching consequences for the marine environment. Coastal zone management is complex as it involves not only two different but interconnected environments, but many different administrative jurisdictions.

Marine environmental conservation in Australia involves a large number of international, regional, Commonwealth, State and Territory, and local government agreements, arrangements and agencies, and involves a large number of different management strategies. These include: water quality standards; prohibiting or regulating destructive and unsustainable activities; protecting important habitats and areas; zoning for particular uses to separate and control incompatible uses; environmental impact studies to minimise effects of developments; protecting vulnerable and threatened species; and regulating fisheries through licences, size limits, quotas (total allowable catches), closed seasons and other mechanisms.

This Part describes jurisdictional and legal aspects of marine environmental management; agreed and proposed strategies for coastal zone management; and the status of marine science and education. Marine protected areas in Australia and marine conservation in the States and the Northern Territory are described in detail as these are a major focus of the Ocean Rescue 2000 program.

Administrative and legal aspects

This section describes Australia's maritime zones, international borders and intergovernmental arrangements (Chapter 58); environmental impact assessment procedures around Australia (Chapter 59); and national and international responsibilities for the protection of marine species (Chapter 60).

Management strategies

This section examines the agreed national strategy for ecologically sustainable development in the coastal and marine environments, and critically discusses its implications to economic and marine ecological theory (Chapter 61). It also summarises the major findings and recommendations of the Resource Assessment Commission's Coastal Zone Inquiry (Chapter 62) which, at the time of writing, have not yet been responded to by government.

Marine science and education

Effective science-based environmental management relies on a sound knowledge of the subject, effective dissemination of information, and community commitment to the ideals and knowledge of regulations. Chapter 63 critically reviews the status of marine science in Australia and its contribution to marine environmental management. Chapter 64 describes marine environmental monitoring, information management and state of marine environment reporting. Chapter 65 describes formal marine education in schools, and Chapter 66 describes community marine education.

Marine protected areas

Marine protected areas (MPAs) are important tools for marine environmental management. Chapter 67 examines the status of MPAs in Australia, and Chapter 68 describes the Ocean Rescue 2000 MPA program to date.

Australia's major MPAs are then described: The Great Barrier Reef Marine Park (69); Ningaloo Marine Park (70); Solitary Islands Marine Reserve (71); Jervis Bay Marine Reserve (72); the offshore National Nature Reserves (73); the Torres Strait Protected Zone (74); and the Antarctic (and Subantarctic) Territories (75).

Marine conservation around Australia

Marine environmental conservation and marine protected areas in each State and the Northern Territory are specifically described in the concluding section (Chapters 76-82).

Chapter 58. Australia's maritime zones[1], international borders[2], and intergovernmental arrangements[3]

Stretching from the tropical Timor Sea and Torres Strait to subantarctic Heard and Macquarie Islands and the Antarctic Territory, Australia's marine domain incorporates many biogeographic provinces, a wide diversity of marine ecosystems, and myriad plants and animals. Their management involves a complexity of jurisdictions and administrative responsibilities involving international and regional agencies, the Commonwealth Government, and State, Territory, and Local Governments in Australia.

The fragmented and often duplicatory responsibilities in the coastal zone have been identified by the House of Representative Standing Committee on Environment, Recreation and the Arts (HORSCERA 1991) and the Resource Assessment Commission (RAC 1993) as severe impediments to effective planning and management.

This chapter deals with the international laws relating to Australia's maritime claims, the international maritime borders, and the arrangements between the Commonwealth, State and Territory governments for the management of coastal waters.

Australia's maritime zones[1]

Australia's claims to maritime areas were originally made under international laws such as the Geneva Conventions on the 'Territorial Sea and Contiguous Zone', the 'High Seas', the 'Continental Shelf' and the 'Fishing and Conservation of the Living Resources of the High Seas'. They are now based on customary international law as reflected in the 1982 United Nations Law of the Sea Convention (UNCLOS). UNCLOS entered into force on 16 November 1994.

The UNCLOS allows states to claim six maritime zones: Territorial Seas, Contiguous Zones, Exclusive Economic Zones (EEZ), Continental Margin, Archipelagic Waters and Internal Waters. The maximum seaward limits of the first three zones, as measured from the baseline along the coast, are 12, 24 and 200 nautical miles (n miles).

Baselines

In 1983 the Federal Government, under section 7 of the *Seas and Submerged Lands Act* 1973, proclaimed the baseline or inner limit from which Australia's territory is measured for the purposes of international law. The greater part of this follows the lowest astronomical tide mark.

Territorial Sea

Before 1990 Australia had laid claim to only a 3 n miles Territorial Sea but in that year this was extended to 12 n miles. The Government announcement stated that 'this would allow Australia to more effectively control its marine environment ... (and give) the ability to enforce oil and other marine pollution measures, as well as regulate navigation ... (and) will be another safeguard in protecting such valuable areas as the Great Barrier Reef.'(DFT 1990)

Controls on navigation enabled the introduction of compulsory pilotage in the Great Barrier Reef Channel in 1991. As certain shipping lanes in Bass Strait lie within the Territorial Sea 'normal passage' of shipping has been replaced by 'transit passage' giving Australia greater control on vessels using the lanes.

Contiguous Zone

In September 1991 the Government announced that Australia would declare a 24 n mile Contiguous Zone (by inclusion of a provision in the *Seas and Submerged Lands Act* 1973) to enhance the enforcement of customs and other laws. This is based on UNCLOS Article 33.

Continental Shelf

Australia has also decided to incorporate the UNCLOS definition of the continental shelf into domestic law. This definition has two elements: the geomorphological component which extends the shelf to the outer edge of the continental margin; and the distance component which extends the shelf a distance of 200 nautical miles from the baselines of the territorial sea. The outer limits must be within

Based on papers by: [1]Dr A. Bergin, Department of Politics, Australian Defence Force Academy, Canberra, Australian Capital Territory; [2] Dr V. Prescott, Department of Geography, University of Melbourne, Victoria; [3] Dr M. Haward, Department of Political Science, University of Tasmania, Hobart, Tasmania.

either 350 nautical miles of the Territorial Sea baselines, or 100 nautical miles of the 2,500-metre isobath, whichever is greater.

It has been estimated that the area of legal continental shelf around Australia and its territories (including the Australian Antarctic Territory) is over 15 million square kilometres. This is 1.5 times the area of the continent, and one of the largest continental margins in the world.

Australian Fishing Zone and Exclusive Economic Zone

In 1979 Australia established a 200 n mile Australian Fishing Zone (AFZ), with an area of 8.94 million square kilometres, in accordance with customary international law as reflected in UNCLOS. This was seen as the first step towards exercising its 200 nautical mile Exclusive Economic Zone (EEZ) rights. The AFZ excludes the area around the Australian Antarctic Territory.

In September 1991 the Government announced that it would declare an EEZ. Aspects of an EEZ regime which have already been effected include control over marine mammals (*Whale Protection Act* 1980), non-petroleum installations and structures (*Sea Installations Act* 1987) and dumping in the AFZ (Sea Dumping Regulations, 1984 No. 423). No jurisdiction on pollution has been asserted. At present Australian control and enforcement of MARPOL standards, defined in the International Maritime Organisation (IMO) 'International Convention for the Prevention of Pollution from Ships' in relation to foreign-flag vessels, extends only to pollution incidents within the territorial sea.

(Source: AGSO)

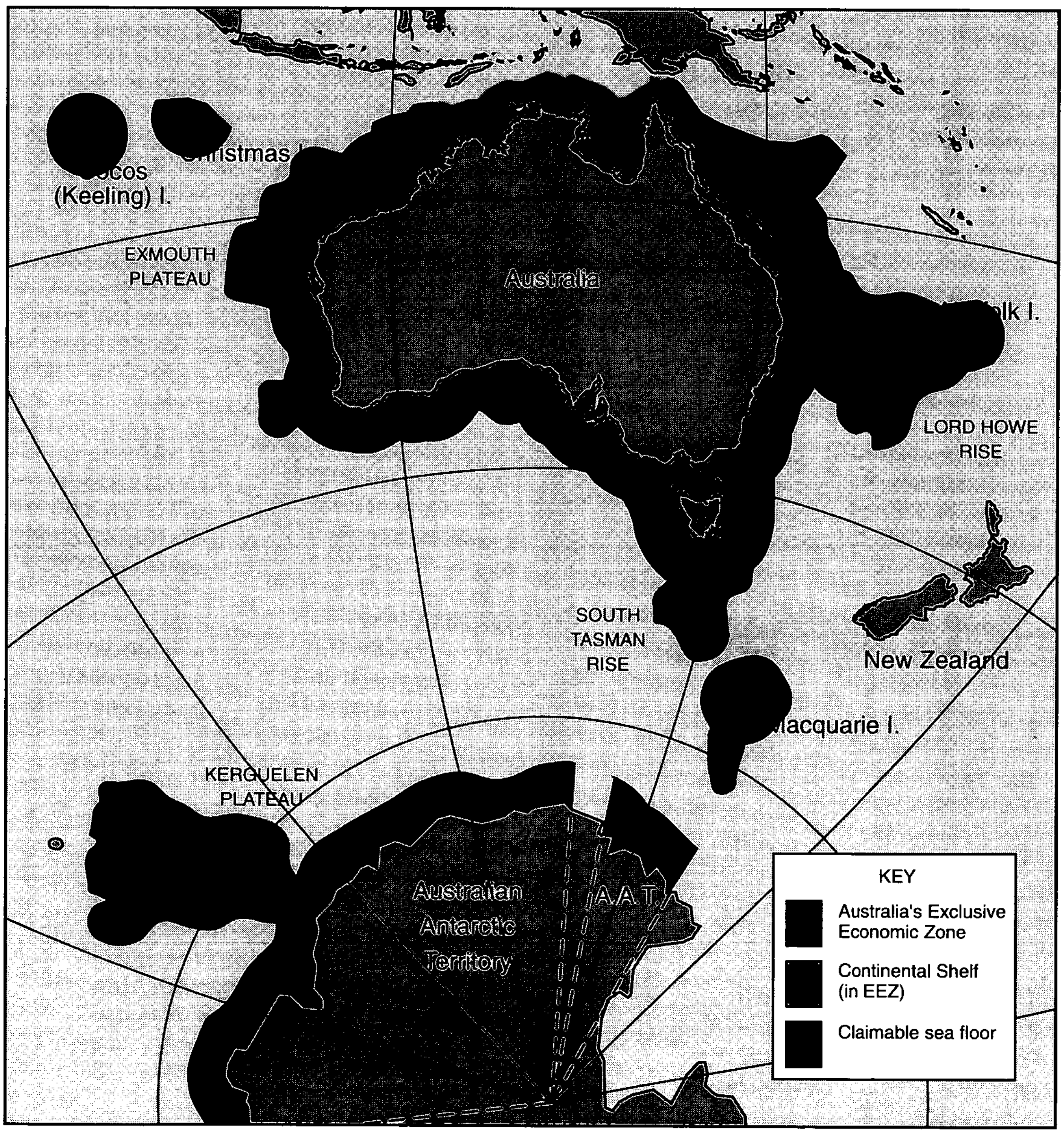

Figure 58.1: Australia's 200 n mile Exclusive Economic Zone and area of legal continental shelf (shaded).

Australia's Exclusive Economic Zone was declared on 1 August 1994, and entered into force on 16 November 1994. The area of Australia's EEZ is around 11.1 million square kilometres as it includes the waters off the Australian Antarctic Territory. This is one of the largest EEZs in the world.

Australia's international maritime borders[2]

Maritime claims under UNCLOS by neighbouring countries may overlap, necessitating negotiated boundaries to divide the overlap. Australia has six neighbouring territories close enough to produce overlapping national maritime claims.

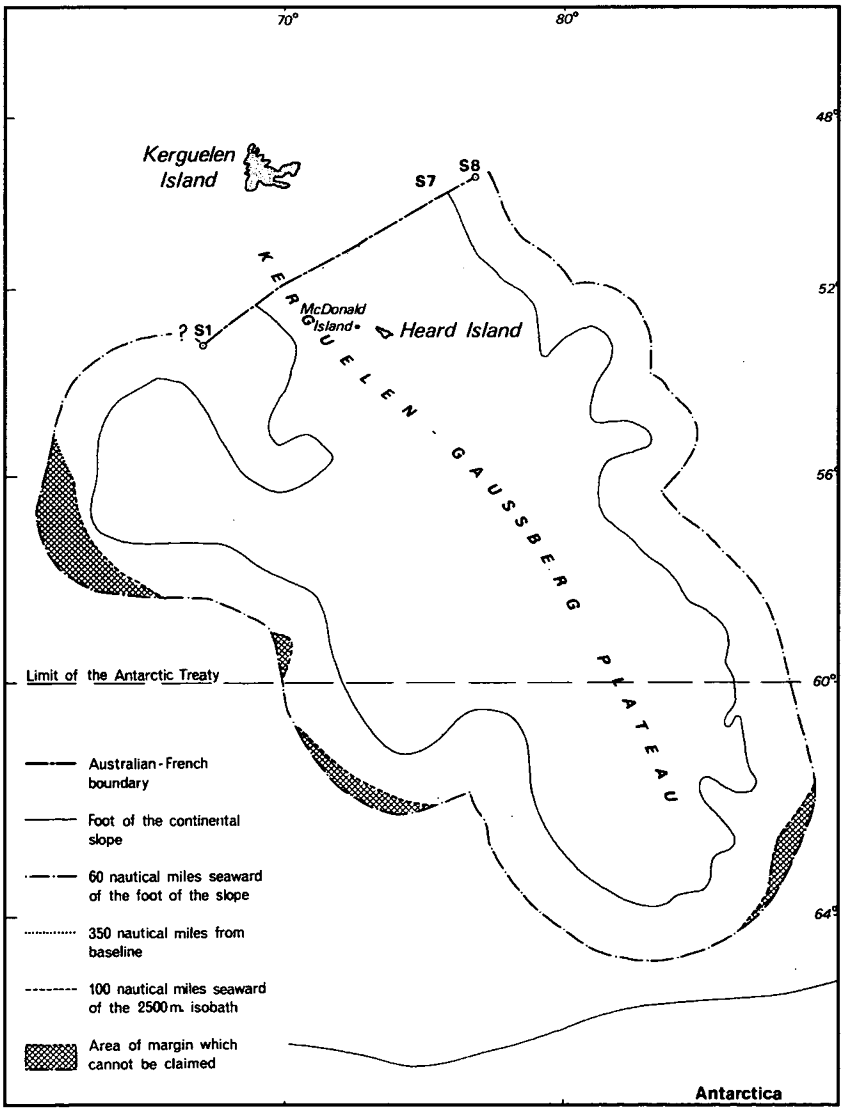

Figure 58.2: Heard, McDonald and Kerguelen Island boundary.

Iles Kerguelen

This island lies to the north-west of Australia's Heard and McDonald Islands, and is part of the Territory of the French Southern and Antarctic Lands. The boundary, agreed in treaty in January 1982, lies equidistant from the nearest points on the opposite shores.

Indonesia

Australia and Indonesia agreed on a series of boundaries between 1971 and 1989. The seabed boundaries follow a line of equidistance to the Timor Trough, which was claimed by Australia but disputed by Indonesia. A compromise gave Australia 70% of the disputed area. The 'Timor Gap' which existed in the border with former Portugese Timor since 1972 was 'plugged' in 1989 with a complex three-part zone to allow for exclusive and shared mining zones. Portugal is currently challenging Australia on these arrangements in the International Court of Justice. A provisional fisheries surveillance line was agreed following the declarations of Australia's Exclusive Fishing Zone and Indonesia's EEZ in 1979.

Papua New Guinea

Australia's border with Papua New Guinea (PNG) was difficult to negotiate as Australia owned all Torres Strait islands, to a stone's throw from PNG shores. Under the 1979 treaty the seabed was divided equally and runs close to 9°40'S parallel. The Australian islands outside this retain their 3 n mile territorial waters. The fisheries boundary diverged northwards to give Australia fishing rights on PNG seabed. An additional Protected Zone was established to protect the traditional fishing interests of PNG and Torres Strait Islanders (Chapter 74).

Solomon Islands

A boundary for the seas and seabed following a line of equidistance was settled in 1988.

New Caledonia

A boundary of equidistance was agreed in 1982.

New Zealand boundary to be determined

No boundaries have been drawn with New Zealand but in light of the long harmonious relationship, no difficult problems are anticipated.

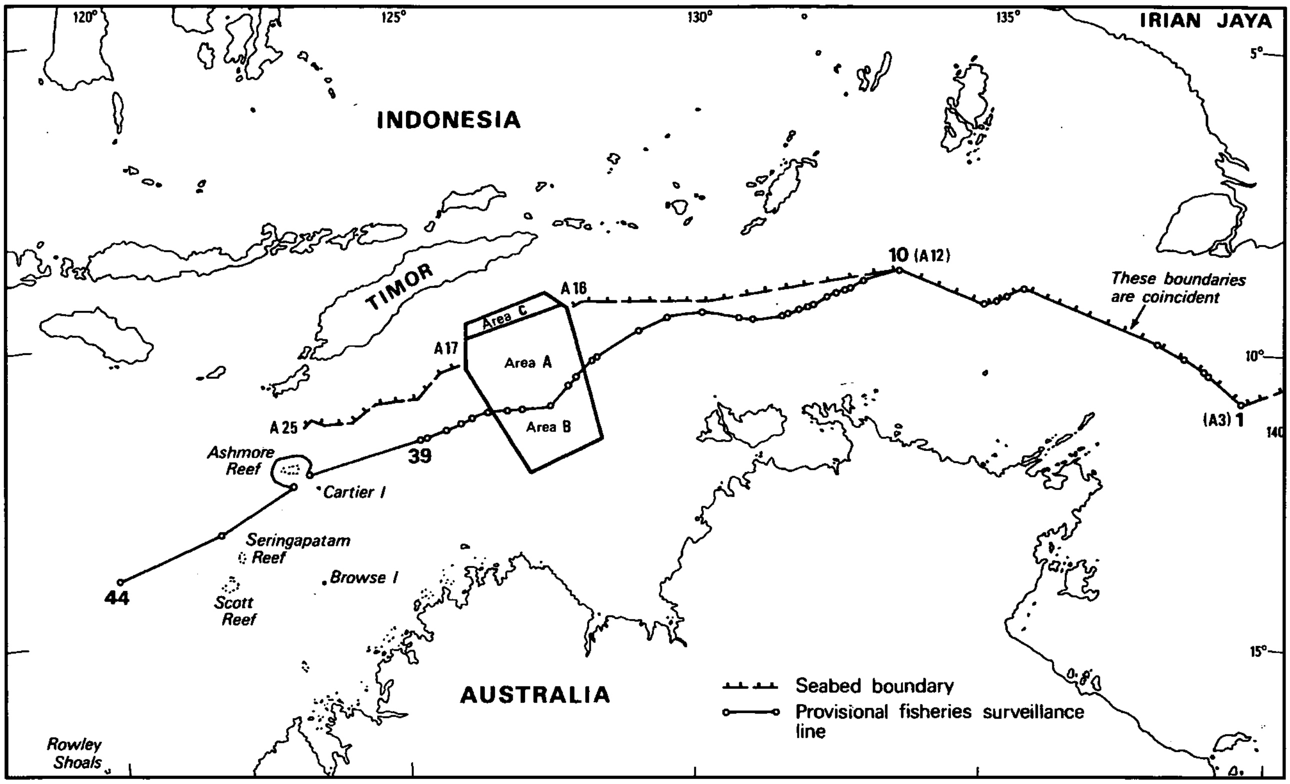

Figure 58.3: The Australian-Indonesian maritime boundaries and Zone of Cooperation.

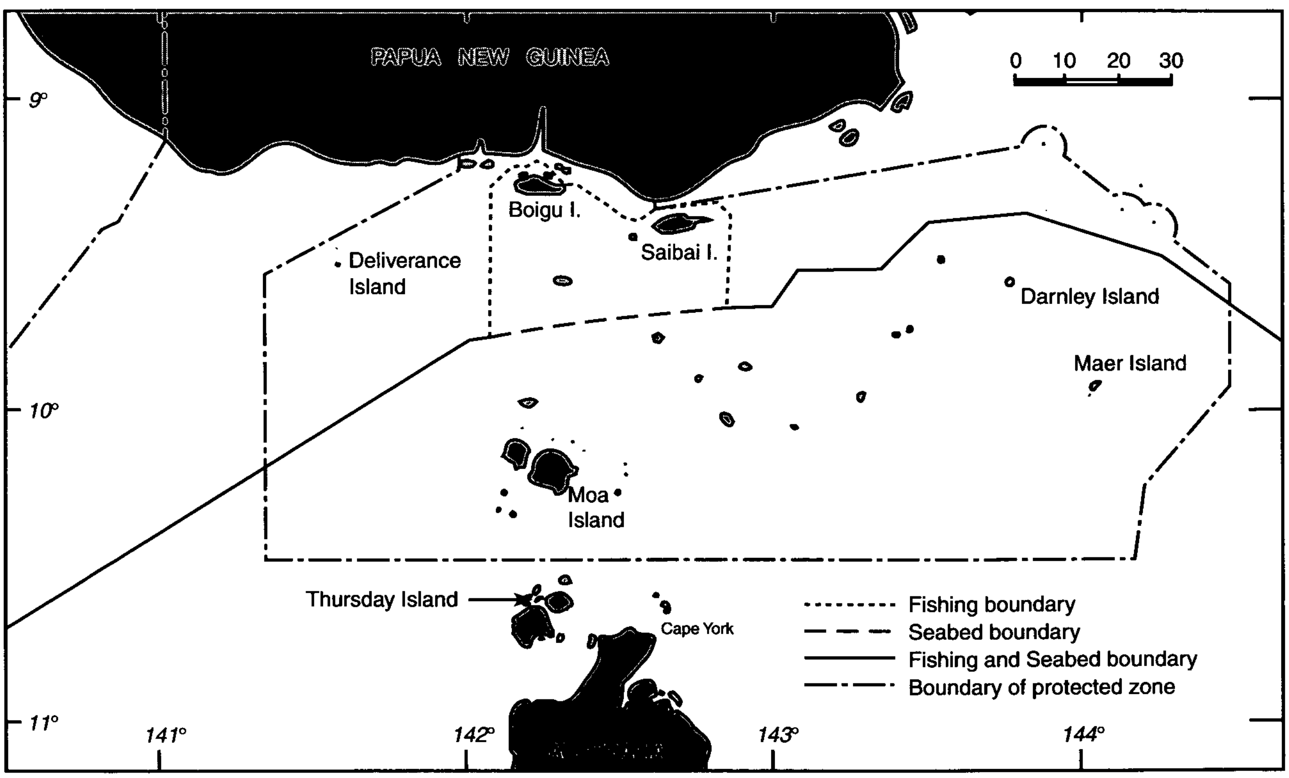

Figure 58.4: Australia's maritime boundaries with Papua New Guinea.

Intergovernmental relations[3]

As Australia's marine environment transcends the numerous administrative and political boundaries between the Commonwealth Government and the State, Territory and Local Governments, its management is undertaken through specific intergovernmental arrangements. These arrangements are therefore an important dimension in managing marine resources. The most significant of the multilateral intergovernment agreements are the Offshore Constitutional Settlement and the recently negotiated Intergovernmental Agreement on the Environment.

The Offshore Constitutional Settlement

Jurisdictional disputes over marine resources rose in the 1960s and 1970s as Commonwealth interests and international responsibilities came into conflict with established arrangements and activities of the States. It culminated with the Whitlam Government's *Seas and Submerged Lands Act* 1973 which declared Commonwealth jurisdiction from the low-water mark. Its legality was challenged by the States, but was upheld by the High Court in 1975.

Negotiations between the Commonwealth and the States were held to resolve the dispute. The interests and objections of the States and the Commonwealth's obligations and interests in managing the marine domain were resolved in a complex inter-governmental agreement, known as the Offshore Constitutional Settlement (OCS), which formalised their respective responsibilities. This agreement remains the primary arrangement governing the management of marine resources in Australia.

In 1979 the OCS established that the States would be responsible for management within the 3 n mile limit, with the Commonwealth responsible from this boundary to the edge of national jurisdiction as defined by UNCLOS (above). The Commonwealth *Coastal Waters (State Powers) Act* 1980 extended State jurisdiction three miles offshore and the *Coastal Waters (State Titles) Act* 1980 returned legal ownership of the seabed within this area to the States. The later *Sea Installations Act* 1987 gave to the States the power to administer Commonwealth legislation outside the 3 n mile limit.

The OCS includes a range of 'agreed arrangements' relating to management of marine resources covering oils and gas; other seabed minerals; fisheries; Great Barrier Reef Marine Park; other marine parks; historic shipwrecks; ship-sourced marine pollution; shipping and navigation; and crimes at sea.

The Intergovernmental Agreement on the Environment

An important watershed in Commonwealth-State relationships on the environment, The Intergovernmental Agreement on the Environment (IGAE), came into effect in May 1992 after two years of intensive negotiation. The IGAE is intended to provide: a cooperative national approach to environmental management; a better definition of the roles of respective governments; a reduction in disputes over the environment; greater certainty of government and business decision making; and better environmental protection. The IGAE includes nine schedules which cover such areas as data collection, environmental impact assessment, the management of World Heritage Areas, and nature conservation.

Section 2 of the Agreement delineates for the first time the responsibilities and interests of each of the three spheres of government. In doing so, it recognises that the States and Territories have responsibility for the majority of environmental issues within their borders. Nevertheless, it makes provision for the Commonwealth Government to become involved in the issues where it has demonstrated responsibilities and interests (ESDC 1992 P.116).

As the resolution of interests of Commonwealth and States, and the financial implications to the States of Commonwealth decisions, are likely to be contentious, the IGAE contains provisions and guidelines to resolve disputes. It recognises that the development of national standards relating to the environment will need to take account of the ability of State Governments to implement or comply with the guidelines.

Present legal and administrative arrangements on the marine environment

The OCS established that both Commonwealth and State governments have important roles in the management of the nation's marine environment, while the IGAE provided the opportunity for further development of intergovernmental arrangements.

The OCS arrangements are generally flexible on management of the marine environment. The fisheries arrangements established stock-based rather than jurisdiction-based management, and many of Australia's fisheries are now managed by the Commonwealth (Chapter 30). Offshore oil and gas remains the responsibility of the States, the Commonwealth sets broad policy and pricing of crude oil, and 'well-head royalties' are shared between the Commonwealth and States.

The OCS allows joint Commonwealth-State management where appropriate, for example where marine parks transcend the 3 n mile boundary between Commonwealth and State. The Great Barrier Reef Marine Park, jointly managed by the Commonwealth and Queensland, has been cited as a model of Federal cooperation.

Intergovernmental relations and management of the marine environment

Management of marine resources is based on a number of Commonwealth laws with regulatory arrangements deriving from this legislation.

The States and Local Councils are responsible for a number of activities which impact on the marine environment. Land use planning and approval for development in the littoral zone is a Local Government responsibility, subject to State government overseeing, and where applicable, to Commonwealth investment guidelines. Sea dumping and other ship-sourced pollution is regulated by the Commonwealth while emissions from pipelines are regulated by State law. The regulation of non-point source pollution is complex and may involve an intergovernmental dimension.

Commonwealth legislation

The Commonwealth has considerable responsibility regarding the marine environment. Major legislation includes the *Beaches, Fishing Grounds and Sea Routes Protection Act* 1932 (the nation's first anti-pollution law); the *Fisheries Act* 1952; various joint legislation with the States in the 1960s; and the *Great Barrier Reef Marine Park Act* 1975 (described as one of the cornerstones of national environmental policy). As a signatory to international and regional agreements, the Commonwealth has prohibited the States from permitting the dumping of low-level nuclear wastes at sea, and from 1995 when the amendments to the London Dumping Convention enter force, will prohibit dumping of wastes at sea.

Mechanisms for cooperation on the marine environment

Intergovernmental arrangements in Australia are established through a wide variety of mechanisms ranging from formal treaties to exchanges of memoranda of understanding.

Ocean Rescue 2000

The Commonwealth's Ocean Rescue 2000 program for the establishment of a national network of representative marine protected areas has increased the salience of the Commonwealth's interest in the marine environment. It has particularly highlighted the necessity for intergovernmental collaboration at all stages of a project, from conception to execution.

Summary and conclusions

1. The multiplicity of jurisdictions and administrative responsibilities involving Commonwealth, State and Territory, and Local governments has been a major impediment in the effective, integrated management of Australia's marine environment.

2. The Offshore Constitutional Settlement and the Intergovernmental Agreement on the Environment have provided a framework for Commonwealth/State cooperation on the management of the marine environment.

3. The establishment of a national marine management strategy and a network of marine protected areas will necessitate close cooperation by the Commonwealth, States and Territories.

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Acknowledgments:
The technical paper by Dr A. Bergin was reviewed by Dr D. Rothwell, Faculty of Law, University of Sydney, NSW; that by Dr M. Haward was reviewed by Professor B. Boer, Law Faculty, University of Sydney, NSW; and that by Dr V. Prescott was reviewed by D.J. Mason, Director, Sea Law and Ocean Policy Group, Legal Office, Department of Foreign Affairs and Trade, Canberra, ACT.

Chapter 59: Marine environmental impact assessment[1]

The EIA process is the 'orderly and systematic evaluation of a proposal including its alternatives and objectives and its effect on the environment, including the mitigation and management of these effects'.

(ANZECC 1991)

Within this definition the 'environment' includes physical, biological, social, economic and cultural factors. A 'proposal' includes a policy, program, plan or development project although at present most emphasis is placed on specific projects rather than policy level decisions.

What is an environmental impact assessment?

Environmental impact assessment (EIA) is an important instrument in Commonwealth, State and Local Government environmental policy in Australia. EIAs may involve some degree of public input or external peer review, or may be internally undertaken by an agency through environmental checklists or similar instruments. The latter, routine assessments occur in over 90% of proposals. The remainder are more involved (Figure 59.1).

Basic information on proposal

Is EIA required?

yes ◄—————————► *no*

Decision made as to appropriate level

Informal EIA ◄— **EIS type** —► *Public inquiry*

guidelines for EIS prepared

EIS exhibited and comments received

comments considered: EIS may be revised

recommendations ◄ **EIS assessed** ► *recommendations*
and recommendations made as to proposal

final decision: conditions may be set

monitor and audit if proposal proceeds

Figure 59.1: Generic EIA processes.

A tool for ESD

With the endorsement of the National Strategy for Ecologically Sustainable Development (ESD) in 1992, the governments of Australia have formally undertaken the task of attaining a greater integration of economic, environmental, social and equity variables into decision-making than is presently the case.

EIA is generally seen as a practical tool to assist this integration, and should operate to institutionalise the full consideration of environmental factors prior to the commitment of substantial financial resources to a proposal, and before political and economic pressures become too great. An effective EIA process can deliver both 'environmental' and 'economic' return by assisting in the development of rigorous environmental management plans to mitigate or eliminate adverse effects over a whole range of activities and by discouraging development not consistent with the maintenance of functioning marine ecosystems.

Key players in EIA

Proponent:
the developer, proposer, partner in joint venture or initiator of a proposal. This may be an individual, corporation, government department or authority.

Environmental consultant:
individual or group contracted by the proponent to undertake environmental evaluation of a proposal. The formal report describes methodology, data and conclusions on predicted impacts, with recommendations on a management program incorporating mitigatory measures and monitoring.

Assessing authority:
the relevant State/Territory or Commonwealth environment protection agency or other department which critically reviews the report and advises the decision-maker on its adequacy. It may attach 'conditions' of approval.

Decision-maker:
the designated Local, State/Territory or Commonwealth department or authority with responsibility for the final decision. It may impose certain conditions as part of the approval.

Public:
includes wider lay public, local community potentially most affected by a proposal, and conservation and other interest groups who may wish to contribute.

[1] Based on a technical paper by Dr A. Martyn and Professor B. Boer, Australian Centre for Environmental Law, Faculty of Law, University of Sydney, New South Wales.

EIA and other approval mechanisms

The operation of EIA in Australia must be considered in the context of the overall planning and approval process within each jurisdiction. A decision on a particular proposal must often consider a wide range of other legislation and government policy, such as:

Planning law and policy

Most States/Territories have a formal planning policy which incorporates planning legislation and regional development policies on coastal and marine activities.

Pollution and hazardous waste legislation

Regulations under the Commonwealth *Environment Protection (Sea Dumping) Act* 1981 and associated State legislation set minimum standards for any discharges into the adjacent marine environment.

Resource management

Government policy may provide guidance on methods by which natural resources may be managed, for example, it may specify use must be consistent with ESD principles.

Heritage legislation

Commonwealth and State heritage laws may be relevant. The *Australian Heritage Commission Act* 1975 provides for objects and places of significant natural and cultural heritage. Under World Heritage listing, the Commonwealth must consider international treaty obligations to protect heritage values.

Marine parks and reserves

Legislation may restrict activities within marine protected areas.

Responsibility for EIA in the marine environment

Responsibilities for invoking EIAs depend on jurisdictions (Chapter 58). The States and Northern Territory are responsible for the marine environment to the three nautical mile limit, and the Commonwealth to the edge of the 200 nautical mile Exclusive Economic Zone, offshore territories, the Great Barrier Reef Marine Park, and military zones. Due to the status of the Antarctic under international law, the Commonwealth has limited the operation of EIA legislation in the Australian Antarctic Territory.

Commonwealth and State/Territory arrangements for EIA

Situations in which both State/Territory and Commonwealth EIA processes may be triggered by a marine development are covered by bilateral agreements between Commonwealth and States/Territories, except in Queensland where *ad hoc* negotiations may be held. Under the 1992 Intergovernmental Agreement on the Environment, it is likely that these will be replaced by the National Agreement on EIA.

EIA in Commonwealth, State and Northern Territory governments

EIA procedures vary amongst Commonwealth, States and Territory governments.

Commonwealth

The *Environmental Protection (Impact of Proposals) Act* 1974 and accompanying Administrative Procedures apply to actions undertaken by the Commonwealth or its authorities 'that affect the environment to a significant extent.' Administrative Procedures require that effects on the relevant ecosystems and endangered flora and fauna, the aesthetic, scientific, social or historical significance of the area, and likely long-term effects or pollution problems be taken into account.

A decision on 'significance' is usually made during consultations with the Commonwealth Environment Protection Agency (CEPA) and the particular Commonwealth department concerned. Should the proposal be of environmental significance, the Minister for the Environment issues a directive about the level of assessment. Around 90% of proposals to which the Act applies are assessed internally by CEPA. The remainder undergo intensive scrutiny through an Environmental Impact Statement (EIS), or a somewhat less comprehensive Public Environment Report (PER). Public Inquiries may occasionally be undertaken as part of an EIA, for example, the 1993 Inquiry on Shoalwater Bay (Qld).

Guidelines for the content and methodology for an EIS or PER are produced through a scoping process so it focuses on key issues. After a satisfactory draft is completed, EIS or PER documents are generally made available for public review, and the document is revised, if necessary, to consider these comments. CEPA considers the findings and makes recommendations to the Minister responsible for the action. The EIA process may entail monitoring in which the appropriate authority periodically undertakes inspections or tests to ascertain whether the conditions placed on the proposal are being met, and environmental auditing which involves comparison of the actual impacts with the predicted impacts under the EIS or PER. Although it has not been conclusively settled, decisions under the Act are not reviewable by the courts (i.e. the 'correctness' of the assessment cannot be legally challenged).

Northern Territory

The model of EIA under the *Environmental Assessment Act* 1982 (NT) is similar to that of the Commonwealth. The coordinating and review body for EIA is the Environment Protection Unit of the Northern Territory Conservation Commission.

The main application for EIA to the marine environment of the Northern Territory is for port and ship loading facilities, residential and tourist development affecting mangroves, and mariculture projects. The triggering criterion of 'significant effect' is entirely a discretionary decision by the Minister for Conservation. A Preliminary Environmental Report may be initially carried out to determine if a full EIS is warranted. Following assessment of the EIS or Preliminary Environmental Report by the Environment Protection Unit, the Minister makes recommendations concerning the proposal. As these are advisory only, there are no grounds for appeal.

Queensland

The State *Development and Public Works Act* 1971 and the *Local Government (Planning and Environment) Act* 1990 are the principal Acts invoking EIA. The triggering of the first Act is entirely discretionary, but Government departments, authorities and local governments have a 'responsibility' to take into account environmental effects of a development where it 'appears' they are 'major'. Arrangements do not provide for the institutionalisation of input from community groups, nor is the final assessment of the Impact Assessment Study (IAS) by the relevant government authority. EIAs are most frequently applied to tourist resorts involving marinas, port facilities, and joint assessments with the Commonwealth, particularly in the Great Barrier Reef Marine Park.

Under the latter Act, a local authority is required to take into consideration any 'deleterious effect' on the environment in its decisions on developments. The local authority has discretion on whether an IAS is necessary except in certain situations. IASs are mandatory in 'designated developments' (mariculture facilities, marinas, tourist facilities over a certain size, and excavation of certain tidal areas) and for certain areas or ecosystems (Coastal Management Control Districts, fishery reserves, National Parks and tidal wetlands). In some cases, a third party may appeal a decision on the grounds that the local authority failed to adequately consider environmental impacts.

New South Wales

EIA is carried out under the *Environmental Planning and Assessment Act* 1979. Compared with other jurisdictions, there is less emphasis on Ministerial discretion as to the triggering of EIA, subsequent procedural steps and to matters to be addressed. The Act also allows any person to challenge the legality of an assessment before the Land and Environment Court where provisions of the Act have not been followed.

An EIS is required in the case of designated developments (e.g. canal development, marinas and associated works over a specified size, port facilities, oil refineries), or if the proposed activity is 'likely to significantly affect the environment.' The Assessments Branch of the Department of Planning reviews the EIS and makes its recommendations to the decision-making authority.

Victoria

The *Environmental Effects Act* 1978 gives the Environment Minister discretion to order a Preliminary Environment Report (PER) or Environmental Effects Study (EES) for: public works carried out by government or statutory bodies that have a significant effect on the environment; other works that could have a significant effect in which a 'decision' by a government officer is required; and other Ministerial decisions or actions.

Most procedural details relating to EESs are contained in administrative guidelines. One includes the establishment of a Consultative Committee, comprising Local and State government interests, the proponent, and community representatives. In difficult or contentious cases, a Public Inquiry may be established. Rights of appeal are limited.

Tasmania

EIA process is regulated under the *Environmental Protection Act* 1973, a law largely on pollution control. EIA administration is the responsibility of the Division of Environmental Management of the Environment Department. Proponents of scheduled activities (generally polluting and extractive industries, such as oil refineries and sewage outfalls) may be ordered by the Director of Environmental Management to provide such information as required (in effect an EIA). For non-scheduled activities, the Director may only 'request' information.

EIAs are carried out at three, increasingly detailed levels: (1) an administrative assessment incorporating public input through advertisements; (2) production of a Development Proposal and Environmental Management Plan; and (3) a full EIS. Appeal is possible only at the final licensing decision of the Director.

South Australia

The *Planning Act* 1982 provides three methods for the triggering of the EIA process: (1) the Minister of Environment and Planning is of the opinion that a proposed development is 'of major social, economic or environmental importance'; (2) The State Governor may declare certain geographic areas or classes of development as requiring an EIA (e.g. oil refineries and marinas); and (3) in cases of public works, a recommendation is given to the Minister by the Planning Commission.

PERs and EISs are currently employed but no formal criteria have been established on their use. In the case of an EIS, after drafting and public comment and assessment by the Department of Environment and Planning, the Minister decides on 'necessary' amendments. The decision-making authority depends on who triggered the EIS (above). Appeals against a decision of the Planning Commission are possible on legal grounds. Amendments to the Act are currently planned under the Development Bill in 1993.

Western Australia

The *Environmental Protection Act* 1986 may trigger an EIA if a proposal: appears likely to have a significant impact on the environment; is of a prescribed class (none have yet been prescribed); or generates public concern about its likely effect on the environment.

Decisions on the EIA procedure are made by the Environment Protection Authority (EPA). As in Tasmania there are three levels of assessment. The EPA publishes a public report of its assessment, which is considered by the Minister and decision-maker. Public Inquiries may be ordered by the EPA with consent of the Minister. Appeals by third parties are possible regarding: decisions not to subject a proposal to EIA; the 'level' of EIA carried out; and the contents and recommendations of the EPA's assessment report. Proponents may appeal against any conditions imposed by the Environment Minister. All appeals are ultimately decided by the Environment Minister.

Evaluation of marine EIA in Australia

EIA has been operating at the Commonwealth level for almost 20 years, and in the States/Territories for half that. It has been accepted by government as a workable tool for the management of adverse environmental impacts of development.

However, it is considered that the potential contribution of EIA to the overall management of the marine environment has not yet been fully realised in Australia.

perspectives of management ...

Is the EIA process effective in managing the marine environment?

Environmental education
Many environmental managers believe that the principal benefit from EIA is, in fact, educational. Both the general public and project proponents learn from involvement in the process. For the general public, there can be increased understanding of natural processes, of decision-making and of the economics of development versus protection of existing environments. For developers, awareness of the potential environmental consequences of their proposals can be very enlightening, and frequently leads to modification of projects.

Public input and empowerment
It is also very important for communities to feel they have some control over, or at least input to, decisions that affect their surroundings. EIA can in fact reduce to a complex form of popularity poll in which subjective emotion-based objections to proposals (based on the principle of 'not in my back yard!') are disguised as objective argument using the EIA process as the catalyst. This is not necessarily undesirable, but it is not a commonly acknowledged objective of EIA.

Addressing Aboriginal interests
EIA has also become a vehicle whereby the interests of Aboriginals can be very effectively canvassed, and the process of Reconciliation can be assisted. This has benefits for both the Aboriginal communities concerned and the general public who are often not well informed on the issue.

EIAs may become shams
In some cases, EIA may be debased into an elaborate public relations exercise. This is often the case where decisions to proceed have already been made, but are 'subject to EIA'! The general public is becoming more aware of this, and increasingly demands that such *faits accompli* do not occur.

Does EIA lead to 'better' decisions?
'Yes', if only because a modern, open and accountable EIA process has the effect of keeping all parties honest. In terms of the marine environments, specific proposals are more likely to be the subject of decisions closer to the public interest than would be the case in the absence of EIA.

'But', the public may be duped by the concept of EIA. Despite what the public may believe, it would be exceptional for the fate of a project to rest entirely on the results of EIA, particularly at the Local or State Government levels, where most decisions are made. Decision-makers are not generally swayed by the responses of individuals as such responses are often counterbalanced by opposing individual views. But concerted lobbying by groups can be very effective and may lead to decisions that are more likely to be influenced by politics than by strict environmental criteria.

by M. Bugler, Director, Environmental Impact Management, Great Barrier Reef Marine Park Authority, Townsville, Queensland.

Part of the explanation lies in the deficiencies of Australian EIA processes in general:
- inconsistency of application;
- lack of total transparency in decision-making;
- failure to systematically incorporate cumulative impacts;
- questions of resource allocation; and
- biases of environmental consultants towards the proponent (their client).

In particular, the complexities of jurisdiction, legal and policy instruments in the coastal zone retards the integration of EIA into any strategic coastal planning process. The emphasis on project-specific assessment and the complexity of the land/sea interface makes regional assessment necessary, but this infrequently occurs in practice. Finally, comparatively little work has been done on the design and application of EIA 'framework' guidelines for use in the marine environment.

The House of Representatives Standing Committee on the Environment, Recreation and the Arts inquiry in 1991 on protection of the coastal environment particularly commented on the multiplicity of public agencies, arbitrary administrative boundaries and the failure to consider cumulative effects of decisions (the 'tyranny of small decisions').

Summary and conclusions

1. The EIA process is the 'orderly and systematic evaluation of a proposal including its alternatives and objectives and its effect on the environment, including the mitigation and management of these effects'.

2. EIA is an important instrument in Commonwealth, State and Local Government environmental policy in Australia.

3. Responsibilities for invoking EIAs depend on jurisdictions. The States/Territories and Northern Territory are responsible for the marine environment to the three nautical mile limit, and the Commonwealth to the edge of the 200 nautical mile Exclusive Economic Zone.

4. The nature of the EIA process differs in the Commonwealth, States and the Northern Territory.

5. In general, the potential contribution of EIA to the overall management of the marine environment has not yet been fully realised in Australia.

6. Deficiencies of Australian EIA processes include: inconsistency of application; lack of total transparency in decision-making; failure to systematically incorporate cumulative impacts; questions of resource allocation; biases of environmental consultants towards the proponent (their client); and the complexities of jurisdiction, legal and policy instruments in the coastal zone.

7. Comparatively little work has been done on the design and application of EIA 'framework' guidelines for use in the marine environment.

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Chapter 60: Protection of marine species: national and international responsibilities[1]

In recent years the Commonwealth Government has increasingly recognised the great diversity of marine species in Australian waters, and has undertaken their protection through a variety of legislative and international instruments. These include several Commonwealth Acts and a number of bilateral and multilateral agreements and conventions.

This chapter provides a review of relevant Commonwealth legislation and international conventions for the protection of marine species.

Commonwealth legislation

National Parks and Wildlife Conservation Act 1975 and National Parks and Wildlife Regulations

All marine wildlife within the nine marine protected areas managed by the Australian Nature Conservation Agency (ANCA) (Chapter 73) is protected under the provisions of this Act and Regulations, and specific management plans. Regulations protecting some designated organisms also apply in waters outside protected areas (e.g. the External Territories of Christmas Island, Cocos (Keeling) Islands and the Coral Sea Islands Territory), unless taken in accordance with a Commonwealth or Territory commercial fishing law or otherwise exempted under regulation 48 ('Animals and plants may be declared to be unprotected').

Marine organisms listed as protected on Schedule 1 of the National Parks and Wildlife Regulations in all Commonwealth waters over the continental shelf (out to the limit of the Australian Fishing Zone) include sea snakes, crocodiles, turtles, birds, dugong, seals, fur seals, sea lions, and all pelagic algae. These protected organisms may be collected only under licences which are only issued for the purposes of scientific research, educational study or non commercial propagation, or if the taking is in accordance with a management program. To date, no licences have been issued.

Whale Protection Act 1980

This Act prohibits the killing, injuring, taking or interfering with any cetacean (whale, dolphin or porpoise) in waters under Commonwealth jurisdiction, and such actions by Australian residents and Australian registered vessels elsewhere in the world. Between 1991 to mid-1993, eight permits were issued to conduct research on whales in Commonwealth waters and by Australians in areas outside the Australian Fishing Zone.

Wildlife Protection (Regulation of Exports and Imports) Act 1982

This Act implements Australia's obligations under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (below). Generally, wild specimens of listed native marine organisms may only be exported commercially where the specimens are subject to a management program approved under the Act, or where the specimens have been declared as controlled specimens.

Australian marine taxa and species listed on Appendix II of CITES and on Schedule 2 of the *Wildlife Protection (Regulation of Exports and Imports) Act* 1982

Arctocephalus spp. (southern fur seals)
Mirounga leonina (elephant seal)
Dugong dugon (dugong)
Crocodylus porosus (saltwater crocodile)
Coenothecalia ('blue' hard corals)
Tubiporidae (organ pipe corals)
Antipatharia (black corals)
Scleractinia (hard corals)
Milleporidae (hard corals)
Stylasteridae (hard corals)
Tridacnidae (giant clams)

Endangered Species Protection Act 1992

This Act applies to Commonwealth and Commonwealth controlled areas. It includes provision for a scientifically based listing process that identifies nationally endangered and vulnerable species, endangered ecological communities, and key

[1]Based on a paper by Dr A. Ivanovici, G. Anderson, F. Antram, J. Crennan, B. Male, R. Moore and K. Weaver, Australian Nature Conservation Agency, Canberra, Australian Capital Territory.

threatening processes; the use of recovery plans and threat abatement plans to assist in the recovery of endangered species and to control key threatening processes; assistance to States and Territories for preparing recovery plans for these, and for implementing approved recovery and threat abatement plans.

Great Barrier Reef Marine Park Act 1975 and Great Barrier Reef Marine Park Regulations

The Great Barrier Reef Marine Park covers approximately 350,000 square kilometres of marine (and some island) habitats off Queensland (Chapter 69).

The Great Barrier Reef Marine Park is a multiple-use marine protected area. Zoning plans are the main instruments for environmental conservation and management of uses. In Preservation and Scientific Research Zones entry into the zone and the taking of marine species is totally prohibited other than for the purpose of scientific research. In Marine National Park zones and General Use A zones, the habitat of marine species is protected by non-allowance of highly impacting activities such as trawling.

In zones where limited collecting is allowed, invertebrates (apart from protected coral and some mollusc species) and aquarium fish may be collected up to the bag limit of five of any one species in any 28 day period. Only hand-held implements are allowed to be used for the collecting. Higher levels of collecting require a permit. Permits are granted for the taking of turtle and dugong for purposes of scientific research and traditional use. The taking of endangered species of turtle for the latter use is not permitted.

International agreements

The Australian Government has responsibilities for the protection of marine species and environments under a number of international nature conservation treaties. Implementation generally occurs through the application of State and Territory legislation for species protection.

The Bonn Convention

The Bonn Convention on the conservation of Migratory Species of Wild Animals ('CMS') is an inter-governmental treaty that aims to conserve terrestrial, marine and avian species over the whole of their migratory range. The Convention arose from a recommendation of the 1972 United Nations Conference on the Human Environment that recognised the need for countries to cooperate in the conservation of animals that migrate across national boundaries or between areas of national jurisdiction and the high seas. This recognised that migratory species are particularly vulnerable to a wide range of threats, such as shrinking habitat in breeding areas, excessive hunting along migration routes and degradation of feeding sites. The Bonn Convention must also meet the new challenge presented by the 1992 United Nations Conference on Environment and Development (UNCED): that of reconciling conservation and development interests.

Implications of section 211 of the *Native Title Act* 1993 on protection of marine species

The Commonwealth *Native Title Act* 1993 came into force on 1 January 1994. It applies to all of Australia including offshore areas and the external territories.

Section 211 of the Act addresses the issue of preservation of certain native title rights. Where a law requires people to have a permit to take various living resources or access an area for cultural or spiritual activities, and the law is not one for the benefit of native title holders, then those native title holders may undertake that act without a permit in respect of the area or resource over which they have native title.

In Commonwealth legislation such as the *Great Barrier Reef Marine Park Act* 1975 and the *Endangered Species Protection Act* 1992, native title holders may in some areas be able to take species, including endangered species, without a permit due to the operation of s. 211. In respect of those areas, it may be argued that the law in place regulating the take of marine species through permit processes is not one for the benefit of native title holders. It can be argued that such a provision will actually assist in the conservation of species such as dugong and turtles because it empowers the native title holders to take responsibility for the protection of the populations of those species within their traditional clan estates.

It should also be appreciated that s. 211 does not allow access to areas for which access is prohibited, nor does it allow the taking of species where such taking is totally prohibited other than for the purpose of scientific research.

(Source: Dr S. Sparkes, Great Barrier Reef Marine Park Authority, Townsville, Queensland)

Australia became a Contracting Party to the Bonn Convention in 1991. It has successfully nominated marine turtles of the Indo-Pacific Region as priority species for the next triennium. This includes developing of a regionally coordinated review paper on the status and threats posed to marine turtles with a strategy document detailing possible cooperative initiatives. ANCA considers that bilateral and multilateral measures for regional marine turtle conservation are essential.

Bilateral migratory bird agreements

These Agreements aim to promote cooperative conservation of birds migrating between the Australia and other range states. They prohibit taking and trading in migratory birds, their eggs and derivatives, with exceptions for scientific, breeding or other purposes consistent with the Agreements. Special protection is extended to species in danger of extinction, whose import and export are to be strictly controlled. The Contracting Parties undertake to exchange data and publications in respect of migratory and endangered species and to establish research programs for their protection. They are required to take measures to prevent danger to such birds and their habitats (such as to establish reserves), to control cross-boundary trade in such birds and to avoid introducing species which would upset the ecological balance.

International Convention for the Regulation of Whaling 1946

The International Whaling Commission (IWC) was established under the International Convention for the Regulation of Whaling. The Australian Nature Conservation Agency has provided extensive support to Australian participation in the IWC for many years, and provides the Australian Commissioner to the IWC.

Within the IWC, Australia has maintained its opposition to whaling and its commitment to seeking worldwide protection for all cetaceans. Moves for special interim catches for small-type coastal whaling operations in Japan have been successfully opposed within the IWC and the moratorium on commercial whaling remains in place.

At the 1993 meeting, the Commission considered a proposal for a sanctuary in the Southern Hemisphere for all waters south of 40°S, which was put forward by the Government of France. This was successfully adopted at the 1994 meeting.

Another concern in the IWC has been the status of some dolphin and porpoise populations as well as populations of some species of small toothed whales. Direct hunting, incidental catches in commercial fisheries and habitat modification, degradation and pollution threaten some species, particularly those in inshore waters. Because of different views within the Commission on responsibility for management of such species, however, it has been restricted to providing advice to the Governments concerned.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

Many species are declining in numbers because of loss of habitat and increased exploitation as human populations grow, including trade. The wildlife trade is a lucrative business and involves a wide variety of species as live specimens and as products. Millions of live animals and plants are shipped around the world each year to supply the pet and ornamental plants trades. Tourists buying souvenirs also contribute to this trade. This international wildlife trade has contributed to declines in the numbers of many species of animals and plants.

Agreements on migratory species

Japan-Australia Migratory Birds Agreement

The Agreement Between the Government of Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (JAMBA) was signed in 1974. Cooperative projects include a survey of Latham's snipe and a taxonomic study of the little tern. At the 1991 consultative meeting, Latham's snipe, little tern and eastern curlew were also nominated as 'special interest species' in an effort to focus research effort and exchange of information.

China-Australia Migratory Birds Agreement

The Agreement Between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment (CAMBA) was signed in 1986. In September 1991 the Government of the People's Republic of China hosted the First Consultative Meeting. Under CAMBA, joint projects have been proposed including surveys in China, personnel exchanges and, as with JAMBA, three species (eastern curlew, great knot and red-necked stint) have been nominated as 'special interest species'.

Memorandum Of Understanding for Cooperation with Indonesia

In 1990 the Australian Environment Minister and the Indonesian counterpart State Minister for Population and the Environment signed the Ministerial Statement of Intent Between Australia and the Republic of Indonesia in the Field of the Environmentally Sound and Sustainable Development. This Statement recognises the need for cooperation between Australia and Indonesia for the conservation of migratory species.

Table 60.1: International Treaty obligations. The Australian Nature Conservation Agency has specific responsibilities in relation to a number of international nature conservation treaties. Implementation of these treaties requires the cooperation of State and Territory governments, as the Commonwealth does not have the necessary legislation with respect to land management or species protection. These conventions and agreements impose obligations upon Australia to protect coastal and marine environments. (Source: ANCA 1992)

International Convention	Obligations	State Involvement	Coastal Implications
Convention on Wetlands of International Importance (Ramsar Convention)	list appropriate sites as wetlands of international importance;	essential	Currently 18 of the 40 nominated Wetlands of International Importance are located in the coastal zone.
	to promote the wise use of wetlands concept;	essential	
	to cooperate with neighbours in protecting shared wetlands resources (such as migratory birds in Australia's case);	essential	
	to establish training programs for managers and education programs for the community;	important	
	to promote the conservation of wetlands and waterfowl by establishing nature reserves on wetlands.	essential	
Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)	to protect endangered and threatened migratory species as listed in the annexes to the Convention;	essential	An Asian Migratory Birds Agreement which aims to protect migratory species of birds and their environments throughout the East Asian Flyway and the Central Asian Flyway is currently under development. Most of these bird species visiting Australia are reliant on the coastal zone.
	to establish regional agreements for the conservation of migratory species and their important habitat areas.	essential	
Japan-Australia and China-Australia Migratory Birds Agreements (JAMBA and CAMBA, respectively)	to protect birds migrating between the two countries, as recognised under the agreed annexes, and their important habitat areas;	essential	Under each Agreement the respective Governments are required to endeavour to preserve and enhance the environment of birds protected under the Agreements through damage prevention, environmental management, establishment of sanctuaries and control of importation of wildlife.
	to develop cooperative research projects to assist future management;	desirable	
	to share information and expertise relevant to the conservation management of these species;	important	The majority of bird species protected under the agreements are coastal inhabitants.
	JAMBA has specific obligations related to the protection of endangered bird species.	essential	
Convention on Conservation of Nature in the South Pacific (Apia Convention)	to encourage the creation of protected areas;	essential	Encourages signatory countries to declare protected areas (including marine and estuarine protected areas).
	to protect endangered species;	essential	
	to make provision for traditional use of areas and species;	essential	
	to cooperate with other Contracting Parties, especially within the framework of the South Pacific Commission.	desirable	
International Convention for the Regulation of Whaling	to provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry.	essential	
	State legislation applies in 3 km coastal sea.	essential	*Whale Protection Act* 1980 which provides protection to all cetaceans, prohibits any killing, taking, injuring or interfering with cetaceans in the Australian Fishing Zone.
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	to protect certain species of wild fauna and flora against overexploitation through international trade.	important	Australia's obligations under CITES are implemented through the *Wildlife Protection (Regulation of Exports and Imports) Act* 1982. This Act is a significant piece of legislation affecting the utilisation of many species occurring in the coastal zone which are or may become endangered due to trade (but not those listed in Schedule 4 of the Act, which includes marine fish and certain marine invertebrates which are harvested commercially).

The CITES treaty of 1973 aims to protect wildlife against such overexploitation and to prevent international trade from threatening species with extinction and now has more than 100 member countries. These countries act by banning commercial trade in an agreed list of currently endangered species and by regulating and monitoring trade in others that might become endangered.

CITES controls international trade in two main categories of species. Endangered Species, listed in Appendix I to the Convention, are species threatened with extinction which are, or may be affected by trade. The list includes all sea turtles and great whales. Other species at serious risk include species which might become endangered if their trade is not controlled and monitored 'in order to avoid utilisation incompatible with their survival'. These species are listed in Appendix II to the Convention. To prevent threatened species from being traded under the guise of non-threatened species similar in appearance, some non-threatened species are also included in the appendix.

Programs arising from legislative and international conservation responsibilities

Cetacean Conservation Program

ANCA conducts a cetacean conservation program which aims to provide for effective conservation of all cetaceans in Australian waters through implementation of the *Whale Protection Act* 1980 and to foster the development of regional and international cetacean conservation measures. ANCA also coordinates activities undertaken under the National Cetacean Stranding Contingency Plan which includes assistance to States and the Northern Territory for helping stranded cetaceans, production of publications and collaboration with community groups and schools, and collection and analysis of strandings data. ANCA provides funds for a long-term monitoring program of the recovery of southern right whales off Western Australia and of humpback whales off the east and west coasts. Whale watching and ANCA's guidelines for whale watching are discussed in Chapter 18.

Endangered Species Program

The Endangered Species Program was established in 1989 to reduce further extinctions of Australian wildlife, to prevent further species and communities from becoming endangered, and to restore endangered species and communities to a secure status in the wild. Two advisory committees have been established under the *Endangered Species Protection Act* 1992, the Endangered Species Advisory Committee and the Endangered Species Scientific Subcommittee.

Major activity areas of the Endangered Species Program are: identifying species most at risk, reviewing threatening processes and clarifying priorities; action on the recovery of individual species or communities; research and management associated with key threatening processes that impact on a number of endangered species; and educational activities to encourage community understanding and involvement in endangered species conservation.

Action plans have been commissioned for most of the vertebrate taxa groups including cetaceans, seals and dugong. These plans review the conservation status of the target group; provide a brief recovery outline for each threatened species and subspecies; briefly review past and current management and research; and describe and cost future conservation action. They prioritise species-based actions and where possible, identify common threatening processes affecting species groups and the actions that should be initiated to reduce these threats.

Recovery plans define the research and management actions necessary to stop the decline of and support the recovery of, the species or community so that its chances of long-term survival in nature are maximised.

The Endangered Species Program has commissioned a number of important marine projects, including a review of endangered species and threatening processes in the marine environment; overviews of the conservation status of dugong, Australian seals and sea lions and sea turtles; and accounts of seabird species.

Current major initiatives for marine wildlife include development of action plans for Australian cetaceans, seals and dugong; a threat abatement plan to reduce the incidental by-catch of albatross by commercial longline fishing operations; and a research plan for Gould's petrel.

Other regional activities

ANCA is also involved in a conservation program for marine turtles in the Indo-Pacific Region, and the South Pacific Regional Environment Program (SPREP) Marine Turtle Conservation Program. Expected outcomes include development of a regional marine turtle conservation and management program for the six species occurring in the region. The Turtle Conservation Program includes establishing the SPREP marine turtle bibliography, tagging and migration database involving the South Pacific area; producing educational materials including posters referring to turtle tagging information and promotion of turtle conservation available in nine languages; and training for different field techniques and the SPREP bibliographic data base.

Summary and conclusions

1. Australia's marine wildlife are protected under a range of legislation and regulations, the principal being the *National Parks and Wildlife Conservation Act* 1975, the *Whale Protection Act* 1980, *Wildlife Protection (Regulations of Exports and Imports) Act* 1982, and the *Endangered Species Protection Act* 1992.

2. Australia also has responsibilities for the protection of marine species and environments under a number of international nature conservation treaties, the principal being the Bonn Convention on migratory species, various bilateral migratory bird agreements, the International Convention for the Regulation of Whaling 1946, and the Convention on International Trade in Endangered species of Wild Fauna and Flora (CITES).

3. Programs arising from these responsibilities include the Cetacean Conservation Program, the Endangered Species Program, and various regional activities on turtles.

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Chapter 61: Ecologically sustainable development: the national strategy and implications for marine environmental management[1]

In the past few years the concept of ecologically sustainable development (ESD) has captured the imagination of many Australian environmental managers, conservationists, economists and industrialists as an important unifying goal for conservation and development. ESD has been widely embraced as a means of managing increasing human demands on the ultimately limited capacity of the natural environment. The ESD Strategy has been formally endorsed by all levels of government in Australia and is of fundamental importance to the Ocean Rescue 2000 program.

The concept of 'sustainable development' was placed on the global agenda through the 1987 report of the World Commission on Environment and Development entitled 'Our Common Future' (the Brundtland Report). The definition of sustainable development it proposed was:

> *Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.* (WCED 1987, p. 43)

The Commonwealth Government took up the challenge and embarked on a process of exploring what sustainable development would mean for Australia. The term 'ecologically sustainable development' (ESD) was adopted for use in the Australian context. A Commonwealth Discussion Paper on Ecologically Sustainable Development proposed the following definition:

> *Ecologically sustainable development means using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.* (COA 1990, p. (i))

This chapter summarises the ESD Process and National Strategy in Australia, its economic and ecological implications, and discusses its relevance to the management of coastal and marine environments in Australia.

The ESD 'Process' in Australia

The ESD 'Process' in Australia involved the formation of Working Groups consisting of representatives of

What is ESD? ESD Working Groups discussions

The Chairs of the ESD Working Groups had extensive discussions on what ESD entailed. The following extract emphasises the issues and practical considerations involved in the concept of ESD:

We know that ESD involves both economic (including social) development and ecological sustainability. Defining economic development provides less ambiguity in principle than ecological sustainability. Economic development is wider in context than economic growth as it has been traditionally understood. Development includes material well-being but also non-material well-being, satisfaction and quality-of-life elements. Intrinsic to these considerations is the quality of the environment, the evidence being that in Australia, as in most countries, environmental conditions are an increasingly important contributor to quality of life. The social aspects of economic development encompass economic stability and security (including freedom from want) and social equity (including equality of opportunity). These go well beyond what we normally mean by economic growth, although without economic growth, other economic and social objectives will be difficult to achieve.

The policy challenge is how to achieve the necessary integration of economic development and ecological sustainability. What is important is the understanding that as a broad principle there is no necessary conflict between economic and environmental goals, and indeed that both have to be pursued simultaneously and in harmony in an economic development process that is ecologically sustainable. Ecological factors provide the complexity, in part because they are the less familiar part of the package, but in part because of their intrinsic complexity.

(ESD Working Group Chairs 1992, p. 2).

[1]Based on a paper by S. Driml, Australian National University, Canberra, Australian Capital Territory; with contributions by Dr L. Zann, SOMER Coordinator.

the three levels of government, industry, unions, environment groups, community groups and experts in various fields. These addressed 'sectoral' issues which included fisheries, tourism, and transport. The Chairs of the Working Groups also addressed the Greenhouse effect and a number of other intersectoral issues which included population, urban issues, the coastal zone, water issues and Aboriginal issues.

Draft reports were initially released for public comment and final reports were released in 1991-92. An Intergovernmental ESD Steering Committee was then established to examine and respond to the reports and recommendations of the Working Groups. The National Strategy for ESD was endorsed at a meeting of the Council of Australian Governments in December 1992. The Council of Australian Governments noted, on endorsing the National Strategy for ESD, that the rate at which it would be implemented depended upon budgetary priorities and constraints.

ESD and the Precautionary Principle

The National Strategy for ESD called for a precautionary approach in assessing development proposals. The concept of a precautionary principle has developed as an approach to decision-making in the face of uncertainty about the environmental impacts of actions, particularly where the impacts might be significant or irreversible.

In essence, the precautionary principle reverses the burden of proof, placing it with those who wish to take actions, and requiring demonstration that significant or irreversible impacts will not eventuate. Recognising that absolute proof is not possible, real world applications provide for a cautious approach in decision-making and management. Practices which put the precautionary principle into effect include: environmental impact assessment procedures, monitoring programs, stepwise adaptive management approaches, performance bonds, specifying best available technology and setting safe minimum standards.

National Strategy for Ecologically Sustainable Development

The Goal
'Development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depend'.

The Core Objectives
'to enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations

'to provide for equity within and between generations

'to protect biological diversity and maintain essential ecological processes and life support systems'

The Guiding Principles
'decision-making processes should effectively integrate both long and short-term economic, environmental, social and equity considerations

'where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation

'the global dimension of environmental impacts of actions and policies should be recognised and considered

'the need to maintain and enhance international competitiveness in an environmentally sound manner should be recognised

'cost effective and flexible policy instruments should be adopted, such as improved valuation, pricing and incentive mechanisms

'decisions and actions should provide for broad community involvement on issues which affect them.'

(COA 1992(a), p. 8)

Variations of the precautionary principle have been incorporated into international treaties, legislation and policy in recent years, particularly in Europe, and increasingly in Australia. The Intergovernmental Agreement on the Environment (IGAE) (1992) was important in setting the agenda for legislation and policy for all levels of government in Australia. The IGAE definition of the precautionary principle is: 'Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the principle, public and private decisions should be guided by (i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and (ii) an assessment of risk weighted consequences of various options.'

ESD in the marine environment

One ESD Working Group specifically examined fisheries management, and considered general aspects of marine ecosystem maintenance, including marine protected areas. Coastal zone issues were given some attention, but all recommendations refer to the Resource Assessment Commission's Coastal Zone Inquiry which was in progress at the time (Chapter 62).

Recommendations on marine protected areas

The new initiatives recommended in the National Strategy included to 'establish across the nation a comprehensive system of protected areas including representative samples of major ecosystems, both terrestrial and aquatic' (COA 1992(a), p. 54). The current Ocean Rescue 2000 marine protected area network program is an implementation of this recommendation.

ESD Working Group Report on tourism

The Working Group on Tourism found that the tourism industry has grown to be significant to the Australian economy in terms of contribution to GDP, employment and foreign exchange earnings. The prospects for the future are for steady growth of domestic tourism and for growth rates of up to 7 to 8% per annum in international visitor arrivals.

The potential for tourism to have impacts on the natural environment was noted and examples of types of impacts and instances of negative impacts (e.g. habitat loss, pollution) were recognised.

From the point of view of ESD, it is important to recognise that a major motivation for tourism activities in Australia, both domestic and international, is to experience aspects of our natural and cultural environment. Tourism development which exploits and degrades the environment is not only contrary to the principles of ESD, but is also likely to be ultimately self-defeating. (ESD Working Groups 1991(b), p. xviii).

However, the report was optimistic that planning and management of tourism developments can minimise potential impacts. The Working Group made 31 recommendations aimed at directing tourism towards consistency with ESD. Major recommendations included a call for regional planning based on ecological systems or biophysical regions, complemented by the establishment of a national system of protected areas. It also recommended that strategic plans for tourism should be developed within the context of the regional plans.

Measures recommended for reducing impacts included environmental impact assessment, research, education, industry codes of practice, design, consultation with indigenous people, performance bonds and fines. Approaches recommended to enhance the benefits of tourism included interpretation, staff training, community participation in planning, and raising management funds through 'user-pays'.

ESD Working Group Report on fisheries

This Working Group emphasised that fisheries resources occurred as an integral part of marine ecosystems and that fishing effort can impact the ecosystem while other impacts on the ecosystem can impact fishery resources. It placed high priority on ecosystem management, including: pollution control; conservation of critical habitat; the development of a national marine conservation strategy, incorporating a system of marine protected areas; environmental monitoring and reporting; controls on the introduction and translocation of exotic species; and incorporating freshwater fisheries management into integrated catchment management.

The Fisheries Report contained 31 recommendations. A major recommendation was for the appointment of a Management Advisory Committee which would represent all users including recreational fishers and indigenous peoples, and the public, and would work with management authorities for each fishery. It also recommended the development of 3-5 year strategic management plans for all fisheries, in which recreational and indigenous fisheries would be included. Issues which should be tackled on a fishery by fishery basis under this arrangement include strategic planning, resource sharing, reduction in fleet capacity and controls on fishing effort.

The Working Group emphasised accountability in fisheries management through public input in strategic planning, and annual reporting on achievements against sustainability criteria and on the state of fish stocks and ecosystem integrity. Other recommendations included promotion of codes of practice, training, enforcement, and value adding processing. Recommendations on research emphasised modelling for stock assessment and adaptive management (ESD Working Groups 1991(a)).

The Strategic Approach for Fisheries developed for the National Strategy for ESD states: '*Governments will seek to enhance the decision-making capacity of management authorities, resource users and individuals, in particular through enabling them to make decisions which are based on the knowledge of the likely consequences for the resource and the environment. Elements of a fisheries ecosystem management approach include: data collection and research on fish stocks and environmental factors to enhance management on an ecosystem basis; steps to address cross-sectoral issues between coastal management, total catchment management and fisheries management; awareness and education campaigns, for both users and the general public; and development of strategic management plans, framed within the principles of ESD, in conjunction with rationalisation of fishing capacity in overexploited fisheries.*' (COA 1992(a), p. 26)

Putting policy into practice: Is ESD achievable?

As ESD has economic and ecological dimensions, it is necessary to examine what the fields of economics and ecology can contribute to addressing ESD.

ESD and economic theory

The basis of neoclassical welfare economics, which is the prevailing approach to economics, is to allocate resources according to the demands of individual consumers. This approach is not sufficient to ensure that the outcomes of market transactions will lead to ESD. In order to move towards ESD, there is a need to practice economics somewhat differently so as to account for: non-market values of goods and services provided by natural environments; incomplete information on impacts; and intergenerational equity - between present and future generations.

There is a body of work developing in economics to address ESD goals. A useful principle is that sustainable consumption across generations is dependant on reinvesting the 'economic rents' earned from resource use to maintain the value of capital stocks over time. A key question is the ability to substitute human made capital for natural resources. Where substitution is possible, sustainability can be achieved if the rents are invested in any type of capital stock, for example, if rents from mining are invested in building hospitals. If we consider that it is not possible to manufacture effective substitutes for the functions and services of natural environments, sustainability requires the maintenance of natural environment resource stocks.

A practical distinction may be made between renewable and non-renewable resources. Mineral resources may be depleted but this use may qualify as sustainable if the rents are captured and invested in alternative ways of producing the same services, for example by recycling or alternative energy generation, and if there is no other significant environmental impact of mining. Many of the renewable harvested resources (for example, fish and timber), have a role in the functioning of ecosystems as well as being valued by consumers, and it may not be possible to substitute for the ecosystem functions. Providing exploitation of renewable resources is managed at a sustainable yield levels, then ESD may be achievable.

The consequences for economic analysis and policy are a recognition that some judgements must be made outside the market and incorporated into the economic system. Approaches include the setting of safe minimum standards, pricing the use of natural resources at their full cost, and adopting new ways of calculating optimum resource use rates which do not so heavily favour present consumers. The principles and actions of markets can still be used most effectively within these constraints to bring about efficient resource use. The use of economic instruments such as taxes and subsidies and transferable rights and quotas is effective here.

There is a trend in Australia to incorporate environmental considerations in economic analysis and policy development for individual resources and sectors. Environmental considerations, however, are not generally taken into account in developing options for national macroeconomic policy on issues like economic growth and taxation.

Much of the economics literature relevant to ESD assumes that the ecological information is available to allow limits to be set. Ecologists may not agree.

ESD and ecological theory

The concept of ESD has not been widely debated amongst Australian marine (or terrestrial) ecologists. During interviews conducted with marine ecologists as a background for this chapter, the ESD National Strategy was generally dismissed as a set of 'motherhood statements'. Many scientists did not even know of its existence.

Nevertheless, the concept of 'sustainable development' has generated lively debate in the United States of America in recent years. The Ecological Society of America has developed an ambitious, strongly worded set of goals, the 'Sustainable Biosphere Initiative', which is similar to Australia's concept of ESD. This defines sustainability as 'management practices that will not degrade the exploited system or any adjacent systems' and emphasised that it is necessary to fix consumption standards that are within bounds of ecological possibility.

Unlike the Australian ESD Process, the first phase of the Sustainable Biosphere Initiative focused on the scientific issues. The second phase focused on how ecological science can contribute to environmental decision-making. It noted that 'ecologists will have to break away from the intellectual and professional traditions that have constrained their involvement in social, economic, and political matters' and that the problems of sustainability are 'not just scientific, but include peoples' value systems and expectations'. The third phase is currently bringing together basic ecological, social and economic expertise to examine the issues.

This concept of 'sustainability' has been severely criticised by some United States' ecologists. Ludwig, Hilborn and Walters (1993) argued that 'sustainability' was not feasible because: (1) scientific understanding and consensus in ecology is hampered by the lack of controls and replicates, so that each new problem involves learning about a new system; (2) the complexity of ecological systems precludes a reductionist approach to management; and (3) large levels of natural variability mask the effects of overexploitation.

These criticisms prompted a wide range of responses. Some ecologists simply dismissed the concept of 'sustainable development' as an oxymoron, or conflict of terms ('at some stage continuing development of resources must reach a stage where it can no longer be sustained'). Other ecologists agreed with the basic criticisms but took a more optimistic view that ecological research could positively contribute to environmental management. Many of these believed that basic changes in the science of ecology were needed before this was possible. Most ecologists in the debate stated that sustainability could only be possible if human population and consumption growth was controlled.

It is difficult to incorporate the concept of ESD in current ecological understanding. It is also important to recognise that principles for ecologically sustainable development of terrestrial systems will not be readily transferable to the marine environment because of the fundamentally different nature of the two systems.

The Great Barrier Reef Marine Park as a model for ESD

The Great Barrier Reef Marine Park (GBRMP) has been cited as a model for integrated planning and ESD. The Corporate Plan of the Great Barrier Reef Marine Park specifically has the objective of 'ecologically sustainable use'. The GBRMP Act specifically protects the ecological keystone species, the coral, and prohibits what was perceived as the major threat at the time, oil drilling. Recognising that threats may come from outside the area, the Act also contains the powers of intervention outside the park boundaries. It stipulates that all reasonable use should be allowed, and that community consultation is essential.

Large-scale, regional approach to management
A regional approach to management is taken. Zoning plans consider groups of reefs, and reefs connected by currents as 'units' of management.

Emphasis on maintenance of water quality
Growing concerns on water quality, particularly on the increase in sediments and nutrients, have forced a wider perspective in recent years; clearing of catchments and land use may have major effects on reefs some distance away.

Fisheries and tourism management
Fishing is managed through zoning and through regulations on effort (number of vessels, gear, seasons, size limits etc). A major coordinated research program is underway to assess the effects of fishing. Tourism is managed through permits and zoning. Sustainability is explicit in management of both activities.

Ecological research a focus
Research has focused on ecological processes (e.g. causes of crown-of-thorns starfish outbreaks; mass coral spawning events; connectivities of reefs by ocean currents). It has greatly contributed to management by identifying ecological issues, although it has been less successful in providing answers.

Monitoring of the health of the GBR
This is required under the GBRMP Act. A major monitoring program has been established. The revision of zoning plans requires monitoring of their effectiveness. Developments also require monitoring where impacts are uncertain.

Establishment of centre for ESD
A Cooperative Research Centre (CRC) for the Ecologically Sustainable Development of the Great Barrier Reef was established at James Cook University in Townsville in 1993. This is a joint venture between the University, the Association of Marine Park Tourism Operators, the GBRMP Authority, the Australian Institute of Marine Science, and the Queensland Department of Primary Industries. It aims at enhancing the viability of and expanding sustainable Reef-based industries and economic activity, with particular emphasis on tourism, and providing an improved scientific basis for Reef management and regulatory decision-making.

The CRC is undertaking integrated, applied research, training and extension programs in three areas:

- Regional environmental status of the GBR (looking at the health of the GBR through studies of physics and chemistry of waters, sediments and nutrients, and their effects on organisms).
- Operations (which involve tactical research solving problems associated with the use of reef resources issues, tourist activities and needs).
- Engineering research (aimed at better information and guidelines for structures on the reef and infrastructural developments in reefal environments).

Constraints to ESD
While policy may exist for ecologically sustainable use, the realities of the GBR make its achievement difficult to assess. The nature of the task is daunting: coral reefs are amongst the most complex ecosystems in the biosphere, and the GBR is the largest coral reef complex in the world. Many reefs have never been visited by scientists, and scientific understanding of coral reef function, and of the characteristics and threats to the GBR remains rudimentary. Detailed monitoring of the 'health' of a complex and interconnected ecosystem comprising almost 3,000 different reefs, and hundreds of species of corals and tens of thousands of other species (many of which are undescribed) is not possible in the short-term.

But despite these constraints, management has proceeded pragmatically, based on available scientific understanding, and management of human uses, issues and perceived threats.

ESD and marine environmental management

Despite the difficulty in firmly basing the concept of ESD in ecological knowledge and theory, it does provide some important considerations for marine environmental management. For example:

- The maintenance of ecosystem function must be a primary objective in all marine areas, not just in the protected areas. Sustainable fisheries and tourism rely on maintaining ecological function.
- A large-scale or 'systems' approach to management is required. This extends terrestrial 'integrated catchment management' into the sea.
- Maintenance of water quality is an essential prerequisite for management in the marine environment. Ecosystem function and fisheries landings cannot be maintained in polluted waters.
- Management (and therefore research) might primarily focus on maintaining the ecologically important functional groups. These include 'keystone' and 'umbrella' species upon which a large component of the community depends (see Chapter 15). Such species include seagrasses and mangroves in estuaries; macroalgae in temperate reefs; dominant, reef-forming coral species in coral reefs; micro-organisms in benthic communities; and micro-organisms and phytoplankton in the water column.
- Marine protected areas (MPAs) are an important tool in ESD and for managing biodiversity. Given the great lack of knowledge in marine ecology and uncertainty in environmental management, MPAs are an important precautionary approach to maintaining biodiversity, and for fisheries refugia to supply larvae and juveniles to surrounding areas.
- MPAs established for the purpose of maintaining biodiversity should be of a sufficiently large size and spatial arrangement to ensure that ecological functions are maintained. These MPAs should also be sufficiently large to encompass interconnected systems and to ensure retention of mobile species and larvae.
- Monitoring is an important tool for management under ecological uncertainty. The condition of the environment must be monitored to ascertain if management techniques have been effective. Ecological indicators should include the keystone and umbrella species, species with a known sensitivity to likely impacts, and in the case of fisheries, the target species.

Future directions in implementing ESD

'What happens now?'. The ESD Working Groups produced recommendations for action that were endorsed by the interest groups represented. The process exposed the community to principles that underlie the ESD concept. The Commonwealth and State and Territory governments have endorsed large number of objectives and actions. There appears to be general consensus that ESD is a desirable goal.

However there will be trade-offs required, and some redistribution of costs and benefits in reorienting resource uses. This aspect of adopting the ESD goal has not been given much emphasis so far, but is a real issue in sectors such as fisheries. In addition, information on the workings of ecological systems and interactions with economic systems is the key to effective design of policy and this is, and always will be, incomplete. Meeting the cost of necessary research and management will continue to be a challenge. These are the real world considerations that will stand in the way of changes in the status quo.

Fortunately, pursuing ESD does not mean a total revolution in the way we do things. Environmental awareness has been improving over the last few decades with initiatives such as environmental impact assessment, integrated catchment management and strategic planning. ESD brings the importance of these into focus and attempts to integrate these with economic development rather than act in opposition.

A potential impediment to the achievement of ESD is the sectoral nature of most government departments. Unless explicit 'cross-sectoral' processes are put in place and maintained, programs such as Landcare, Integrated Catchment Management and ESD may wither away.

Has ESD momentum been lost?

Concerns have since been expressed by some industry and the conservation groups who participated in the ESD Working Groups that there has been little or no action in implementing the 500 recommendations contained in the Working Group reports.

There have been claims that the 37 Interdepartmental Committees established to discuss the implementation of the recommendations have rewritten or 'watered-down' the recommendations in the draft policies, and that the government has lost the political will to implement the ESD recommendations because of the economic recession.

ESD is a bold and exciting concept and should provide the bases for future environmental management in this country. With clear signs of an economic recovery in Australia, it is hoped that the impetus of ESD can be revived.

(Source: S. Prior, ABC Radio National 1994)

Moving towards ESD will necessarily be an iterative process and the risk exists that some of the 'big picture' will be missed despite a multitude of policies and actions. There remains a need for integration of approaches, continued development of thinking about ESD and the application of techniques, and of reaffirmation of ESD as a policy goal if the current popularity of the concept is to translate into making a concrete difference to our patterns of resource use. It is now up to institutions and individuals to take up the principles of ESD if the momentum is to continue.

ESD: keystone of Ocean Rescue 2000 program

The Ocean Rescue 2000 program has been formally recognised as part of the ESD process. It provides the mechanism for the execution of one of the major recommendations of the ESD Working Group in fisheries, that is, the establishment of a national marine conservation strategy or plan, which includes a network of marine protected areas. Ocean Rescue 2000's proposed national marine conservation plan is firmly based on ESD principles.

Summary and conclusions

1. The ESD process in Australia was an important step in bringing together traditionally antagonistic groups to seek common ground and work together for mutually agreed goals.

2. The ESD Working Groups on fisheries emphasised the importance of maintaining ecosystem function. Its recommendations included the development of a national marine conservation strategy incorporating a system of marine protected areas.

3. The implementation of ESD poses particular challenges to the disciplines of economics and ecology. Economists must take into account the values of non-market goods and services from the natural environment and must take a precautionary approach to incomplete information and incorporate concerns on intergenerational equity. Ecologists must likewise take into account social, economic and political factors, and develop mechanisms to assist decision-makers in situations of scientific uncertainty.

4. Implications of ESD to marine environmental management include the necessity to maintain ecosystem function; the requirements of a large-scale or 'systems' approach; the necessity to maintain water quality; the importance of large marine protected areas; and the importance of monitoring because of scientific uncertainty.

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Acknowledgments:
The technical contribution by S. Driml was reviewed by M. Common, CRES, Australian National University, Canberra, ACT; and Dr T. Hundloe, Industry Commission, Canberra, ACT. The contribution by Dr L. Zann was reviewed internally in the Great Barrier Reef Marine Park Authority; by Dr T. Hundloe, Industry Commision, Canberra, ACT; and by Dr C. Crossland, CRC: Reef Research Centre, James Cook University, Townsville, Qld.

Chapter 62: Findings and recommendations of the Resource Assessment Commission's Coastal Zone Inquiry[1]

The Inquiry's terms of reference

COMMONWEALTH OF AUSTRALIA

Notice of Referral of a Resource Matter under s.16 of the *Resource Assessment Commission Act 1989*

For the purpose of decisions that the Commonwealth may take in the exercise of its powers,

I require the Resource Assessment Commission to conduct an inquiry into Building, Tourism, Mariculture and associated development in Australia's coastal zone,

The scope of the inquiry shall be to:

- examine and report on the future use of Australia's coastal zone resources with particular reference to the integrated management of building, tourism, mariculture and associated development, particularly outside metropolitan areas;
- examine and report on the use including potential use, of regulatory and economic instruments and institutional arrangements to promote integrated coastal zone management.

In preparing its report, the Commission should:

- take into account and give due weight to, the findings of previous related inquiries and existing background and policy work by Commonwealth, State, Territory and Local Governments;
- take into account and give due weight to the work and objectives of the special Premiers' Conference aimed at providing a clear definition of the roles and responsibilities of the different spheres of government; reducing duplication and overlap of functions and services; and providing more integrated and efficient delivery of programs and services;
- assess the environmental, cultural, social, industry, and economic impact of such development;
- develop criteria for evaluating the future use of coastal zone resources.

The report of the inquiry is to be given to me by 25 November 1993.

RJL Hawke
Prime Minister

The Resource Assessment Commission (RAC) defined the marine boundary of the coastal zone as 200 nautical miles seaward of the low-water mark. Consequently most of the findings of the Coastal Zone Inquiry are directly relevant to managing the marine environment. The boundary adopted by the RAC reflects the linkages in ecosystems, processes, resources and uses between land and sea. This boundary marks the extent of the Australian Fishing Zone and encloses an area of sea greater than the whole of the Australian land mass.

Concerns on increased coastal resource use

The many earlier inquiries relating to the use and management of the coastal zone are reflected in the terms of reference for the Coastal Zone Inquiry. The RAC examined in detail some 29 reports produced since 1980 and considered the recommendations of a further 30 Inquiries into coastal issues between 1960 and 1980. These inquiries and reports repeatedly made conclusions and recommendations regarding the need for coordination and integration to overcome the short-term and fragmented approach which underlies continuing degradation of the coastal zone, its ecosystems and resources.

The RAC confirmed that many current uses of coastal zone resources have significant direct, indirect and cumulative impacts on the environment and that the intensity of use of many coastal resources is increasing.

[1]Based on a paper by R. Kenchington, Great Barrier Reef Marine Park Authority, Canberra, Australian Capital Territory.

Impacts of Increased Coastal Resource Use

- continuing degradation and loss of many coastal habitats, especially wetland and fish-breeding areas;
- increased risks to endangered species;
- overexploitation of fishery resources;
- introduction of exotic species into marine and terrestrial habitats;
- accelerated erosion and loss of coastal soils;
- erosion of beach and dune systems;
- declining water quality in estuaries, wetlands and the ocean caused by pollution; and
- increased demands on terrestrial and marine environments to absorb the impacts.

(RAC 1993, p35)

In the course of its inquiry the RAC confirmed the findings of many preceding inquiries that the major underlying problems flow from fragmentation of management between competing sectoral agencies within and between spheres of government. It found that there had been recent improvements in the level of coordination among the large number of institutions involved in coastal zone management. Despite these improvements the RAC concluded that coordination and integration remained inadequate leaving major shortcomings in the systems of management of Australia's coastal zone.

Shortcomings in management of coastal zone

The following were identified by the RAC as major shortcomings in the systems of management of Australia's coastal zone:

- different and usually uncoordinated approvals systems operate for public and private land;
- management and use of resources spanning marine and terrestrial areas is particularly impeded by a lack of integration and coordination of management systems;
- existing systems do not provide for effective long-term management of coastal zone resources; Approvals procedures are complex, time consuming and often sequential rather than concurrent, making them costly for applicants and governments; and
- although some Commonwealth, State and Local Government agencies have developed policies to achieve coastal zone management objectives, the policies and objectives are often not implemented and they are rarely integrated with social, economic and environmental goals.

(RAC 1993, p. 83)

It is clear that effective long-term ecologically sustainable management of the coastal zone will not occur without a system of strategic and integrated approaches. The RAC concluded that a national approach is needed but was under no illusions as to the difficulties of and resistance to achieving such an approach.

National approach to coastal zone management required

RAC considered that a National approach to the problems of Australia's coastal zone is essential for four main reasons: (1) no single sphere of government can manage the zone alone; (2) issues of national significance and great public concern are involved; (3) the socioeconomic development of the coastal zone is of profound importance to the nation; and (4) Australia has international obligations in the zone that necessitate coordination between the spheres of government.

A National approach will ensure that government agencies have common objectives for coastal zone management, thus minimising duplication and conflict. It will ensure more effective use of human and financial resources, by pooling experience, resources and knowledge. It will also provide a framework for national leadership and financial support and for the mobilisation of community and industry involvement throughout the coastal zone.

Rivalries between the spheres of government make achievement of a national approach to any issue a difficult task in a federated nation such as Australia. But it is a necessary task if Australia is to avoid the coastal management problems that beset other parts of the world such as the Mediterranean, the North Sea and parts of the United States.

Australia is one nation; it is not a loose configuration of States. It is bound by a national constitution that has as joint aims the preservation of the rights of the States and the forging of one nation with common goals and aspirations. The whole is greater than the sum of its parts, and it is in the interests of the States, Local Government and the Commonwealth to act cooperatively to protect what is probably Australia's greatest asset - its coastal zone. (RAC 1993, p. 95)

In the face of the history of continuing coastal degradation and failure to establish an adequate integrated approach to coastal zone management, the RAC concentrated on examining the institutional and socioeconomic issues which must be resolved to achieve a national approach to coastal management. It paid particular attention to institutional and administrative arrangements which could overcome rivalries within and between the spheres of government and give effect to the unprecedented and broad intergovernment integration required to achieve sustainable coastal zone management.

RAC recommendations

RAC recommended that a:
'National Coastal Action Program for the management of the resources of Australia's coastal zone be adopted by the Council of Australian Government and implemented by the three spheres of government in consultation with community and industry groups that have responsibility for and interests in coastal zone management.'
(RAC 1993 Recommendation 01)

In all, the RAC made 69 recommendations, identified 11 principal aims and proposed an agenda for the implementation of the National Coastal Action Plan and listed changes needed to achieve the aims.

Eleven Principal Aims for the National Coastal Action Program

- reduce degradation caused by urban sprawl and activities in urban and rural locations in the coastal zone;
- provide better facilities for recreation in the coastal zone;
- provide better management and preservation of natural processes in coastal areas;
- achieve more effective and rational use of land in the zone for building, development, tourism and other uses;
- improve recognition by the community of the value of the resources of the zone;
- improve recognition of indigenous peoples' interests in management of the zone;
- improve water quality in streams, estuaries and coastal seas;
- improve management of fisheries through more effective management of sea-based resources of the zone;
- establish a sounder base for mariculture;
- improve understanding of the effects of human activities on coastal ecosystems and social systems; and
- enhance community appreciation of the natural processes that operate in the coastal zone.

(RAC 1993, p. 100)

The RAC considered the changes needed to achieve the aims are:

- land use and resource management planning that better provides for the wider effects of development decisions;
- more efficient processes for approval for use and conservation of land- and sea-based resources in the zone;
- better coordination of policies and programs;
- improvements in expertise, knowledge of coastal processes, and the management skills of on-ground managers;
- encouragement of widespread community, industry and indigenous involvement in management;
- provision of more resources, from government, industry and communities for coastal zone management; and
- more effective monitoring of the effects of activities in the coastal zone.

(RAC 1993, p. 100)

The RAC identified four main elements for the National Coastal Action Program: a set of nationally agreed coastal zone management objectives; arrangements for implementing the Program; greater community and industry involvement; and innovative management mechanisms.

Agreed National Coastal Zone Management Objectives

In the course of the Inquiry, the RAC developed a set of national objectives and principles of coastal zone management which were discussed with a wide range of stakeholders: representatives of State, Local and Commonwealth governments and the community, including the indigenous community and conservation and industry groups.

In keeping with its recognition of the importance of coordinated action by the three spheres of government the RAC recommended that:

- *'the Council of Australian Governments agree and adopt the national objectives and principles of coastal zone management proposed by the Inquiry; and*
- *all governments with coastal zone responsibilities develop local and regional coastal zone management objectives that are consistent with the agreed national objectives and that provide firm guidelines for integrated management of resources within each government's jurisdiction.'*

(RAC 1993, recommendations 02 and 03)

Arrangements for implementing the program

The usual means of intergovernment coordination is a Ministerial Council. But the breadth of issues which must be addressed to achieve integrated coastal zone management is so great that, at very least, three Ministerial Councils would be involved. Regular coordination between councils would not be effective and efficient. This means that the Council of Australian Governments is the only available framework for the necessary intergovernment decision making.

The Council of Australian Governments is serviced by a Standing Committee of senior officials. It has created an Ecologically Sustainable Development Steering Committee which has an important role in the lead up to the National Coastal Action program but does not have the time or expertise required to implement it. Because of this and despite general reluctance to establish new agencies or legislation the RAC recommended:

- *'the Commonwealth enact a Coastal Resource Management Act, which, among other things, would provide that Commonwealth funding of coastal resource management activities - whether in the form of direct expenditure by Commonwealth agencies on coastal zone management or as grants to State and Local Governments for specific elements of coastal zone management - be confined to activities consistent with the objectives and principles of the National Coastal Action Program.' (RAC 1993, Recommendation 7)*

It also recommended the creation of a National Coastal Management Agency with the following functions:

- to supervise the preparation of the proposed agreement to establish the National Coastal Action program;
- to implement objectives and principles for coastal zone management;
- to coordinate and monitor implementation of the National Coastal Action Program;
- to promote the incorporation of the agreed objectives and principles in government policies and programs;
- to facilitate the adoption of innovative management techniques;
- to advise on existing funding priorities and to manage financial allocations for elements of the National Coastal Action Program;
- to prepare proposals for changes to the National Coastal Action Program in the light of changing circumstances and outcomes; and
- to prepare annual reports on the implementation of the National Coastal Action program. (RAC 1993, p. 132)

The RAC envisaged an expert agency with a board comprising a representative from each of the States, who would preferably be the heads of the State coastal coordinating committees, and representatives from the Commonwealth, Local Government and Australia's indigenous people. It would have a small expert staff.

'Secretariat staff of the National Coastal Management Agency should be officers selected on the basis of their experience in coastal zone management and their ability to understand coastal zone issues in the variety of jurisdictions represented in the national Coastal Management Agency. Staff may be seconded to the secretariat from State and Local Government sources'. (RAC 1993 p. 132)

Community and industry involvement

In order to provide for peak stakeholder groups to have direct access to the Agency, the RAC recommended that:

> 'a national Consultative Council be established, to advise the National Coastal Management Agency. The Council should include representatives selected from the nominees of peak bodies, research institutions and other bodies with major interests in the management of coastal zone resources.' (RAC 1993, Recommendation 9)

Other recommendations concerned the establishment of Coastcare groups, and measures to ensure that community groups are provided with the opportunity to participate in the formulation of policies and conduct of programs relating to the management of coastal zone resources.

The importance of an approach which involves indigenous people in the management of the coast and particularly of conservation areas including national parks, marine parks and World Heritage Areas is addressed by 12 recommendations. Implementation of those recommendations would provide for indigenous communities to participate effectively in the National Coastal Action Plan to complement and extend initiatives for community involvement.

Innovative management mechanisms

In keeping with the terms of reference, the majority of the RAC recommendations relate to improvements and innovations in management:

- at the local and regional level;
- more efficient approval and impact assessment systems;
- funding of coastal zone management;
- economic and financial instruments;
- meeting research and information needs for coastal zone management;
- surveillance, quarantine and management response; and
- coordination with other National Strategies.

The introduction of innovative and/or consistent management approaches can be a matter of some sensitivity in a situation involving several jurisdictions. Many of the recommendations may be seen as setting the agenda for designing future management rather than providing precise prescriptions for specific actions. Thus, several of the recommendations set an agenda for consultation and collaborative action by the parties to review and develop approaches rather than providing a ready-made solution which may not be appropriate in all circumstances. For example:

- 'Local and State governments examine existing arrangements to ensure that community groups are provided with the opportunity to participate in the formulation of policies and programs relating to the management of coastal zone resources.' (RAC 1993, Recommendation 14)
- 'the National Coastal Management Agency and State coastal coordinating committees evaluate the role that strategic environmental assessment procedures can play in assessing cumulative impacts of development proposals.' (RA, 1993, Recommendation 41)
- 'the Ministerial Council on Forestry, Fisheries and Aquaculture conduct an urgent review of options for dealing with breaches of fisheries regulations in all State and Commonwealth waters.' (RAC, 1993, Recommendation 62)

Outcomes of the Inquiry

At the time of writing this review, the Commonwealth response to the RAC was being finalised and discussions were being held with State and Local Governments. Informal discussions had indicated that the report had addressed the heart of the coastal management problem by focussing on cooperative and innovative management approaches involving the three tiers of government and the community. The key issue is to work through the jurisdictional, institutional and administrative boundaries within and between the spheres of government to achieve management systems which address the scale, processes of the natural systems of coastal and related marine environments. This will require long-term vision and determination in the face of short-term priorities generated by the normal political and bureaucratic dynamics of Federal, State and Local Government interactions.

The outcome will be critically important to achieving the capacity to provide a concerted and coherent response to the issues discussed in the State of the Marine Environment Report. Even though most of the Australia's marine environment comes under the jurisdiction of the Commonwealth, the key to achieving ecologically sustainable use and conservation of biodiversity lies in the management of impacts and activities in or originating from areas under Local and State Government jurisdiction. No single sphere of government can manage the coastal zone or the marine environment in isolation and a single sphere attempting to manage without the others will be limited in its achievements.

Summary and conclusions

1. Almost 60 government reports and inquiries have been undertaken on the coastal zone since 1960.

2. The Resource Assessment Commission's (RAC's) Coastal Zone Inquiry (1993) was undertaken to examine and report on the future use of coastal zone resources and on the use of regulatory and economic instruments and institutional arrangements to promote integrated coastal zone management.

3. The RAC found evidence of continuing degradation and loss of many coastal habitats; increased risks to endangered species; overexploitation of fishery resources; introduction of exotic species; erosion and loss of coastal soils and dune systems; declining water quality in estuaries, wetlands and the ocean caused by pollution; and increased demands on terrestrial and marine environments to absorb the impacts.

4. The RAC identified shortcomings in management as: uncoordinated approvals systems; lack of integration and coordination of management systems; lack of effective long-term management of coastal zone resources; complex, time consuming and costly approvals procedures; and policies and objectives are often not implemented.

5. In all, the RAC made 69 recommendations, identified 11 principal aims and proposed an agenda for the implementation of a National Coastal Action Program. These included a Coastal Resource Management Act, a National Coastal Management Agency to establish the Program, a National Consultative Council to represent community groups, and a Coastcare program.

Selected reference

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Acknowledgments:
This chapter was reviewed by P. Glyde, Prime Ministers and Cabinet Office, Canberra, Australian Capital Territory.

Chapter 63: The status of marine environmental science in Australia and a critical review of its contribution to management[1]

The State of the Marine Environment Report (SOMER) of Australia is a testimony to the status of marine science in Australia. Some subjects and geographic areas are reasonably well known but many serious gaps in knowledge and understanding of the marine environment remain. Of particular concern is the great lack of long-term information which precludes a more qualitative approach to SOMER.

Australia's marine environmental science is relatively young and vigorous. Marine science in Australia entered a period of rapid growth in the early 1970s in response to growing concerns about the marine environment. Today there are over 60 marine research institutions in this country, and Australia has achieved a pre-eminence in areas of study such as coral reefs and tropical marine biology.

However, much is still to be learnt about the marine environment, and much of the existing scientific knowledge has yet to be applied to management. Coastal zone managers have often been critical of major deficiencies in knowledge about the marine environment and the application of scientific knowledge to its management. Scientists and environmental managers in Australia (as elsewhere) have an often poor record in communication and common enterprise.

Different types of research are necessary for marine environmental management: basic research into coastal and marine processes to understand the nature of the resources and effects of their uses; applied research to develop procedures and mechanisms for management; surveys and inventories to document the resource and its usage; and monitoring to assess the status of an ecosystem, community or population and to assess the effectiveness of management activities.

This chapter briefly traces the history of marine science in Australia, summarises the major findings of recent inquiries into its status, and critically assesses the application of marine scientific knowledge to the management of the marine environment. Marine environmental monitoring, information and state of the environment reporting are discussed in Chapter 64).

A brief history of marine science in Australia

The indigenous people of Australia have had a long association with the sea and its inhabitants, and developed a rich maritime culture. Their traditional knowledge of the marine environment has only recently been tapped by marine scientists (e.g. Grey and Zann 1987; Johannes and Macfarlane 1991).

The first written accounts of Australian fish and other marine life were probably made by the English privateer William Dampier off the west coast in 1699. The foundations of Australia's modern marine science were subsequently laid by the naturalists on the great English and French exploratory voyages which visited Australia during the late eighteenth and early nineteenth century who described and collected a range of Australian marine life. Cook's crew fished at Botany Bay and the Endeavour River, and Cook made observations on the Great Barrier Reef.

Matthew Flinders made many observations on marine life on his various voyages around the coast, and speculated on the formation of coral reefs. The British survey vessels which followed in the 1830s and 1840s carried the first of the modern scientists, among them Charles Darwin and Thomas Huxley. The last of the great British marine explorations of discovery, the Challenger Expedition, visited Australia in 1874.

While few scientists were resident in the infant colony for most of last century, extensive collections of marine life were made by amateurs, and these contributed in advancing the debate on evolution in Europe. It was only late in the century when State governments became interested in fisheries that the first resident marine scientists appeared, amongst whom were William Saville-Kent who worked in

[1]by Dr L. Zann, SOMER Coordinator.

zoology and fisheries in Tasmania and Queensland, and Horace Lamb who undertook pioneering research on hydrodynamics in South Australia.

Growth in marine sciences continued to be slow for the first half of this century. Soon after Federation in 1901, the Commonwealth appointed a Norwegian, Harold Dennevig (who was later lost at sea), the first Director of Fisheries. It was not until 1937 that the Council for Scientific and Industrial Research established a fisheries section, and in 1956 this became the Department of Fisheries and Oceanography in the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Since then CSIRO has played a major role in research in marine physical, chemical and biological sciences around Australia.

Marine science in Australia began a period of rapid growth in the 1970s due to increasing public concerns on environmental issues such as heavy metal pollution off southern capitals, and the oil drilling debate and crown-of-thorns starfish outbreaks on the Great Barrier Reef. The Australian Institute of Marine Science was established in 1974; the Great Barrier Reef Marine Park Authority was established in 1976; and the Australian Marine Science and Technology Council (AMSTAC) was established in 1977. The marine research effort doubled between 1980-85. By 1988 government funding for marine research was in excess of $100 million per year, and there were around 2,000 marine scientists and technologists in Australia (Hammond 1988).

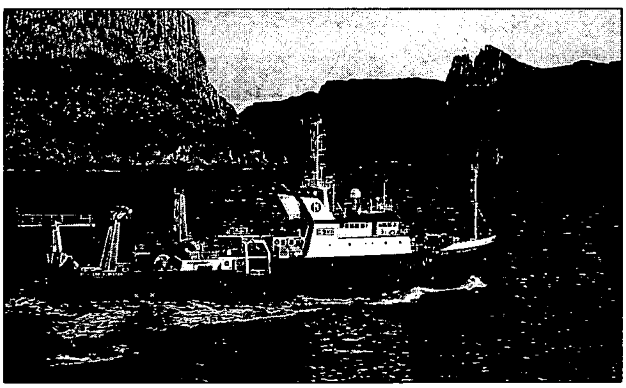
(Source: CSIRO)

Figure 63.1: CSIRO's research vessel Southern Surveyor.

Marine science policy in Australia

Although marine research has now been very active for the past two decades, Australia still lacks a coherent national policy on marine science. This is despite the recommendations of three recent reviews on marine sciences in Australia: the Senate Standing Committee report 'Australian Marine Science' in 1981; the DITC report 'Oceans of Wealth?' in 1989; and the Review of Marine Research Organisation by Professor K. McKinnon in 1993.

The 1993 review, which was prompted by a controversial proposed amalgamation of the Australian Institute of Marine Science and CSIRO marine divisions, pointed to a serious lack of focus in Australia's marine research, the absence of committed technological effort, the imbalance of research efforts, the inadequacies in resource management information, and the poor use of infrastructure. It recommended the development of a national marine council to represent marine agencies, researchers, industry and universities to develop a national Oceans Management Policy, setting strategic priorities, encouraging and supporting balanced marine research and technology development, and improving communication between researchers and clients (McKinnon 1993).

Australian Marine Sciences Association (AMSA) seeks national research policy

AMSA, the main society representing marine scientists and technologists in Australia, has also been critical of the lack of a national policy in marine science. With a membership of around 1,100, AMSA's main objective is to promote the marine sciences, particularly through representations and submissions to government and other authorities. It is also a main focus of communication among marine scientists through its conferences and scientific meetings (Middleton 1990).

Status of marine science in Australia

Recent reviews of the status of marine science in Australia have been undertaken by the Department of Industry, Technology and Regional Development (DITC 1989, DITARD 1993). The earlier report, titled 'Oceans of Wealth?' reviewed the funding, projects, and publications in considerable detail. This section summarises its major finding.

Marine science funding

During the 1980s Commonwealth expenditure on marine research and development (R&D) rose from $23.4 million in 1980, to $63 million in 1987, to reach $123.2 million in 1991/92. However, R&D allocations remained very low compared with the worth of Australia's marine industries, around $16 billion annually, $4.5 billion of which is gross export income.

Almost all marine R&D in Australia is government funded; the private sector is responsible for only 2.4% of marine science R&D. This is thought to be much smaller than in comparable nations. An exception is the fishing industry, which provides 25% of funds for the Fisheries Research and Development Corporation.

Australia is rated among the top ten nations in the world, in proportion to its population, in marine research effort and output. Marine biological research is proportionately higher in Australia's overall R&D spending than in the other countries but Australia spends considerably less on other marine R&D than Canada, Germany, Japan, the United Kingdom and the United States because of our smaller population.

Australia's 200 nautical mile Exclusive Economic Zone (EEZ), over 11 million square kilometres in area, is one of the largest in the world. However, Australia's population is the smallest of any continent (other than Antarctica), and our research effort per area is therefore very much less than in comparable nations.

Obligations under UNCLOS

In addition to providing rights for maritime nations to exploit the natural resources within 200 nautical miles of their coast (or baseline), the 1982 United Nations Convention on Law of the Sea (UNCLOS) also obliges these countries to protect and preserve the marine environments within their EEZs, to prevent land-based pollution, and to further advance knowledge of their EEZs by undertaking marine scientific research.

'Critical mass' in marine science achieved

The numbers of marine research projects undertaken in marine science in Australia rose steadily during the 1980s, from 863 in 1981, to 1,113 in 1985, and 1,262 in 1988. Since then they have declined, to 778 in 1991, the last year for which figures are available. The numbers of publications in marine science rose in the 1980s and Australian publications in marine science now comprise around 4% of the world's total.

DITC (1989) considered that Australia has reached the level in marine science capability and infrastructure to provide a 'critical mass', sufficient to allow it to play a significant role on the world scene. Australia has now gained pre-eminence in some areas such as coral reef biology and management, but remains weak in areas such as aquaculture and marine technology.

Australia's marine science: strengths and weaknesses

'Oceans of Wealth' found Australia's marine research is of world class, or of potential world class, in some areas but weak in others. (DITAC 1989)

Strengths...

- coral reef/tropical marine studies
- marine ecology;
- marine geosciences;
- physical oceanography;
- aspects of fisheries research;
- remote sensing techniques;
- coastal hydrodynamics and numerical modelling; and
- marine foundations.

and weaknesses...

- aquaculture/mariculture;
- chemical oceanography;
- marine biotechnology;
- marine chemistry;
- seabed mineral exploitation (excluding oil and gas); and
- ship design and shipbuilding research.

Research priorities

The Review Committee considered that Australia's priorities in marine science should be:

- aquaculture (biology, farm engineering and management, marketing);
- basic processes in the ocean/atmosphere systems around Australia;
- understanding and managing reef and coastal ecosystems;
- exploration of the petroleum potential of offshore sedimentary basins;
- a permanent national network of tide gauges and data loggers;
- market-driven bio-technical research;
- technical development in shipbuilding etc; and
- fostering a competitive edge in consulting, education and information services.

(Source: M. Johnson, GBRMPA)

Figure 63. 2: Australia has expertise in some areas, such as coral reef ecology and management, but not in others.

Impact of the technical revolution

The technological revolution has greatly aided marine science at sea and in the laboratory. It was the invention of scuba in the 1940s which enabled marine scientists to explore the sea with ease, but no less dramatic has been the advent of the space, computer and video technologies. Today satellites monitor sea temperature, ocean currents and ocean productivity; researchers at sea can fix their positions within a few metres using inexpensive global positioning systems; data loggers left at sea automatically monitor temperature, salinity, currents and other parameters for months at a time; remote video cameras explore deeps beyond scuba range; and study animals can be tagged with transponders and microchips. Researchers can now monitor in real time the exact movements and behaviour of a particular whale or dugong, via satellite, in the comfort of their laboratories.

The revolution in information technology

The present revolution in 'information technology' has enabled marine scientists and managers to take advantage of the 'information explosion' of the past three decades. Portable computers, CD ROM, electronic mail and faxes, links to library databases, interlibrary networks, electronic libraries and other technological marvels have been widely embraced by Australian science, long plagued by the 'tyranny of distance'.

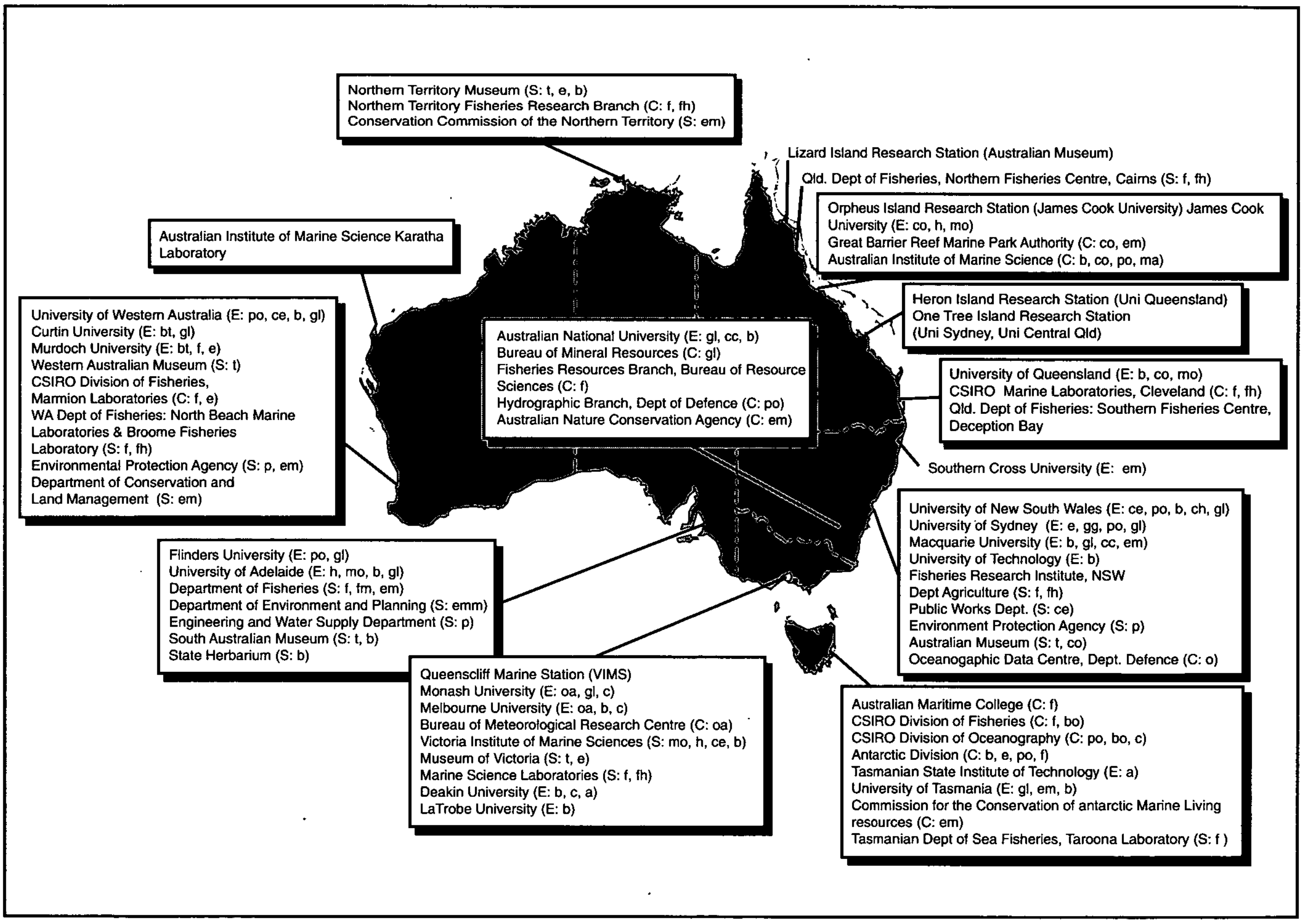

Figure 63.3: Marine science institutions and activities around Australia. There are around 60 major marine research institutions, operated by educational (E), State government (S) and Commonwealth (C) bodies. Marine research subjects undertaken at these include: aquaculture (a); biology (b); biological oceanography (bo), biotechnology (bt); chemistry (ch); climate change (cc); coastal engineering (ce); coral reefs (co); ecology (e); environmental management (em); fisheries (f); fisheries habitats (fh); geography (gg); geology (gl); hydrodynamics (h); mangroves (ma); modelling (mo); ocean/atmospheric systems (oa); physical oceanography (po); pollution (p); and taxonomy (t). (Based on Middleton 1990)

Marine research institutions

The major Commonwealth agencies undertaking marine research are CSIRO, the Australian Institute of Marine Science (AIMS), the Australian Geological Survey Organisation, the Royal Australian Navy Hydrographic Service, the Fisheries Research and Development Corporation and the Great Barrier Reef Marine Park Authority. A number of other agencies also undertake marine research programs.

Various State government agencies also undertake marine research, sometimes in collaboration with Commonwealth agencies. Most of the tertiary education institutions located on the coast undertake marine research through funding from the Australian Research Council and other sources. The private sector currently undertakes limited basic marine research. A growing number of private consultants carry out environmental impact studies.

The development of integrated research programs

Although marine research has not been strategically planned or adequately integrated or coordinated in the past, the development of multidisciplinary, management-related research programs in recent years has been an important advance. This began in Victoria with the Western Port study in the early 1980s, and was adopted by other agencies (for example, the Great Barrier Reef Marine Park Authority's multidisciplinary crown-of-thorns starfish research program in 1986).

Cooperative research programs have been facilitated by the establishment by the Commonwealth Government of the Cooperative Research Centre scheme which provides long-term funding for consortiums of research institutions jointly working on applied research problems.

Commonwealth agencies and research programs (1991/92 budget)

CSIRO
Division of Fisheries ($15.0 m); Division of Oceanography ($2.5 m); Coastal Zone Research Program ($1.7m). The last has four programs: land use and water quality; in-stream processes; estuarine mixing models; sediments; marine eutrophication, and databasing (CAMRIS).

Australian Institute of Marine Science (AIMS)
AIMS undertakes four research programs: coastal processes and resources; coral reef ecosystems; environmental studies and biotechnology; and tropical oceanography ($16 m). Its focus to date has largely been in the north-east but is now beginning operations in the north-west.

Australian Geological Survey Organisation (AGSO)
Programs include offshore mineral and petroleum exploration, and geology and resources of coastal zone ($20.7 m).

Royal Australian Navy (RAN)
Hydrographic Service conducts hydrographic surveys and operates Australian Oceanographic Data Centre ($33 m).

Fisheries Research and Development Corporation (FRDC)
FRDC funds research in stock assessment, fisheries science, environment, aquaculture etc partly through an industry levy ($7.5 m).

Great Barrier Reef Marine Park Authority (GBRMPA)
GBRMPA funds management-related research. Major programs: crown-of-thorns starfish; water quality; effects of fishing; Torres Strait baseline; long-term monitoring; State of the Marine Environment Report for Australia ($3.3 m).

Other agencies and programs
Department of Environment, Sport and Territories (Ocean Rescue 2000, impact of climate change, biodiversity, Antarctic and Southern Ocean); Australia Nature Conservation Agency (marine wildlife management and marine protected areas); Bureau of Resource Science (fisheries); Land and Water Resources Research and Development Corporation (water quality); Australian Heritage Commission (protection of coastal and marine heritage sites); Australian Bureau of Agricultural Resource Economics (resource economics); Australian Bureau of Statistics (environmental and use statistics); Australian Quarantine and Inspection Service (introductions); Australian Maritime Safety Authority (shipping safety, oil and chemical spills).

(from RAC 1993 and other sources)

Some Cooperative Research Centres (CRC) relevant to coastal and marine management, and Commonwealth financial contributions

CRC for Aquaculture ($2.2 million pa for 7 years)
Fifteen institutions including: University of Tasmania; CSIRO; fisheries sections in Queensland, New South Wales, Tasmania, and Northern Territory; James Cook University; and Australian Institute of Marine Science.

CRC for Ecologically Sustainable Development of the Great Barrier Reef Marine Park ($2.0 million pa for 7 years)
Five organisations: Association of Marine Park Tourism Operators; Australian Institute of Marine Science; Great Barrier Reef Marine Park Authority; James Cook University; Queensland Department of Primary Industries. (Total financial commitment $46 million over 7 years).

CRC for Waste Management and Pollution Control ($2.0 million pa for 7 years)
12 organisations, including: University of NSW; University of Western Sydney; CSIRO; ANSTO: BHP; ICI; NSW Water Boards; NSW Environment Protection Agency; NSW Public Works Department; Brambles Aust Ltd.

CRC for Antarctic and Southern Ocean Environment ($2.0 m pa for 7 years)
5 organisations: University of Tasmania; CSIRO; Australian Antarctic Division; Bureau of Meteorology; Bureau of Mineral resources, Geology and Geophysics

Marine research by bioregion

Marine research institutions and research effort are not uniformly distributed around Australia. With the notable exception of the Great Barrier Reef Region, marine research institutions are largely clustered in the State capitals in the eastern coasts, and the south west (Figure 63.3).

Research effort is rather more widely distributed (Table 63.1). In 1991, the last year of operation of the Australian Marine Research in progress (AMRIP) Database, most research projects were undertaken in the Great Barrier Reef Region (31% of all undertaken in Australia), followed by the New South Wales coast (16%), Bass Strait (12%), the south-west coast (5%), and north-west (3%). Around 40% of research projects were undertaken in the tropics.

Table 63.1: Number of researchers (Res) and research institutions (Inst) undertaking research in identified regions (AMRIP Code), and number of research projects (proj) in 1991 in each region.

Code/Region	Res	Inst	Proj
B: Bass Strait	115	92	7
G: South Aust Gulfs	23	20	17
D: Great Aust Bight	5	4	4
S: Southern	5	3	3
W: S-W Aust	70	70	36
E: N-W Aust	35	30	22
Y: NT (excl. Gulf Carp)	17	15	12
C: Gulf of Carpentaria	12	11	8
J: Torres Strait	8	8	7
R: Great Barrier Reef	305	265	202
Z: Coral Sea	6	5	4
Q: other Qld. waters	45	119	47
N: NSW	151	125	107
T: Other Tas waters	31	29	20
H: Southern Ocean	3	3	3
V: Antarctica (>60°S)	19	16	12
P: Pacific Ocean	44	39	23
I: Indian Ocean	4	14	3
A: within AFZ	63	58	49
O: Worldwide	3	3	2
X: Other	63	66	-

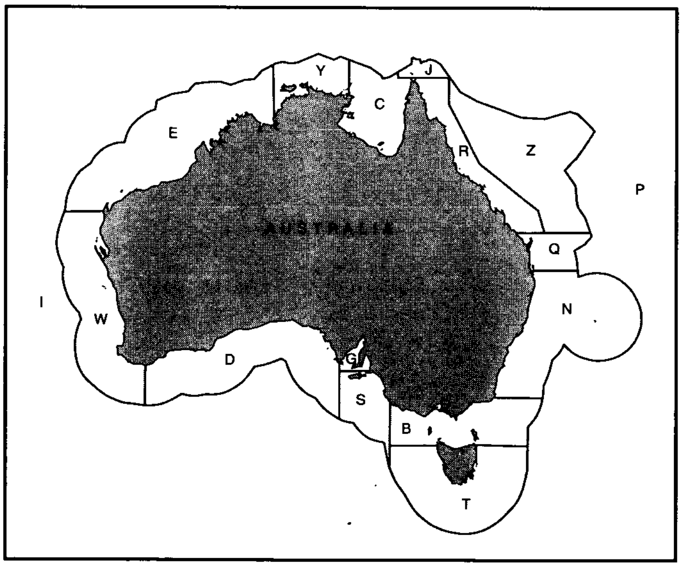

Figure 63.4: AMRIP regions.

Information requirements of marine environmental managers

Although Australia is now considered to have pre-eminence in some areas, the recent Resource Assessment Commission (RAC) Coastal Zone Inquiry found that 'there are serious deficiencies in the knowledge available for management of coastal resources, and there are deficiencies in the arrangements for access by coastal resource managers to the information they need' (p 254, RAC 1993).

Areas of deficiencies

RAC considered that the major areas of inadequacies were: impacts and management of non point-sources of pollution including agricultural and urban run-off; social and economic impacts of urban development; criteria for determining adequacy of protected areas; cumulative impacts of development; and coastal ecosystems, habitats and species, including ecology of seagrasses, mangroves, sandy beaches, mudflats and saltmarshes.

Poor management: the result of poor information?

Part of the reason for the poor management of the coastal zone in Australia was attributed by RAC to poor information availability. Local government planners do not have a good knowledge of the coastal resource, the ecosystems and their characteristics, fish breeding grounds, migratory birds, and rare fauna and flora. Because inventories are inadequate, reserve areas are inadequate. This is basically the result of inadequate recognition of the importance of the coastal environment at the local government level, and inadequate funding.

A study commissioned by RAC on the information requirements of coastal zone managers (largely drawn from Local Government) identified the most important types of information require for management relate to ecosystems, habitat and species; environment impact assessments; and the condition of rivers, estuaries and oceans (Brown and Bourke 1993).

The debate on applied versus basic research

RAC (1993) considered that applied research such as resource inventories and monitoring programs had been neglected in Australia because they have traditionally been viewed by marine scientists as less prestigious than basic research. The Australian Science and Technology Council also considered that there was a serious lack of long-term environmental research and monitoring in Australia because of the constraints of competitive granting schemes; trends towards cost recovery; annual budget cycles; and political pressures for quick solutions to high profile problems (ASTEC 1990). RAC recommended that the Commonwealth should take responsibility for funding resource inventories and long-term monitoring but that private developers who use this information should pay.

Table 63.2: What information do coastal zone managers require?

A questionnaire of over 1,000 coastal zone managers by the RAC Inquiry in 1993 asked for the five most important areas for management.

Areas, in order of importance	% respondence
Ecosystems, habitats and species	44.4
Environment impact assessments	43.2
Condition of rivers, estuaries and oceans	41.8
Recreation and tourism	33.9
Community priorities for coastal areas	33.0
Strategic plans	26.7
Condition of soils and beaches	25.5
Integrated resource management	24.9
Public participation	22.3
Coastal hazards (cyclones, oil spills)	21.5
Pollution indicators	20.4
Waste management	16.7
Regulations and by-laws	16.6
Development costs	16.2
Land ownership and tenure	14.9
Water management	14.5
Visual and aesthetic values	13.7
Community services	12.5
Heritage values	12.0
Infrastructure costs (eg roads, water)	11.0
Dollar values of natural environment	10.2
All others	43.9

Information access often lacking

While there are serious deficiencies of information in key areas in the marine environment, in many cases some information does exist but is not readily accessible. This was particularly evident during the production of SOMER. Some information exists in unpublished reports and environmental impact studies and, given some effort, is accessible. However a great proportion of information remains as unpublished manuscripts and as raw data in the filing cabinets of environment management agencies and individual researchers.

An information review on Port Phillip Bay (Vic) recently undertaken by CSIRO as part of a major environmental study showed that a great deal of data had been collected on the Bay. However a comprehensive understanding and use of the information for environmental quality management reflected a lack of focus in the scientific activities and lack of access to information which had not been collated or assessed. Identification of important information which had previously been collected led to significant changes in the proposed program and cost savings.

Synthesis of information generally lacking

'Status of understanding' reviews (as opposed to literature reviews), are essential pre-requisites for cost-effective, strategic research on particular complex issues or problem areas.

During the production of SOMER it was found that in many cases a considerable body of information on a particular subject or geographic area existed, but it had never been collated, synthesised and interpreted by scientists or environmental managers. In other cases the scientific knowledge had been synthesised, but had not been 'interpreted' for management. This may be a result of the increasing specialisation both within the sciences and management agencies, the *ad hoc* nature of much research, and the sheer volume of information (mainly irrelevant for practical purposes) which smothers scientists and managers.

The trend for integrated multi-disciplinary research programs, pioneered in the major Bays studies in Victoria, and developed in the Great Barrier Reef Marine Park and the Cooperative Research Centres, is a positive development. These 'models' for the application of science and management could be greater applied to smaller-scale studies.

The gap between science and management: between the devil and the deep blue sea

The application of scientific information to environmental management is a perennial issue. The natural environment is inordinately complex, interconnected and constantly changing, and ecology is a relatively new and very imprecise science. Invariably, environmental managers want simple, quick (inexpensive) and unequivocal answers to complex issues, whereas the professional ethics of environmental scientists is based on caution, rigorous experimentation and statistical probability. As a result, academic marine biologists and ecologists have not contributed as much as they could to the environmental movement, the ecological sustainable development (ESD) process and its implementation in Australia, and in the world concern on biodiversity.

Environmental management agencies, for their part, are often driven by political and bureaucratic structures and people to whom science and scientific processes are foreign or seemingly irrelevant. The 'fault' is two sided and reflects the lack of a national policy or strategy, and lack of effective communications, between scientists and managers.

An apparent exception in the science/management debate is fisheries management where scientific estimates of stocks and maximum sustainable yields (MSY) have long been employed, albeit often unsuccessfully. However, fisheries scientists complain that MSY recommendations have often been overridden by bureaucrats and politicians in the short-term interests of the industry.

The gap between marine science and management may be wide, but it is narrowing. Australian academics are increasingly involved in applied research on critical national problems such as the effects and causes of crown-of-thorns starfish and *Drupella* snail outbreaks on coral reefs; the effects of nutrients on the Great Barrier Reef; and the decline of temperate seagrasses. Research scientists now often serve on government advisory committees. Many researchers undertake, or peer review, environmental impact studies, and have greatly contributed to the development of appropriate methodologies and statistically robust experimental designs in this area. But caution still prevails, and it is still rare for a scientist to enter the public debate on a conservation issue.

Environmental managers are increasingly frequently drawn from a research background. These people are better able to interpret scientific results, and recognise their relevance to management.

Environmental consultants who undertake environmental impact assessments for developers have also been a catalyst in breaking down the barriers between science and management. Most consultants have a scientific background, but have developed firm linkages with industry and a rapport with environmental managers.

Environmental consultants and scientists working in environmental management are learning to accommodate the uneasy compromises which must be made between scientific rigour, and financial and political realities. However, amongst peers the move from science into management still involves a loss in professional status as well as a decline in production of scientific publications, the yard-stick of the professional scientist.

Monitoring, databases and environmental reporting

The lack of long-term data on Australia's marine environment, its uses and their effects, has been noted by all previous Commonwealth reviews on marine science and the environment (e.g. DITEC 1989, ASTEC 1990, CEPA 1992, RAC 1993) and recent State government 'State of the Environment Reports' (e.g. Victoria LCC 1992; NSW 1993). It is also a conclusion of most of the 130 contributors to the 'State of the

Marine Environment Report'. In very few subjects or geographic areas is scientific knowledge sufficient to detect trends with a high degree of statistical confidence.

It is apparent that without adequate temporal and spatial information on the natural environment, levels of human usage, concentration of contaminants, size fish stocks, and other factors, it is not possible to quantitatively assess the state of the environment, and the effectiveness of its management.

Data management and information systems

A vast amount of information exists in Commonwealth and State government agencies, universities and other research agencies, and in the private sector on aspects the marine environment. National databases and geographic information systems are being established by CSIRO (the 'Coastal and Marine Resources Information System', CAMRIS) and by the Environmental Resources Information Network in the Department of the Environment, Sport and Territories ('the 'National Marine Information System, NATMIS) (Chapter 64).

Monitoring marine research

Until 1991, marine science research projects in Australia were databased in the Australian Marine Research in Progress (AMRIP) database, a cooperative database maintained by CSIRO, the Australian Institute of Marine Science, the Great Barrier Reef Marine Park Authority and the Victoria Institute of marine Sciences. This is publicly available for on-line searching via CSIRONET AUSTRALIS. Funding for AMRIP lapsed in 1991.

Summary and conclusions

1. Marine science has grown rapidly over the past 20 years in Australia, and has achieved pre-eminence in some areas. Proportional to its population, Australia is among the world's top ten nations in marine research effort and output. However, proportional to the vast area of the newly declared 200 mile EEZ, the research effort remains minuscule.

2. A coherent national policy on marine science continues to be lacking in Australia despite the recommendations of several recent inquiries and reviews.

3. Serious deficiencies exist in the information required for effective coastal and marine management. The production of inventories and long-term monitoring has often been given a low priority.

4. Access by environmental managers to existing scientific information is generally not good. Effective mechanisms do not currently exist for the identification and acquisition of unpublished information.

5. A large body of information on the marine environment does exist in many geographic (particularly metropolitan) and subject areas, but in few cases has this been adequately collated and synthesised.

6. Such is the lack of long-term, quantitative data on the marine environment that it is not possible to determine with confidence the trends in most areas of concern.

7. Long-term monitoring will be essential to quantitatively assess the state of the marine environment and the effectiveness of management. Monitoring is a fundamental aspect of environmental management.

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Chapter 64: Marine environmental monitoring, information management and reporting[1]

Monitoring of the marine environment is essential to determine its condition or state, to establish the extent of long-term natural changes against which possible human disturbances can be assessed, and to determine whether management actions have been effective. Key elements in the monitoring process are the establishment of appropriate, scientifically and statistically rigorous sampling programs with long-term funding commitment; effective management of large-scale and long-term datasets; regular state of the environment reporting; and appropriate management responses.

As graphically illustrated in this first State of the Marine Environment Report, there are few long-term datasets on any aspect of Australia's marine environment, and this report is largely descriptive in nature. In the absence of long-term monitoring, it is therefore not possible to determine whether the apparently increasing frequency of coral bleaching, or die-back of Tasmanian kelps are early warnings of global warming; whether the outbreaks of crown-of-thorns starfish on the Great Barrier Reef, or *Drupella* snails in Ningaloo Reef are isolated episodic events, or widespread chronic disturbances; or whether controls on industrial effluents at many sites have been effective in reducing levels of various contaminants.

Monitoring occurs at many different spatial and temporal scales, depending on the specific question in each case. It may be short-term, and focused on a specific contaminant (e.g. as a condition of a discharge permit). It may be site specific, to determine possible human impacts on a place such as a small marine protected area, and short or long-term in duration. It may be long-term, and large-scale, to provide general information on natural status and normal variation.

This chapter focuses largely on long-term, large-scale monitoring of Australia's marine environment. It briefly describes the different types of monitoring being undertaken, and discusses key design considerations for monitoring programs. It also describes information systems on Australia's marine environment, and the Commonwealth's new State of the Environment reporting program.

Long-term, large-scale monitoring

In the past three to five years there has been an increasing awareness at the international, national and regional levels that long-term monitoring is an essential component of effective environmental management.

Global perspective

Concerns about global climate change require long-term, global-scale monitoring of physical and biotic parameters, such as ocean temperatures, sea levels, beach erosion and intertidal and inshore communities. The recommendations of the United Nations Conference on Environment and Development in 1992 to prevent, reduce, and control degradation of the marine environment also require global-scale monitoring.

Marine ecosystems which may be under global threat because of human activities require specific monitoring. Two recently established international programs, the Year of the Reef and the International Coral Reef Initiative, both include global coral reef monitoring as a centre-piece of their planned activities.

Monitoring of Australia's vast 11.1 million square kilometre Exclusive Economic Zone (EEZ) is important as the United Nations Convention on the Law of the Sea obliges nations to protect and preserve the marine environment in their EEZs.

Large-scale marine environmental management is implicit in Australia's National Strategy for Ecologically Sustainable Development, various integrated catchment management programs, and is contained the recommendations of the Resource Assessment Commission's Coastal Zone Inquiry. This requires monitoring at appropriately large spatial or regional, and long-term temporal scales.

The Marine Environment Conference at the University of Queensland in February 1995 which considered the major findings of SOMER recommended that a nationally coordinated system of long-term monitoring be undertaken in the marine

[1]By Dr L. Zann, SOMER Coordinator; and Dr J. Oliver, Australian Institute of Marine Science, Townsville, Queensland.

and coastal environments of Australia's large marine ecosystems (Johnson 1995).

Monitoring of marine protected areas

Monitoring is an essential pre-requisite for science-based management of marine protected areas (MPAs). Monitoring provides information on normal variation in water quality, species abundances and community structure; and it provides information on changes and trends over time in relation to anthropogenic influences. Monitoring is also necessary to assess the effectiveness of various management efforts in the MPA. Monitoring programs in major MPAs are discussed in Chapters 69-75, and in State and Northern Territory MPAs in Chapters 76-82.

Managing a large marine park without monitoring data is like trying to fly a jumbo jet without an instrument panel.

Scientific perspective

Monitoring data provide basic information which underpins much pure research, and have been described as an often serendipidous fountain of scientific inspiration. Monitoring data may also provide the raw material which allows the development of hypotheses regarding the cause of observed, long-term processes and trends.

Design considerations

In any monitoring program, and in particular in costly, large-scale, long-term programs, it is essential that careful consideration be given to what parameters or indicators should be monitored, how the data will be consistently collected, how it will be analysed, and how it will be used. Failure to consider these could result in wasted time and effort.

Precise, quantitative data are essential prerequisites for any monitoring program to provide reliable and reproducible data for use in management decisions. The design of the whole data collection program must also be carefully planned, yet flexible. Invariably, compromises will have to be made because of logistical and funding constraints. Finally, data produced from the monitoring program should be provided in a timely manner, and in a form that environmental managers understand.

Steps in monitoring design process ...

- identification of objectives of program in both general and specific terms (particularly, how data will be used for management action);
- identification of long-term funding (the most difficult stage);
- selection of relevant variables or indicators (must be relevant to objectives, and measurable with known and satisfactory levels of precision);
- agreement on the level of change which must be detected in these variables ;
- design of data collection or sampling program and replication to detect above;
- pilot surveys to determine feasibility of the program and to refine sampling designs;
- design of a quality control program (to ensure data are collected in a manner which maintains a consistent and satisfactory level of accuracy and precision; is recorded with minimal errors and archived for maximum long-term security; and is analysed without error or misinterpretation);
- design of data management and archival system which provides safe storage and fast, flexible retrieval of the data;
- agreement with users of the data on the most appropriate format for communicating the results of the program and providing access to the data; and
- establishment of a periodic review procedure that ensures that the program continues to address the relevant objectives in an efficient and effective manner.

Case study 1 CSIRO coastal station network

The aim of CSIRO's coastal hydrology network is to monitor the physical and chemical characteristics of the waters of the continental shelf around Australia. The oldest marine monitoring system in Australia, it was established in the early 1940s along the New South Wales coast and later extended to cover much of the Australian coastline. Unfortunately, most stations were later dropped for economic reasons, and only three now remain: Port Hacking (NSW); Maria Island (Tas) and Rottnest Island (WA).

Long-term information on temperature, salinity and other attributes has been used to determine seasonal and interannual variability of shelf waters, for detecting upwellings off New South Wales and south Australia, and to monitor ENSO-related fluctuations in the Leeuwin Current and western rock lobster settlement off Western Australia. These sites have also been important in interpreting and 'ground-truthing' remote sensed information from satellites and other sources.

The program illustrates the problems associated with establishing and maintaining long-term monitoring networks, including selection of sites, continuity of techniques and reliability of data, difficulties in long-term funding, and the importance of volunteers and contractors in monitoring.

Case study 2 AIMS Long-term Monitoring Program on the Great Barrier Reef

Background

While a number of research projects on the Great Barrier Reef (GBR) have accumulated time-series data over the past decade or so on a range of physical, chemical and biological variables, the AIMS Long-Term Monitoring Program (LTMP) on the Great Barrier Reef is the most comprehensive monitoring program of its type in Australia. It is also the largest and most comprehensive reef monitoring program in the world.

The program, which largely builds on pre-existing monitoring programs, began in 1992 with special long-term funding commitment from the Commonwealth Government and in 1993 was included as a task in the newly formed Cooperative Research Centre for Ecologically Sustainable Use of the Great Barrier Reef.

Objectives

The primary objectives of the LTMP are to: (1) detect and quantify through time changes in corals, other dominant organisms, fish, nutrients and crown-of-thorns starfish on the GBR; (2) to provide decision-makers with information that is pertinent to managing the GBR for ecologically sustainable use; and (3) to relate changes in reef biota and water quality to human use of the reef and adjacent catchments.

Sampling design

The variables for monitoring (Table 64.1) were selected to represent the ecologically dominant macro-organisms and the most important physical and chemical properties of the surrounding water.

Initially, the sampling design has focussed on censusing reefs in one habitat (windward upper reef slope) along known north-south and cross-shelf gradients. Replicate transects are surveyed at three sites on each of three inshore, three mid-shelf and three outer-shelf reefs in each of six cross-shelf sectors spread along most of the GBR. Additional reefs are also surveyed for crown-of-thorns starfish and/or water quality.

Decisions on the final sampling design and desired levels of acceptable change have been deferred until preliminary data can be analysed to determine the precision of current levels of detectable change.

Given the size and scope of the LTMP, it is inevitable that there will be some modifications to the design as it progresses. While there will be an external evaluation of the LTMP every three years to ensure it remains both scientifically rigorous and relevant to the needs of environmental managers, non-essential

Table 64.1: LTMP measurement variables

Task	Description	Variables
Broadscale surveys	around entire reef manta tow surveys perimeter	starfish counts; crown-of-thorns estimates of coral cover; other incidental observations (e.g. coral bleaching, *Drupella* scars, giant clams, reef aesthetics)
Water quality	in-situ measurements; nutrient analysis at stations near reefs and in open water	temperature; salinity; nitrogen (total dissolved, total particulate, NH_4NO_3, NO_2); phosphorous (PO_4, dissolved and particulate); silicate; suspended solids; chlorophyll
Benthos	video transects at selected sites on northern reef flanks	% cover of all identifiable sessile benthos (emphasis on coral)
Fish	visual surveys of fish at selected sites on northern reef flanks	transect counts of most mobile, non-cryptic species

changes to the core design will be avoided where possible to ensure the continuity of techniques and datasets. Ongoing quality control is being undertaken to ensure data is collected in a consistent and reliable manner, and that any errors are identified and appropriate correction factors are applied.

Results of the monitoring program are communicated in a variety of formats, including formal periodic reports, scientific papers, cruise reports and a variety of computer access programs.

Preliminary findings

Results of the LTMP broadscale crown-of-thorns starfish surveys presented in Chapter 49 show that active outbreaks have continued to decline, and the wave of southward propagating outbreaks has petered out in the Whitsunday region. In 1994, no outbreaks were currently active in the Townsville and Whitsunday sectors, and only small outbreaks now exist in the far north and far south of the GBR, where occasional isolated outbreaks appear to be a persistent feature.

An important finding of the LTMP is a significant decline of coral cover and reef fish in the Capricorn Bunker sector, despite the absence of crown-of-thorns starfish or *Drupella* outbreaks, and the absence of destructive tropical cyclones during the period of monitoring. Continued monitoring will establish whether recovery is occurring, or whether a chronic disturbance prevents re-establishment of previous levels of coral cover. The most recent surveys suggest that recovery may have commenced.

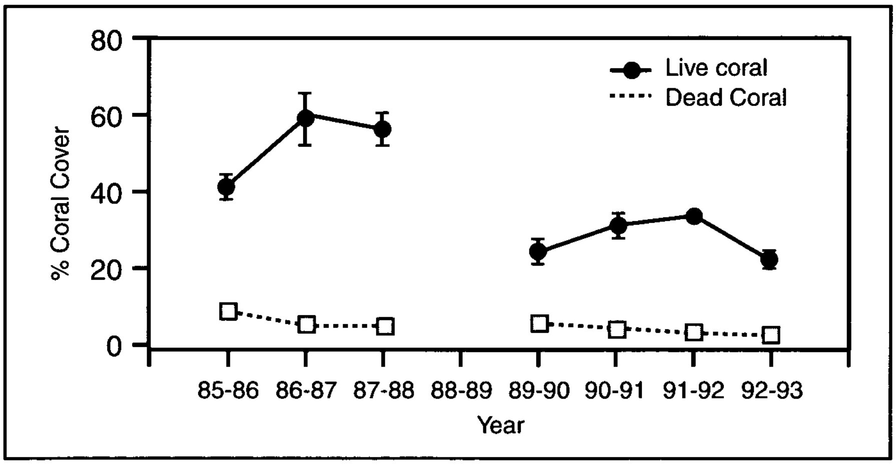


Figure 64.1: Broadscale survey results for the Capricorn Bunker sector showing % of live and dead coral. Error bars represent standard errors.

Case study 3 Identification of key indicators for Victoria's marine and coastal environments

One of the few systematic frameworks for marine and coastal monitoring was developed in 1991 to detect long-term changes in Victoria's marine and coastal environments, although this remains unimplemented to date.

'Valued environmental attributes'

A number of 'valued environmental attributes' of the coastal and marine environments were initially defined as a focus for monitoring. The emphasis of the proposed monitoring program was the detection of any underlying changes in these attributes, and on the ability to discern any trends from the natural 'noise' introduced by seasonal, interannual and random influences on the data. A concept of 'meaningful change' was adopted to describe change in the monitored indicator which is statistically significant.

Attributes and key indicators

Ten 'valued environmental attributes' and a total of 33 'key indicators' were recommended. The attributes (and some key indicators) were: water quality (dissolved oxygen, nutrients, organic carbon, chlorophylla, etc); marine biota (extent and health of seagrass, intertidal algal beds, shorebirds, intertidal animals, commercial fish); sediment quality (characteristics, nutrients, hydrocarbons, heavy metals etc.); coastal morphologies (high-water mark, extent of sand beaches, boundaries of foredune vegetation); marine and intertidal vegetation (mangroves, saltmarsh); estuaries (modifications of salinity regime, estuarine morphology, community structure); marine wetlands (area and period of inundation, salinity, community structure); foreshore vegetation (extent and community structure and condition); aesthetics (area of degraded shoreline, proportion of developed/undeveloped coastline, sensitive locations with visible development, number of coastal planning controls on development); and cultural attributes (number of significant cultural sites and their level of degradation).

While the terms of the project were to identify 'key indicators' to detect changes in condition or state that may be occurring, a parallel approach of monitoring of indicators of environmental processes or activities was recommended. Processes included basic environmental variables (air and water temperature, salinity, turbidity, sea level etc.) and human activity indicators (area of land or seabed utilised or reclaimed, dredging, shipping occupancy rates of marinas, number of boats registered etc).

Why is long-term monitoring data on Australia's marine environment lacking?

The lack of long-term datasets reflects the lack of a strategic approach to coastal zone planning and management in Australia, and specifically, the lack of a long-term marine science strategy. It also reflects a trend for marine science funding in Australia to favour short-term, basic research projects (Chapter 63).

Marine environmental monitoring is very expensive and time consuming, and is generally not rated as a high priority by funding agencies. Monitoring is often seen as the responsibility of management agencies (most of which have very limited funding for management), rather than research grant agencies.

The recent AIMS Long-Term Monitoring Program on the Great Barrier Reef indicates the necessity for an institutional, strategic approach, and the importance of long-term funding.

Information management: national coastal information systems

National coastal and marine databases and geographic information systems are being established by CSIRO (the Coastal and Marine Resources Information System, CAMRIS); the National Resource Information Centre in the Department of Primary Industries and Energy (the National Marine Geographic Information System); and the Environmental Resources Information Network in the Department of the Environment, Sport and Territories (the National Marine Information System, NATMIS). The National Resources Information Centre also manages the National Directory of Australian Resources, a spatially searchable directory of all resource and environmental datasets (including coastal and marine datasets), with access nodes in both State and Commonwealth Government agencies.

Coastal and Marine Resources Information System (CAMRIS)

CSIRO's 'Coastal and Marine Resources Information System' is a small-scale (large area) spatial database and analysis system designed to assist in coastal and marine management and resource allocation. It contains CSIRO Division of Wildlife and Ecology's coastal database (landform, vegetation and land use), and databases on Australian estuaries (Chapter 6), islands, wetlands, climate, bathymetry, onshore drainage basins and river networks, offshore substrates, seagrass meadows, surfing beaches (Chapter 40) and others. It is being used to identify areas of biodiversity value; to develop a coastal pollution susceptibility model; to identify areas of mariculture potential; and to assess coastal response to climate change. CAMRIS has been created in SPANS geographic information system software running under the UNIX operating system. Further analytical capability is provided by multivariate classification (PATN) and statistical (SPlus) packages, and land and sea use allocation (LUPIS) software.

National Marine Geographic Information System

This system was established in 1991 by the National Resource Information Centre (NRIC) using a regional approach, and currently focuses on areas of interest to the resource industries. It is creating a series of regional tiles which will link with other systems under construction, both terrestrial and marine. The system has been used to support the Resource Assessment Commission's Coastal Zone Inquiry, the Cape York Peninsula Land Use Study, the Shoalwater Bay Inquiry and the Shark Bay World Heritage Listing. Regions targeted for future inclusion are the Northwest Shelf and Bass Strait. The NRIC approach is being cloned to form the Indonesian Marine and Coastal Information System and is expected to form the basis of the ASEAN-wide Coastal Zone Environmental and Resource Management Program.

National Marine Information System (NATMIS)

NATMIS, a part of the Department of Environment, Sport and Territories' 'Environmental Resources Information Network' (ERIN), was recently established in the Ocean Rescue 2000 program to: (1) achieve broad-scale regional planning and decision-making, incorporating the principles of ecological sustainable development (ESD) and the conservation of its biodiversity; (2) assist with the identification of marine environmental regions; and (3) develop a capability for long-term monitoring and reporting of the condition of Australia's marine environment. It is anticipated that NATMIS will provide a marine spatial information system for information identified in the State of the Marine Environment Report for Australia (this work), and for the development of both the National Network of Marine Protected Areas, and the National Marine Conservation Strategy. It will also assist in the coordination and rationalisation of activities of government agencies with responsibilities in the coastal zone; identification of polluted areas, coastal surveillance; identification of areas of demographic

SOMER on the World Wide Web

ERIN has established a page on the World Wide Web for those who wish to visit SOMER on the Internet. The address to visit is:

[illegible]

The SOMER pages as well as others are available through the NRIC Internet services at:

[illegible]

pressure; fisheries management; infrastructure, industry and engineering practice; environmental impact assessment; and other activities. ERIN uses the ORACLE relational database management system, a spatial information application and various modelling software.

Coordination

The three agencies establishing these information systems have formed a coordinating group to ensure that duplication of effort is avoided and overlap is minimised. The model of coordination follows that for the National Geographic Information System (terrestrial) being jointly developed by NRIC and ERIN where responsibility for the creation of different layers is assigned to different partners who then swap completed layers to build mirror images of the entire system on their own systems.

Quality control

A knowledge of the quality (spatial and temporal scale, sampling design, and accuracy and precision of data) of each different dataset in an information system is essential for all data users. While there are some expectations that an information system of many different databases will provide users with useful information on spatial and temporal trends for decision-making, the statistical confidence levels of different datasets will invariably differ, and trends must be examined with caution.

State of the marine environment reporting

SOMER is the first comprehensive state of the marine environment report for Australia. Because it was primarily intended to supply information for the preparation of Ocean Rescue 2000's National Marine Conservation Strategy, it is largely descriptive or qualitative in nature. SOMER was intended to be a once-off, baseline report. Future reports on the state of the marine environment will be undertaken in a new, national State of the Environment (SoE) reporting program.

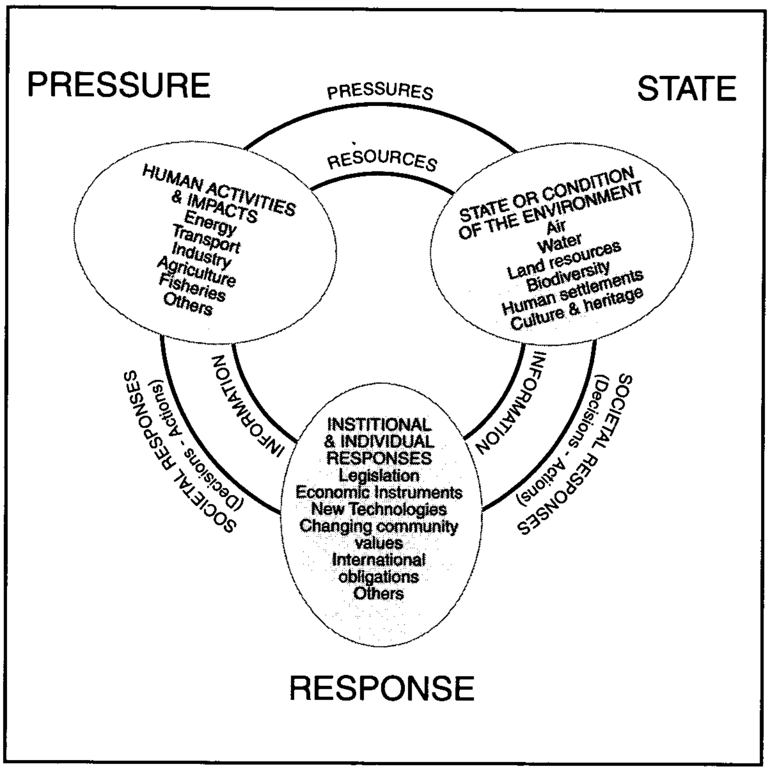
Future national state of the environment (SoE) reporting

A national SoE reporting system is being undertaken as a response to the National Strategy for Ecologically Sustainable Development, which calls for the introduction of 'regular national state of the environment reporting' to enhance the quality, accessibility and relevance of data relating to ecologically sustainable development. It will be undertaken on a regular four-years basis by the Commonwealth Department of the Environment, Sport and Territories, with the first report appearing in late 1996. Most of the information on the estuarine and marine section has been provided by SOMER.

Like many other countries, Australia has adopted the OECD's 'pressure-state-response' approach to SoE reporting. Reports will examine the environmental pressures resulting from energy production and use, population change, urban growth and international trade, and from activities of major economic sectors such as agriculture, manufacturing and transport. They will also examine the state produced by these pressures on atmospheric, terrestrial, inland aquatic, marine and estuarine and urban environments, and report on responses such as policy initiatives, legislative reform and changes in public behaviour.

Major objectives of the national SoE reporting system

- to regularly provide the Australian public, its governments and decision-makers with accurate, timely and accessible information about the condition of, and prospects for, the Australian environment;
- to increase public understanding of the Australian environment, its condition and prospects;
- to facilitate the development of, and review and report on, an agreed set of national indicators;
- to provide an early warning of potential problems;
- to report on the effectiveness of policies and programs designed to respond to environmental change, including progress towards achieving environmental standards and targets;
- to contribute to the assessment of Australia's progress towards achieving ecological sustainability;
- to contribute to the assessment of Australia's progress in protecting biological diversity and maintaining ecological processes and systems;
- to create a mechanism for integrating environmental information with social and economic information, thus providing the basis for incorporating environmental considerations in the development of long-term, ecologically sustainable economic and social policies;
- to identify gaps in knowledge of environmental conditions and trends and recommend strategies for research and monitoring to fill these gaps;
- to fulfil Australia's international environmental reporting obligations; and
- to help decision-makers to make informed judgments about broad environmental consequences of social, economic and environmental policies and plans.



The first SoE report will be descriptive in nature and non-technical in style. An agreed national set of indicators will be developed in a second phase, and it is hoped that future SoEs will be based on quantitative data.

Figure 64.2: The new national SoE reporting framework is based on the 'pressure-state-response' model'.

Summary and conclusions

1. Monitoring of the marine environment is essential to determine its condition or state, to establish the extent of long-term natural changes against which possible human disturbances can be assessed, and to determine whether management actions have been effective.

2. Monitoring occurs at many different spatial and temporal scales and for many different reasons. They range from focused short-term, site specific programs, to long-term, large-scale monitoring of large marine ecosystems.

3. In designing a monitoring program, careful consideration must be given to what parameters or indicators should be monitored, how the data will be collected, how it will be analysed, and how it will be used. Precise, quantitative data are essential prerequisites for any monitoring program to provide reliable and reproducible data for use in management decisions.

4. Few long-term datasets are available on any aspect of Australia's marine environment. The CSIRO coastal station network monitors the physical and chemical characteristics of the waters of the continental shelf around Australia but is very incomplete. The AIMS Long-term Monitoring Program on the Great Barrier Reef is the most comprehensive program in Australia but is relatively young.

5. The lack of long-term datasets reflects the lack of a strategic approach to coastal zone planning and management, and specifically, the lack of a long-term marine science strategy.

6. National coastal and marine databases and geographic information systems are being established by CSIRO (the Coastal and Marine Resources Information System, CAMRIS); the National Resource Information Centre in the Department of Primary Industries and Energy (the National Marine Geographic Information System); and the Environmental Resources Information Network in the Department of the Environment, Sport and Territories (the National Marine Information System, NATMIS).

7. A national State of the Environment reporting system is being undertaken as a response to the National Strategy for Ecologically Sustainable Development. It will be undertaken on a regular four-yearly basis by the Commonwealth Department of the Environment, Sport and Territories, with the first report appearing in late 1995. Most of the information on the estuarine and marine section has been provided by SOMER.

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Chapter 65: The status of formal marine education in Australia[1]

The future of Australia's marine environment depends on Australians understanding it and its importance, recognising the threats to it, wanting to care for it, and knowing how to look after it.

Several factors influence people's values - family, friends, media and personal experience - but it is formal education at schools, colleges and universities that gives people most of the knowledge and skills to make informed decisions, and the ability to act on them.

Changing people's behaviour through education is a longterm process. Today's schooling affects individual behaviour now, but its greatest impact will be when today's students become tomorrow's decision makers. Formal education is also essential for training the scientists, engineers, planners, educators and other professionals and technicians needed to manage the marine environment.

This chapter assesses the extent and content of formal marine education within Australian schools, examines limiting factors and identifies desired outcomes for enhancing formal marine education. It also briefly describes marine education in centres for Technical and Further Education (TAFE) and Universities, but a detailed assessment of these is beyond the scope of this chapter. Community marine education in Australia is described in the next chapter.

History of marine studies in Australian schools

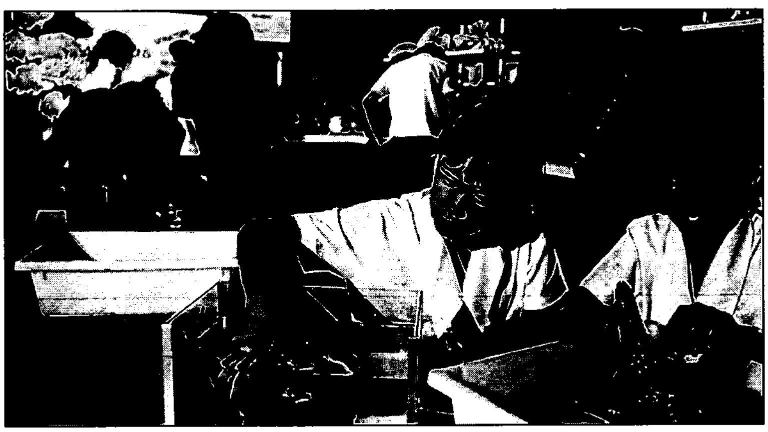
Education has always included various aspects relating to the sea. Subjects such as english, history, science, geography, art and religion have traditionally discussed the sea as a provider of food, as a geographical barrier, for transport, and as a source of literary and artistic inspiration. Biology courses traditionally concentrated on the structure and classification of animals, which included many marine examples. However, generally there was very little discussion of the natural processes in the sea, or the consequences of human actions on it, reflecting limited community interest in past years.

Changes began in the 1960s when a broader range of topics began to be taught across a range of disciplines. During the 1970s there began an evolution from centralised State-based, to school-based subject development and assessment. Together, these trends created opportunities for more marine education in schools.

Formal environmental education was born in the 1970s, and developed with the interdisciplinary trend. Concern for the environment led to the development of cross-curriculum learning aimed at developing an understanding of the environment, and a caring and committed attitude towards it. Specific subjects on the environment were developed in some States, but more commonly, environmental education was included in existing subjects. Most States are developing environmental policies to achieve this.

Marine education in schools

In 1991 Australia had 9,980 schools, 3,075,137 school students and 199,532 full-time teachers (ABS 1991). In Australia, primary and secondary education is the responsibility of each State or Territory, and school curricula are developed by State education departments. The school curricula sets broad guidelines for subjects, including teaching particular values, attitudes and skills, but they generally do not specify content, and this is left to the direction individual schools, subject coordinators and teachers.



(Source: GBRMPA)

Figure 65.1: Some Australian schools offer marine studies. A lab at the Great Barrier Reef Aquarium.

[1]Based on a paper by M. Turner, Great Barrier Reef Marine Park Authority, Townsville, Queensland, which was based on contributions from many educators throughout Australia.

Senior secondary marine subjects

Several States have developed marine subjects at upper secondary level (years 11 and 12). Some subjects meet tertiary entry requirements. The courses combine practical maritime skills with environmental studies, and emphasise knowledge, skills and attitudes as outcomes. Subjects include compulsory core topics and options selected by the schools or students.

Students may select marine studies because they plan a career in a marine field such as marine biology, tourism or fishing, or because they have a recreational interest in the sea.

Some special marine subjects taught in Australian schools

Queensland:
'Marine Studies', was offered in 25 schools (involving around 1,600 students) in 1993. More schools will participate as the course becomes fully approved. The course has two equal parts: 'Mariners' Skills' and 'The Marine Environment'. It is a Board of Secondary School Studies-approved subject, with tertiary entry accreditation.

Other marine subjects are 'Marine Education' (offered in 43 schools in 1993, and taken by approx 2,000 students) and 'Applied Marine Studies' (7 schools and 230 students). Both subjects are Senior Board -registered, and have school-developed curriculum and assessment. Subject matter emphasises practical maritime components rather than environmental aspects.

New South Wales:
'Marine Studies', a Content Endorsed Course, was offered by 50 high and independent schools in 1993. It does not have tertiary entry accreditation. The core units are: 'The Marine Environment', 'Humans in Water', 'First Aid and Resuscitation', 'Life in the Sea' and a local study. Modules include core topics and projects. The resource management module includes topics such as pollution, marine resources, regulatory agencies and conflicts between interest groups, and a project: 'Developing a Management Plan'.

South Australia:
'Maritime studies' is a Senior Secondary Assessment Board of South Australia subject, with tertiary accreditation. It is a new course developed from sail-training on ships. Two schools participated in 1993 and more have since joined. The syllabus includes: knowledge of marine environments; skills to operate safely and responsibly; and ways of conserving valuable natural environments.

Marine components in other senior secondary subjects

A range of other subjects contain marine elements, either as core material or as options. Teachers are often primarily concerned with educational processes, and generally select terrestrial examples due to their greater familiarity with these, because of better teaching resources on them, and because of the difficulties in undertaking marine excursions. At senior levels, students usually complete individual research projects. The media is a major influence on project selection.

Teachers prefer local examples. Coastal schools are more likely to focus on the sea than those inland. Schools in northern States are also more likely to favour marine topics as the climate is better for marine excursions, and because coastal recreation has a higher profile.

Lower secondary marine subjects

A number of schools around Australia offer marine studies subjects at year 9 or 10 level. Other schools include marine units within other subjects.

School-developed subjects at lower secondary level follow broad curricula with process learning goals. They have greater flexibility than senior levels to include marine themes. Broad cross-discipline approaches to subjects increase the potential for inclusion of topics on the marine environment. However, marine content may decrease in some cross-discipline teaching groups as marine-orientated teachers may be in the minority.

Marine subjects in primary schools

Most students leave primary school with only a basic understanding of the sea and how people use it. The extent to which teachers go beyond this varies widely as there is no requirement for teachers to include marine material. There are, however, many opportunities for interested teachers. For example teachers may select a theme such as 'Oceans' or 'Whales' and explore it from different angles, such as language, maths and art. As with secondary teachers,

'Seaweek' focuses awareness on marine issues

Many schools, particularly primary, base their marine studies on 'Seaweek', the yearly national awareness week organised by the Marine Education Society of Australasia (MESA). Special class or school-wide activities are developed in most States. 'Seaweek' has been successful in promoting marine education to teachers and providing them with teaching ideas.

School subjects which include marine components

Geography
Most geography students receive a grounding in marine topics such as geomorphology, the importance of the sea to the earth's climate, and the interaction of humans with the sea. Some teachers may use the sea to demonstrate many themes of geography. However, whilst acknowledging that the sea is important, most teachers still generally choose terrestrial examples in their courses.

Environmental studies
Environmental studies offers the greatest potential for detailed development of marine conservation and management issues. Core elements include marine issues, and marine options can be selected by teachers and students. Environmental studies in particular tend to follow topical media issues, such as oil spills, sewage pollution and whales.

Biology
Marine organisms and marine ecosystems are integral components of biology subjects. However, given the biological diversity, complexity, biomass and contribution to biological processes of the sea, there is still a teaching imbalance towards terrestrial environments. Little training is available for teachers in marine biology, and there are limited educational resources on local marine environments.

General/multi-strand sciences
General science courses at senior level attempt to include all disciplines. They relate science more closely to their students' world than do specialist science subjects. Some teachers in the Northern Territory and Queensland, have developed formal marine options.

Outdoor recreation/recreation studies
These courses teach practical recreation skills. Coastal schools may offer marine skills such as yachting, boating, swimming and diving, emphasising safety training. 'Environmentally friendly' practices are often included in these courses.

established primary teachers are generally more familiar with land environments, and follow tried and proven terrestrial programs.

Marine excursions

In coastal areas, where most Australians live, most primary schools and many secondary schools organise excursions to beaches, intertidal rock platforms, marine field studies centres or aquaria. Excursions act as a focus for marine programs and include additional school-based activities. Activities on excursions may be biological, environmental or recreational, and are often on topical themes.

Distance, transport costs, and the difficulty of replacing teachers whilst they are away may limit the use of marine excursions. Other problems include lack of expertise of teachers, safety and legal liability issues, the high teacher/student ratios required, the specialised equipment needed and the difficulty of access of many marine sites.

Marine education centres

In most States, special marine education or field studies centres provide marine programs and support materials for schools. Teachers who are lacking skills in the marine environment may use the marine expertise of the centre staff. Activities prepared by education centre staff link teachers' educational objectives with the marine environment for all levels of schooling, from pre-school to tertiary.

(Source: GBRMPA)

Figure 65.2: Primary school children on a marine biology excursion. Great Barrier Reef Aquarium.

Marine Education and Field Studies Centres

Victoria:
The Marine Discovery Centre at Queenscliff, established by the Victorian Institute of Marine Science (VIMS), specialises in marine biology.

Queensland:
The Queensland Education Department has Environmental Education Centres at Jacob's Well (mangrove focus), Nudgee Beach (mangrove and mudflat focus), Boyne Island (reef, islands, mangroves), Hollaways Beach (mangroves) and Bilai (operated with the local council and community with a coastal wetland focus).

Northern Territory:
The Northern Territory Education Department's Channel Island Field Study Centre has a strong focus on mangroves and Darwin Harbour.

New South Wales:
No specific marine centres exist. Coastal field studies centres are operated by Department of School Education and focus on coastal and littoral ecosystems (e.g. Coastal Environment Centre, Narrabeen).

Tasmania:
The Woodbridge Marine Studies Centre was the first education centre in Australia to focus on the sub-tidal environment.

South Australia:
Several Aquatic Education Centres teach recreation skills such as snorkelling. Three Centres are currently developing science and environmental programs.

Because of their facilities and staff expertise, field study centres are an efficient way to teach practical marine education.

School camp-sites on the coast may offer aquatic recreational activities and environmental programs. For example, the Somers School Camp in Victoria, has included marine studies in its primary nature studies program since 1959.

Marine environmental education in public aquaria

Aquaria enable students to experience environments normally difficult to access. A number of large public aquaria offer education staff and activities for school excursions. Major aquaria offering education programs include: Underwater World, Perth; Ocean World, Manly; Seaworld, Gold Coast; Underwater World, Mooloolaba; Great Barrier Reef Aquarium, Townsville; and The National Aquarium, Canberra. (Chapter 66).

Activities offered by the aquaria cover a range of themes and year levels. Themes tend to be biology and ecology orientated (e.g. adaptation, behaviour and classification of marine life, and different marine communities). Environmental and human use issues are covered to a lesser extent. Arts and crafts using marine themes are popular activities.

Marine education in museums

A number of maritime museums provide educational programs for visiting schools. These include the National Maritime Museum, Sydney; The Polly Woodside, Melbourne; Flagstaff Hill, Warrnambool; and the maritime museums in Adelaide, Perth and Darwin. Programs focus on the history of shipping, navigation, shipwrecks, immigration and marine recreation. Marine topics are included in education programs at natural history museums. For example, Perth Museum has a marine biology gallery and the museums of Melbourne and Sydney are developing them.

Marine studies resource materials

Two Australian textbooks are devoted to marine education ('Seascape' by T. Ryan, and 'Marine Studies' by B. Moffatt). Both were designed to meet the needs of the Queensland Marine Studies course which includes practical maritime skills and environmental content. They are also used for other marine studies courses. The Great Barrier Reef Marine Park Authority has produced 'Reef-ed', a collection of excursion activities, which can be adapted to other marine environments.

Studies of the marine environment and marine resource management should contain local examples. General text books for geography, environmental studies and general sciences often have little local marine content, possibly reflecting a lack of demand by teachers. Greater marine content in texts would influence teachers to include marine topics in their lessons.

Teachers' resource needs vary. Some experienced teachers require the latest facts and statistics for updating their existing programs. Others, perhaps less experienced, require detailed activities and lesson plans. Types of resources required also vary and include written materials, videos and photographs. CD-ROM education programs in marine studies are now being developed.

Marine studies teaching resources such as books of activities, factual data, posters, slide kits and videos, are produced by the Gould League of Victoria; Victorian Institute of Marine Science; commercial publishers such as Bay Books, Troll Books, Nelson and Wet Paper; and many Commonwealth, State and Territory fisheries and Government agencies.

Informing school children about the state of Australia's marine environment

Because of the need to increase awareness of the marine environment and its conservation amongst school children, the main State of the Marine Environment Report for Australia is written in a non-technical style suitable for secondary schools.

"Our sea, our future: Major findings of the State of the Marine Environment Report for Australia" is available for schools through the Community Information Unit, Department of the Environment, Sport and Territories: Ph. 008 803 772.

Marine education by management agencies

Commonwealth and State coastal management agencies such as national parks services promote marine education using displays, publications and interpretive activities. For example, in Victoria a marine park display caravan is operated for school and community education. The Great Barrier Reef Marine Park Authority produces a range of educational materials and uses an educational aquarium. State fisheries agencies produce material for schools on fisheries and fish habitats. Other government agencies producing marine education material include environmental protection agencies, maritime safety bodies, and ports and harbours authorities.

Other groups involved in marine education

Several conservation organisations have prepared information on the marine environment for schools (Chapter 66).

Many schools have clubs for students to pursue activities such as scuba diving, boating and marine environment issues. Clubs can provide a good educational extension to formal teaching.

Teacher associations enable members to share information via newsletters, conferences, and networking (particularly at a local level).

Teachers of marine subjects come from a variety of backgrounds such as science, physical education, manual arts, and geography. They receive little marine education training, and most entered the subject area because of a strong personal interest and with skills obtained in their own time. As marine education is new, there are few teacher training options, particularly for established teachers wanting to enter the subject area. Training, when available, is usually used to gain certifications for legal teaching of practical skills.

Course content, particularly in the range of optional elements offered, reflect the school location and the interests and expertise of the teachers. Schools do not have the resources to offer all subject options.

Although specialised marine subjects provide the greatest opportunities for students interested in marine education, relatively few schools offer them. This may be due to: lack of interest by the school or teachers; difficulties in fitting the course into an existing full range of school subjects; lack of teachers with appropriate expertise; lack of equipment; lack of release time to enable teachers to develop courses and materials; and legal and administrative requirements for teaching marine skills. Better accreditation of existing marine subjects would increase student participation.

Desired outcomes for marine education (identified by MESA)

- Promotion of marine examples for current and new curricula.
- Marine examples in policies (e.g. environmental education).
- Non-specialist teachers inspired by personal experiences on excursions and workshops.
- Seaweek as a focus of marine education activity.
- Links between schools and marine users and managers.
- Links with community education programs.
- Education authorities supporting in-servicing.
- Good in-services, workshops and conferences.
- More marine content for student teachers.
- More marine education for tertiary lecturers.
- Experienced teachers spreading their knowledge via local working groups.
- A strong active MESA.
- More marine interest by other teacher associations.
- An accredited marine education summer school.
- More marine topics in general education material.
- New marine materials targeting curricula and needs.
- Relevance of existing materials regularly promoted.
- Training of teachers to use existing and new materials.
- Cheap, up-to-date factual information available.
- Computer soft ware with marine themes.
- Support for excursions to marine environments.
- Supported dynamic field study centres.
- Supported education programs in public facilities.
- New marine field study centres near major populations.
- Statewide marine monitoring programs for schools.
- Locally developed excursion and monitoring activities.
- Data on the extent of classroom marine education.
- A survey of resources teachers needs.
- Evaluation of existing education programs and materials.

The Marine Education Society of Australasia (MESA)

MESA began in 1988 to meet the needs for a marine-based subject association. The membership includes a mix of teachers, resource managers, commercial interests and community groups interested in marine education. It provides for good interchange of ideas extending beyond schools. One of their most successful initiatives is 'Seaweek'.

Educating teachers in marine studies

Few oportunities exist for teachers to receive marine education during their formal training. Queensland University, Queensland University of Technology and James Cook University include marine topics in their science education courses. The Victorian Institute of Marine Science runs summer programs for undergraduate teachers.

Teachers may receive training in marine studies through in-service training at field studies centres, aquaria and management agencies. However, economic constraints have made many schools reluctant to release teachers for training during school time and only keen teachers participate in their own time.

Technical and Further Education (TAFE) courses in marine studies

About a million students are enrolled with TAFE in Australia. TAFE courses are designed to train existing and future employees for the work place. They are usually technical in nature and the content is largely influenced by industry and technical requirements. TAFEs are not considered part of the tertiary system, although some units may be tertiary accredited. There is a trend towards national curricula but with each State and college developing its own content.

TAFE marine courses concentrate on maritime skills for coxswains, master mariners, deckhands, engineers and others involved with shipping. The Australian Maritime College in Launceston (Tas) specialises in maritime training in this country.

Marine elements are offered within some TAFE courses (e.g. applied biology, resource management, recreation, aquaculture, engineering, and tourism). The content of these courses closely reflects the interests of industry advisory groups so that employees receive relevant job training. This may have the disadvantage that other material is omitted.

Tertiary courses in marine studies

While marine components have traditionally been a part of university subjects such as botany and zoology, the number of specialised undergraduate and post graduate courses in marine studies has increased greatly in Australia since the late 1970s. A recent review by the Australian Marine Sciences Association (Johnson and Bleakley 1993) has described different subject areas and listed universities offering courses appropriate for research and applied careers in marine areas.

Specialisations in different areas mostly reflect historic and geographic factors, and the academic interests of staff. For example, Curtin University of Technology (WA) offers a course in marine archaeology with the Western Australian Museum, a pioneer in this field. The University of Sydney has long specialised in shore ecology and experimental ecology. Southern Cross University in Northern New South Wales has developed an expertise in coastal management. James Cook University in North Queensland specialises in coral reef science and management, and marine modelling. Few institutions were established primarily for marine studies. The Australian Maritime College was established in Launceston, Tasmania, as a national centre for applied studies in all aspects of fisheries.

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Summary and conclusions

1. While Australia has some excellent examples of marine education programs in schools, the quantity and quality of marine education in Australian schools is generally low.

2. Recent increases in environmental awareness within school curricula have been mainly directed at the terrestrial environment. This is because of greater community interest in the land and the lack of marine knowledge among teachers.

3. Greater support and funding is necessary to raise the profile of marine environments in school courses, and to improve the marine knowledge, skills and resources of all educators. Areas requiring support include: production of resource materials; special training of student teachers; in-service training for teachers; assistance to education departments in curriculum and policy development; and promotion of specialist marine education facilities and educators.

4. Some Technical and Further Education (TAFE) colleges offer applied courses on maritme skills. Insufficient information exists on TAFE courses to assess the extent of other marine courses.

5. Marine studies in universities have greatly increased over the past decade. Most universities offer courses with marine content and many offer specialised courses on certain aspects of the marine environment, including management. University marine studies generally have a greater emphasis on basic science than applied science.

Chapter 66: Community marine environmental education in Australia: shaping public attitudes and behaviour[1]

Marine environmental education programs should not only include formal education in schools and tertiary institutions, but also informal community education for people of all ages and walks of life. Particular attention should be given to user groups, decision makers, indigenous communities, recent immigrants and other special groups. This requires appropriate, targeted marine education campaigns.

An important part of the Ocean Rescue 2000 program has been the establishment of a long-term, national marine education program and development of close links with the community through various non-government organisations (Chapter 26).

> **Ocean Rescue 2000 national marine education program**
>
> The objectives of this program are to provide the community with:
>
> - an awareness, appreciation and understanding of the marine environment and of the need for its conservation;
> - environmentally responsible attitudes; a commitment to work for change; a wide range of skills and behaviour for successfully tackling coastal environmental problems;
> - the ability to actively contribute to the planning and management processes; and
> - a high level of commitment to, and compliance with, future management programs.

This chapter examines the state of informal or community marine environmental education programs in Australia and sources of information the community has on the marine environment.

Why have community marine education?

While there are some excellent examples of marine education programs in this country, most Australians are only being reached superficially, if at all. Environmental education for ecologically sustainable development (ESD) has been treated largely as 'add on' activity to many government management and conservation programs, rather than as an integral part of the management process.

A survey of public opinion on the environment undertaken for Department of the Arts, Sport, the Environment and Territories in 1991 found that the environment was a major concern (Chapter 23). It concluded: *The challenge for government is to continue the community education process to achieve a more realistic understanding of the behaviour change required to make the desired impact on environmental problems. This means taking the community's understanding of linkages a step further, so that it makes a connection between householders' actions and the major environmental problems it sees, such as water pollution* .

Some major user and interest groups, such as fishers, divers, eco-tourist operators and conservation groups, have developed excellent programs to re-shape specific target group attitudes and behaviour toward the sea. Similarly, some marine management agencies, such as the Great Barrier Reef Marine Park Authority, have developed successful community education and user-extension programs.

Education programs for stake holders in the marine environment

Education programs for recreational fishers

Although there are around five million recreational fishers in Australia, it is surprising that State and Commonwealth fisheries managers have only recently recognised the importance of managing this sector (Chapter 3). However, most States have now embarked on programs of community consultation

[1] Based on a paper by D. Alcock, Great Barrier Reef Marine Park Authority, Townsville, and Dr L. Zann, SOMER Coordinator.

and education with recreational fishers, and developing a conservation ethic. For example, the Draft National Policy for Recreational Fishing (principle 13) states: *A strong fishing conservation ethic should be developed and reinforced through community awareness education and enforcement programs which will focus on encouraging a positive change in community attitudes and values.*

Effective management of recreational fisheries relies as much on the adoption of positive attitudes by the community, as on legislation and enforcement. Education programs are required to bring about changes in attitude and behaviour of the many fishers who still have no realisation of the cumulative impact of their activities. Awareness programs should especially target young fishers to help ensure the next generation of fishers will be more aware of their responsibilities, and of the wider concept of ecologically sustainable development. Established fishing clubs have a key role to play in this process.

The community should be properly informed on the reason for management decisions such as bag limits, closures and catch-sharing. This requires use of all the media, and multi-lingual educational material and signage. The latter is important as some of the immigrants from the Pacific, Southeast Asia and the Mediterranean traditionally eat many shore invertebrates.

Catch-and-return and sportfish tagging programs have grown in popularity in recent years with the support of government, industry groups, the media and recreational anglers. In the latter, the tags returned provide not only valuable information on fish breeding, growth and movements to researchers and managers, but helps foster a conservation ethic. In Queensland, for example, over 50,000 fish have been tagged since 1986.

Educational programs for commercial fishers

Self interest can be a strong motivation for protecting the environment, and nowhere has this been so strongly manifested as in the commercial fishing industry in Australia. With the majority of commercially important species being dependent on the inshore environment and therefore vulnerable to the dual depredations of pollution and habitat destruction, commercial fishers are increasingly lobbying for protection for the marine environment.

Habitat protection and water quality are unifying issues and have engendered some interesting coalitions of commercial and recreational fishers, environmentalists and scientists. Although not always recognised at the individual level, fisher organisations are beginning to recognise that resources are not inexhaustible, that ecological sustainable development equates with a decent living in the long term, and the chance to pass on the business to future generations.

Much of the change in attitudes has come from within the industry itself. Government fisheries management agencies have only recently extended from the research and enforcement

(Source: GBRMPA)

Figure 66.1: Fisheries education on the Barrier Reef.

Case study

Recreational fishing in Western Australia

Recreational fishing is a popular pastime for Western Australians. Although their coast is vast, around 60% of the State's 300,000 anglers fish in a narrow coastal and estuarine band from Augusta to Julien Bay. Remote holiday locations such as Kalbarri, Shark Bay, Exmouth and Esperance also attract thousands of anglers each year. Because of high recreational fishing pressure and increasing competition with the commercial fisheries, a major review of the fishery was undertaken in 1989. The review recommended education programs be developed to bring about an attitude change among various groups. It emphasised that education was a far more positive option than increased restrictions or penalties.

Specific recommendations included:

- informing the community on reasons for management decisions and fishing rules;
- programs on ethical fishing behaviour, poster campaigns through tackle shops, media campaigns and face-to-face contacts with fisheries officers;
- a special campaign directed at ethnic groups regarding shellfish gathering and crabbing;
- fishing clinics for children and adults to promote fisher education;
- appropriate regulatory brochures and signage; and
- the development of regional fisheries education and liaison staff.

mould, into education. Fisheries management and environmental management have historically been undertaken by separate department. Further, environmental education agencies generally perceive their client groups to be non-commercial/non-exploitative in nature, and view the fishers as a threat.

The Great Barrier Reef Marine Park (GBRMP) Authority has closely involved the commercial fisheries sector in the management of the Marine Park. They are consulted at all stages in the preparation of zoning plans and are represented in the GBRMP Consultative Committee and other management groups. The GBRMP Authority also produces educational material, including a video magazine specifically for Reef fishers.

Case study

'Deck Hand' video magazine

The 'Deck Hand' video magazine is produced twice each year by the Great Barrier Reef Marine Park Authority to communicate management and conservation messages to north Queensland's 500 commercial fishers. The magazine includes a range of topical news and special interest items in a relaxed presentation acceptable to fishers. Video was found to be a more effective medium for fishers than printed material as most vessels carry a video for entertainment in the long hours at sea.

Consumer surveys, feedback from fishers, and offers of corporate sponsorship indicate a high level of industry support. Interstate interest has also been high and special 'Deckhand' editions have been produced for Western Australian and Victorian commercial fishers.

Ecological Sustainable Development is now a important principle of fisheries management, and promises to be a major milestone in Australia's development (Chapter 61). Management of fish stocks involves issues such as habitat protection, maintenance of water quality and other uses. Environmental education will have a central role in commercial fisheries management in the future. Full-time environmental officers have been already appointed in professional fishing industry groups in Queensland, New South Wales, South Australia and Western Australia.

'Fishers' Fairs' have been organised in many States to improve public relations. Attendance figures testify to public interest. For example in Queensland, 13,000 attended a recent Townsville fair, and 40,000 attended a fair at Redcliff near Brisbane. The Queensland Commercial Fisherman's Organisation is also developing a school education program. It has already found a dramatic change in community perceptions in the industry following their lobbying for better environmental management in Queensland.

Anti-pollution programs for boat users

Commercial and recreational fishers and other boat users have been targeted in anti-litter education programs. The long term effects of anti-litter campaigns such as 'Keep Australia Beautiful' and 'Clean Up Australia' have been effective. Special interest groups, private companies and industry are slowly changing their policy on 'brown' environment issues like waste disposal, recycling and litter reduction.

Case study

'Fishers, do the right thing!' TV campaign

During 1990 the Great Barrier Reef Marine Park Authority undertook a TV advertising campaign to encourage recreational fishers to 'do the right thing'. The campaign consisted of four short advertisements about zoning and enforcement, overfishing, littering and anchor damage. These were broadcast in Maryborough, Rockhampton, Mackay, Townsville and Cairns, the major centres adjacent the Reef.

Amongst the findings of a Queensland University assessment of the campaign's success were:

- 88% of the licensed boat owners in the region saw the advertisements, of whom 76% could recall at least one theme;
- anchor-damage was most often recalled, while zoning was least recalled;
- those who went boating recalled more themes and more solutions;
- 52% of respondents owned a copy of the zoning plan map; and
- 69% knew where fishing was permitted or prohibited;

The campaign enabled the GBRMP Authority to better assess its educational priorities and target groups. Backed up by media editorials, regional seminars and newspaper advertising, the project proved to be highly effective in spreading conservation messages to recreational anglers.

Education programs for marine protected area users

Greater emphasis is being placed on commercial and recreational users of marine protected areas (MPAs) to develop their own 'codes of practice' rather than expanding the role of government control through fines, regulations and permits.

Industry-developed codes of behaviour may relate to either specific geographic locations or broad issues. With adequate interpretive materials and publicity these can be effective in changing user behaviour and resolving management problems.

'Codes of practice' are being produced nationally on issues such as:
- Island camping
- Waste disposal
- Whale watching
- Fish feeding
- Minimal impact diving
- Anchor damage
- Marine litter
- Motorised water sports
- Sport fishing

Local user groups are increasingly forming their own management committees to develop simple policy agreements, to protect their 'patch' and to better communicate members' concerns to management agencies. Some are forming regional advisory groups to address broader fisheries or MPA issues.

Australian scuba diver associations are building formal environmental education courses into their training programs and many dive clubs and schools run marine biology and conservation courses. Several private companies also offer excellent short courses in these areas. 'Dive Queensland' has launch a special 'Ecological Diver Training Program' for open water and instructor level divers visiting the Great Barrier Reef. Many dive clubs are engaging in conservation activities and are active underwater on 'Clean Up Australia Day'.

Marine education for indigenous communities

The greater recognition of indigenous interests in the marine environment has required the development of education programs for Aboriginal and Torres Strait Islander people with a view to exploring traditional values and management of the marine environment. As English is often a second language, the use of various culturally appropriate techniques such as art, role play and stories has been used effectively. For example, a marine education program, 'Caring for our Sea Country Together', was undertaken at a recent Laura Festival on Cape York by Ocean Rescue 2000, GBRMP Authority and Queensland Department of Environment and Heritage. This included mural painting by festival attendees to explain turtle and dugong conservation issues. Scientific programs aimed at explaining traditional management to indigenous communities are also underway.

Figure 66.2: Marine education activities in a Cape York Aboriginal community.

The role of the media in marine environmental education

The media, in particular television, plays a strong part in shaping community attitudes towards the marine environment. According to an ANOP National Attitude Research Analysis poll, the main source of information about the environment in Australia today is television. News and current affairs programs, nature features, and science shows are the major influence. Other, less important sources were newspapers, radio and magazines.

Television

Because of its graphic visual impact, television has been important in raising environmental consciousness and tapping the emotions of the community. Beginning in the 1960's, popular TV shows like 'Flipper' helped establish the dolphin as an icon or symbol of the sea, while the world-renowned underwater explorer Captain Jacques Cousteau and National Geographic specials brought the mysteries of the sea into our living rooms.

Television documentaries about the sea have changed with the times, reflecting changing community perceptions. Documentaries by Australian underwater cinematographers have changed from stories about hunting dangerous man-eating sharks in the '60s, to advocating conservation and shark protection in the '90s. Around Australia, many spearfishing clubs have been renamed, their members catching fish on film rather than by spear.

Some modern children's TV shows and cartoon series have strong 'green themes'. For example, 'Captain Planet' and 'Widget' battle with conservation and pollution issues while entertaining 6 to 12 year olds after school.

Television advertising is a powerful - albeit expensive - way of communicating environmental messages. A series of 'awareness raising' advertisements on marine themes have been widely broadcast for the Ocean Rescue 2000 program as free community service announcements and have generating several thousand responses.

Radio

While not giving the same exposure, radio has two advantages over television: it is cheaper and allows more time to explore complex issues. Over the summer of 1994, Ocean Rescue 2000 ran a series of six radio advertisements featuring celebrities offering advise about how to protect our oceans. Supported as community services announcements, the regional airplay over the 'beach season' by popular youth networks was high. Specific campaigns targeting storm water discharge and water quality were topics for radio talkback interviews and triggered extensive follow-up coverage in local newspapers.

Magazines and newspapers

The 'Green Guide' lists some 54 Australian magazines and newsletters which publish information on the environment. Of these, 17 (with an annual circulation of over 1.6 million) regularly include articles on the marine environment. In addition, magazines on diving, fishing and surfing often run articles on aspects of marine conservation.

What the papers say about the marine environment

Analysis of 500 environment news stories appearing in leading national and State newspapers in August-October in 1992 found that 23% of stories on the environment were on marine topics, with most coverage given to coastal pollution. However, because of the seasonal nature of much of the 'news', the sea may be more regularly featured during summer.

The following summarises the articles by ecological area and subject.

Areas:	
Coast and beach:	33%
Wetlands:	11%
Coral reefs	3%
Sea/general	53%

Subjects:	
Conservation	8%
Oil pollution	27%
Nuclear waste*	10%
Fishing	5%
Overfishing	3%
Sewage	6%
Whales	5%
Crocodiles	2%
Algal blooms	2%
Sea level rise	1%

*this was biased by a single episode of nuclear waste transport

Newspaper articles on the marine environment range from straight 'news' stories such as a stranded whale or an oil spill, to issues and controversies such as ocean drift netting, to detailed 'features' on special aspects of the marine environment such as the Great Barrier Reef. Some controversial marine topics (e.g. the crown-of-thorns starfish, the Greenhouse effect) receive irregular news treatment in such a way that the average reader may believe the problem has disappeared because the newspaper coverage ceases.

Education programs in theme parks and aquaria

While small aquaria, museums and zoos have provided a glimpse of marine life to Australians for decades, it has only been in recent times that large, sophisticated aquaria have been constructed to provide 'real life' underwater experiences for visitors.

Most commercial aquaria now include strong education messages about marine life, the importance of our seas for commercial and recreational purposes, and the need for marine conservation. Most employ specialised education and interpretative staff and operate school programs.

Several million people, including domestic and international tourists, visit these facilities each year. Around 20% who visit are school children on excursions. Opportunities exists for government agencies to provide interpretative and education material on marine conservation to these aquaria. A range of public education programs offered by these facilities is summarised below.

Status of community marine education programs

Despite the large numbers of marine education text books, television programs, brochures, posters and newsletters, there is a paucity of published literature describing and evaluating marine education programs in Australia. (A search of 190,000 records - many duplicatory - on Australia's six major bibliographic databases on culture, geography, natural history, science and fisheries turned up only nine using 'marine education' as the key word). While individual education projects have often been evaluated through traditional methods (such as numbers of brochures distributed, books published, peer review, questionaries), social research is necessary to assess the effectiveness of public marine education programs.

Some aquaria and marine theme parks with marine educational programs

Sea World on the Gold Coast
Over 30,000 school children each year attend the Sea World (Gold Coast) educational programs. Programs include school camps with lectures on marine mammals, sharks and biology; 'oceanographer for a day' (a hands on, real research project for senior physics and chemistry students); sealion visits (which includes studies of anatomy, physiology, behaviour etc.); and water testing (emphasising water quality around the Gold Coast).

Approximate visitations to major aquaria in Australia

Seaworld, Gold Coast (Qld)	>6 million since 1980
Sydney Aquarium (NSW)	2 m since 1988
Oceanworld, Perth	1.5 m since 1988
Underwaterworld (Qld)	1.4 m since 1989
Oceanworld, Manly (NSW)	1.3 m since 1982
Great Barrier Reef Aquarium (Qld)	1.2 m since 1988
National Aquarium, Canberra	0.5 m since 1989
Approx total 1987-92	12 million

Australian National Maritime Museum
This museum aims to increase knowledge, appreciation and enjoyment of Australia's seas and waterways through the acquisition, conservation and presentation of Australia's maritime heritage. Over 2,000 items are exhibited, from a fleet of historic ships to videos. Education programs include public exhibitions, conferences, newsletters, schools programs and adult education courses.

The Phillip Island Penguin Parade
Every night at sunset at Phillip Island, 130 kilometres from Melbourne, groups of the world's smallest penguins, the little (or fairy) penguin, make their way from the sea to their burrows in the sand dunes. The 'Penguin Parade' is watched by almost 500,000 visitors each year, with some nights attracting over 3,800 spectators. It is the most popular single wildlife attraction in Australia, worth around $50 million pa to the Victorian economy. Tourism has saved these penguins as those in other parts of the island have died out.

Manly Oceanworld, Sydney
Manly has recently upgraded its interpretive displays to features such as threats from households to the marine environment. Responding to popular interest from local schools, the display demonstrates the effect of daily waste poured from kitchen sinks.

Great Barrier Reef Aquarium, Townsville
The Great Barrier Reef Marine Park Authority has established the Great Barrier Reef Aquarium, the world's largest living coral reef display, as its main interpretive centre. Visitors to the Great Barrier Reef region can see a coral reef in comfort, touch marine specimens in a 'touch tank', and learn about the Marine Park and its management through interactive computers and graphics, and from a team of volunteers who provide essential support in the interpretative centre.

(Source: GBRMPA)

Figure 66.4: The Great Barrier Reef touch tank.

(Source: COLORSCAN Australia)

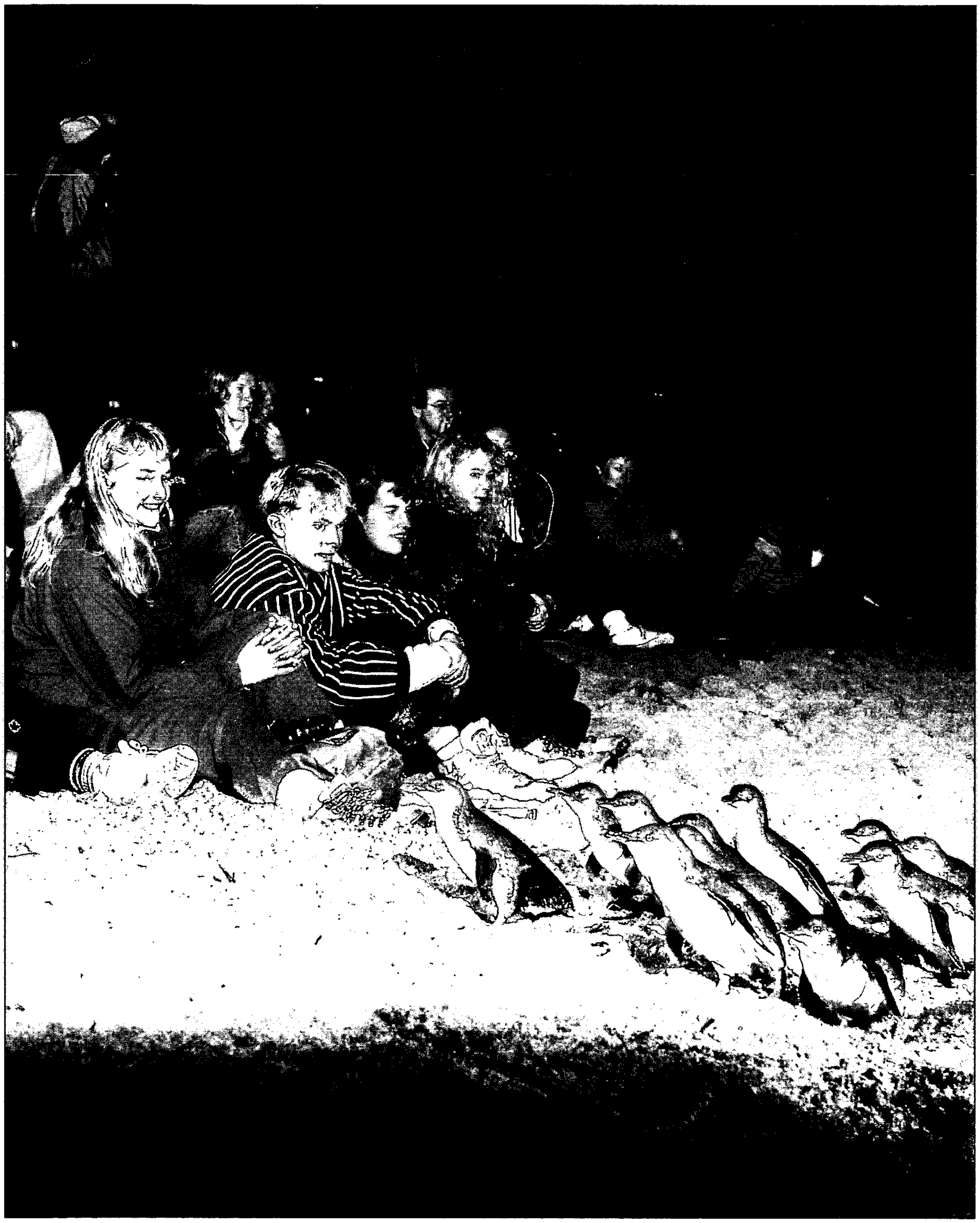

Figure 66.3: The Phillip Island Penguin Parade.

Summary and conclusions

1. There is a paucity of published material on community marine education. Better use of technology and information transfer on coastal and marine environmental issues are required.

2. Opportunities exist for promoting marine conservation, ESD and management messages in public facilities such as zoos, marinas, science centres, museums, aquaria and coastal field study centres.

3. Marine environmental education for ESD has been treated largely as an ancilliary activity in government management programs rather than as an integral part of the management process. Marine environmental awareness and action programs lag behind similar terrestrial-based programs.

4. Television is recognised as one of the greatest influences in shaping community attitudes about the environment. Increased use of news networks and electronic media should be made for community awareness and education programs.

5. Intergovernmental coastal management is fragmented and uncoordinated and community marine education programs reflect this weakness. Integrated and streamlined marine and coastal management programs between Commonwealth, State and Local Governments will make community action make efficient and effective.

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Chapter 67: An assessment of marine protected areas in Australia[1]

'... as an integral component of marine conservation and management, each national government should seek cooperative action between the public and all levels of government for development of a national system of marine protected areas'

(The World Conservation Union (IUCN) 17th Session, Costa Rica 1988)

This chapter assesses Australia's progress in establishing marine protected areas (MPAs). It is based, to a large extent, on assessments of the prime functions of these areas, number, area, jurisdiction, size and region. Space precludes assessment of individual MPAs, but many of these are described in the following chapters.

What are marine protected areas?

A 'marine protected area' (MPA) is defined by the World Conservation Union and the Australian and New Zealand Environment and Conservation Ministerial Council's (ANZECC) National Advisory Committee on MPAs as:

Any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment. (Kelleher and Kenchington 1992)

This definition is very broad and encompassing. The environments and ecosystems that can be included within MPAs include those located in estuarine and intertidal areas such as tidal lagoons, mudflats, saltmarshes and mangroves, as well as in coastal and oceanic waters.

MPAs serve many functions, including nature conservation; protection of commercial fisheries resources; protection of human cultural heritage; and for provision of tourism, recreation, education and research opportunities. They may exist as an intertidal component of a mainly terrestrial protected area or, at the other extreme, as an oceanic reserve far from terrestrial influences.

MPAs are only one of a number of tools used in marine conservation and management. They are recognised internationally and nationally as an important means of protecting biodiversity, and achieving sustainable use of marine resources. They are also recognised in the World Conservation Strategy, the National Conservation Strategy of Australia and in the National Strategy for Ecologically Sustainable Development, all of which have been endorsed by Australian governments.

There are a number of different types and terms for MPAs in Australia: Marine Reserves, Marine Parks, Marine National Parks, Conservation Areas, Nature Reserves, Coastal Parks, Historic Shipwreck Protected Zones, Aquatic Reserves, Wildlife Sanctuaries, Wetland Reserves, Fish Habitat Reserves, Aquatic Life Reserve and Marine National Nature Reserve.

The level of protection that is applied within part or all of a MPA may range from management prescriptions designed to exclude virtually all uses, to less intensive measures designed to accommodate a wide range of uses consistent with an over-riding conservation objective. A MPA can be any size; Shiprock Aquatic Reserve in New South Wales is less than 0.1 square kilometres in area while the Great Barrier Reef Marine Park (GBRMP) is 344,000 square kilometres.

Reasons for establishment of MPAs

There are over 300 MPAs in Australia, with a total area of 428,857 square kilometres. Most of these have been established to meet nature conservation objectives (47%), or fisheries conservation objectives (38%). The number of nature conservation MPAs includes 58 MPAs which are small and intertidal areas that represent the marine components of terrestrial protected areas.

The few large MPAs established to meet multiple-use objectives make up over 90% of the total area of MPAs. The largest of these is the GBRMP which represents about 73% of the total area. Nature conservation MPAs represent around 7% of the total area, while fisheries MPAs represent around 0.4% (or 1.3%, if fisheries MPAs within other MPAs are included). MPAs established for cultural/heritage and other purposes include less than 0.1% of the total area.

[1]Based on a paper by (alphabetically) C. Bleakley, Great Barrier Reef Marine Park Authority, Canberra, Australian Capital Territory; Dr A. Ivanovici, Commonwealth Environment Protection Agency, Canberra, Australian Capital Territory; and P. Ottesen, Great Barrier Reef Marine Park Authority, Canberra, Australian Capital Territory.

Table 67.1: Categorisation of MPAs in Australia by purpose. MPAs were assigned to particular categories on the basis of their primary purpose and management objectives.

Category	Number	Area (sq km)	
Nature conservation	142	32,416	
Fisheries	115	1,827	(5,923)*
Multiple-use	18	428,857	
Cultural heritage	19	88	
Other (e.g. education)	9	12	
Total	**303**	**463,200**	

* Note: there are a number of fisheries MPAs in Qld that are included within multiple-use MPAs (totalling an area of 4,096.25 square kilometres).

Table 67.2: Number and area (square kilometres) of MPAs in Australia by jurisdiction in 1984 and 1992. (a) was transferred to the Commonwealth in 1992.

State	1984 No.	1992 No.	1984 Area	1992 Area
ACT	1	0(a)	8	0
Cwlth	6	14	362,772	405,789
NSW	16	23	37	922
NT	4	8	2,581	2,584
Qld	67	132	2,168	40,967
SA	52	55	211	364
Tas	15	26	487	611
Vic	20	29	50	518
WA	11	16	9	11,445
Total	**192**	**303**	**368,322**	**463,200**

Jurisdiction of MPAs

All governments in Australia with jurisdictions that include the marine environment have established MPAs. Of the 303 MPAs existing in 1992, Queensland has designated the most, with 132 or about 43% of the nation's total. South Australia has designated 55, while all the other States, the Northern Territory and the Commonwealth have fewer than 30 MPAs each.

The rate of establishment of MPAs is increasing in Australia. Between 1984 and 1992 there was a 58% increase in the overall number. All governments increased the number designated in that period, with Queensland, the Commonwealth, the Northern Territory and Tasmania showing the greatest increases.

Analysis of area presents a different picture. MPAs under Commonwealth jurisdiction made up 86% of the total Australian area. However, most of this total (73%) is one MPA, the Great Barrier Reef Marine Park. Queensland MPAs cover the next greatest area with 10.1% of the total.

The total area designated increased by 27% between 1984 and 1992. Most of this activity was due to the actions of New South Wales, Queensland, Victoria and Western Australia. The area protected by the Commonwealth increased by 11.9% in the period. The total area designated as MPAs outside the GBRMP increased by over 275%.

Over 5% of Australian waters are subject to some degree of conservation management as MPAs. Queensland has the greatest area of MPAs relative to the area under its jurisdiction (approximately 67.6%), reflecting the large sizes of the many Queensland marine parks. Western Australia has the next highest with approximately 15% protected. Other jurisdictions range between 1.2 and 5.3%. The Commonwealth area of 4.7% is dominated by the GBRMP.

Table 67.3: Area of MPAs in each jurisdiction, versus total area of marine jurisdiction.

Jurisdiction	Area of jurisdiction	Area of MPAs	% Included
Cwlth	8,652,400	405,789	4.7
NSW	17,400	922	5.3
NT	62,300	2,584	4.2
Qld	60,600	40,967	67.6
SA	31,500	364	1.2
Tas	27,000	611	2.3
Vic	14,400	518	3.6
WA	74,400	11,445	15.4
Total	**8,940,000**	**463,200**	**5.2**

Size of MPAs

Marine protected areas in Australia range in size from less than one square kilometre to more than 344,000 square kilometres. Most MPAs declared in Australia are less than five square kilometres in area. More than 50% of the MPAs for which area figures are available (132) are less than five square kilometres; 28% (74) are between five and 50 square kilometres; and 13% (34) are between 50 and 500 square kilometres. Fewer than 5% (13) are between 500 and 5,000 square kilometres, and only 3% (9) are greater than 5,000 square kilometres.

The waters of the southern and eastern half of the continent (latitudes south of Shark Bay in Western Australia and south of the Queensland/New South Wales border) are dominated by small MPAs in the 0-5 and 5-50 square kilometre size ranges.

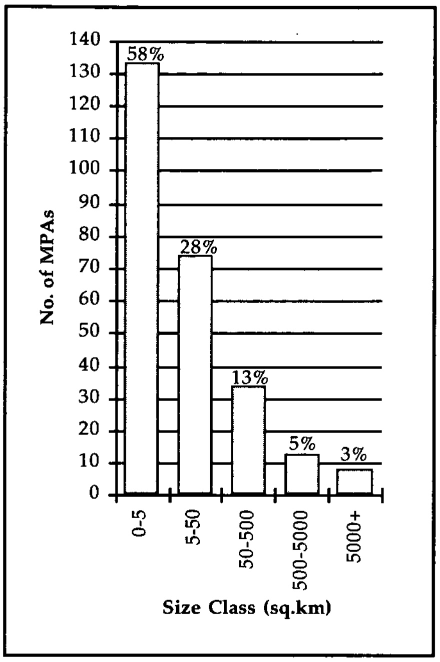


Figure 67.1: Frequency and percentage proportion of Australian MPAs by size class. (Figures above bars indicate percentage.) Information from only 262 MPAs available.

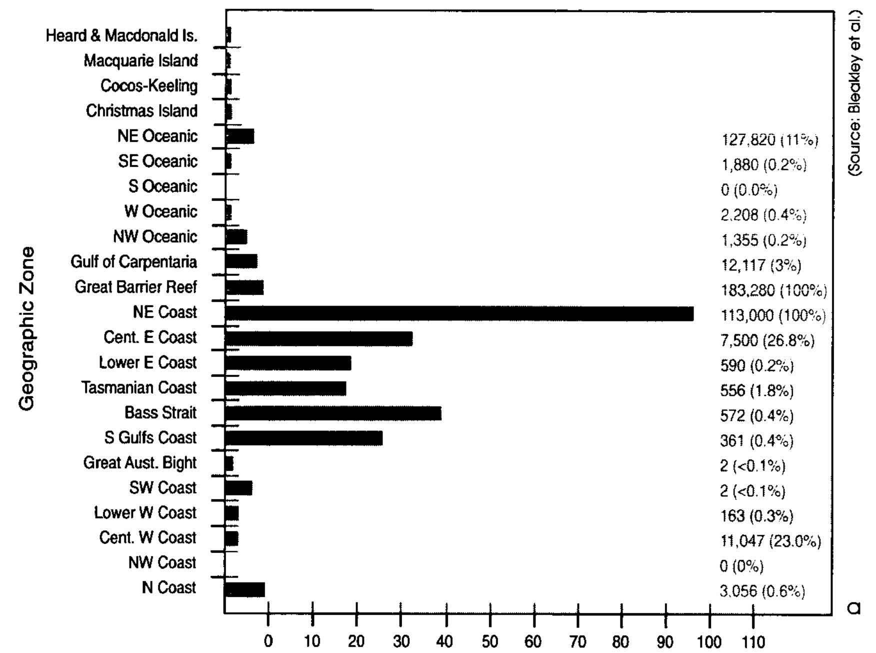
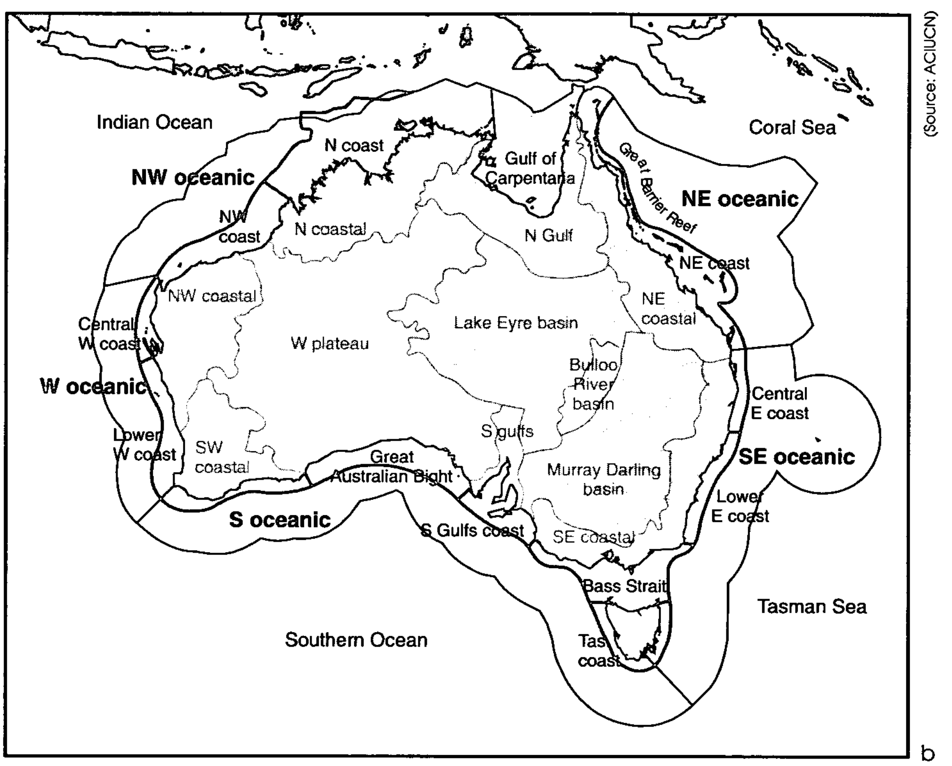


Figure 67.2: CONCOM bioregions and MPAs. The total number of MPAs in each bioregion (b) is shown on the bar graphs (a). The total area of the bioregion is shown at the left (in sq km), and the proportion (%) of each bioregion which is protected is shown in brackets. Only the Great Barrier Reef and the adjacent North East Coast of Queensland are almost totally protected (ca 100%).

MPAs, by biogeographic regions

Australia's marine environment has been classified into 32 biogeographic regions by a technical working group of the Council of Conservation Ministers (CONCOM, 1985; now ANZECC). While this classification has not been widely used by governments and is currently under revision, it can be used to provide some indication of at least the geographic 'representation' of Australia's MPAs. For this analysis 'representation' is the proportion of each region protected.



The CONCOM scheme recognises four broad geographic categories of which three are in the Australian 200 nautical mile Exclusive Economic Zone and are used here: Coastal, Oceanic, and External Territories and Islands. These categories are further divided into biogeographic zones of which 23 are used for this analysis. The distribution of MPAs by location and size class within these geographic zones is shown in Figure 67.2.

Most MPAs are on the east coast; of these more than 90 are in the NE Coast zone. There are few MPAs in the NW Coast, Oceanic and External Territory zones, while the South Oceanic is not represented at all.

There are five zones which have more 10% of their areas protected in MPAs: the Great Barrier Reef (almost 100% of its total area), the North East Coast (93%), the Central East Coast (27%), the Central West Coast (23%) and the North East Oceanic (11%).

These five zones make up over 90% of the total area of Australian MPAs. The Tasmanian Coast (about 2% of its total area) and the Gulf of Carpentaria (1.3%) are the only other zones with more than 1% of their area protected as MPAs.

MPAs above and below the tropics

A comparison of MPAs north and south of the Tropic of Capricorn shows that there are many more south of the tropics (175 as opposed to 98). However, the area protected in the tropics is more than 14 times greater than that in the south. If the GBRMP is excluded from the figures the area of MPAs in the tropics is still more than double the area to the south .

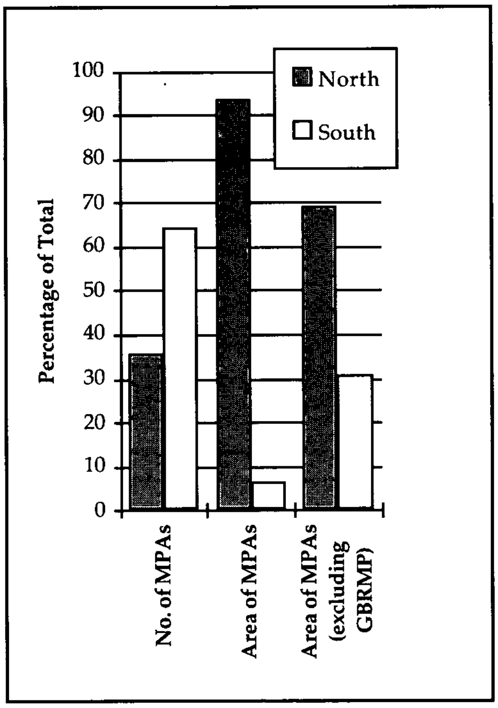


Figure 67.4: Proportion of MPAs by number and area (and area excluding GBRMP) north and south of the Tropic of Capricorn.

Australia's MPAs in a global context

The Marine Protected Areas Program of the IUCN Commission on National Parks and Protected Areas (CNPPA) is promoting the establishment of a global system of marine protected areas. As a first step, a network of working groups have been established to identify and collate information about existing MPAs for 18 marine geopolitical subdivisions or regions of the world (Table 67.4). Australia and its surrounding waters constitutes a single Marine Region. With 303 (24% of the world's total), Australia has the most MPAs.

Table 67.4: Number of existing MPAs in the CNPPA Marine Regions (from Kelleher and Bleakley 1992)

Region No.	Region name	No. of MPAs
1	Antarctic	24
2	Arctic	9
3	Mediterranean	46
4a	North West Atlantic	45
4b	North East Atlantic	34
4c	North Atlantic - Baltic	44
5	Wider Caribbean	76
6	West Africa	125
7	South Atlantic	25
8a	Indian Ocean	25
8b	North West Indian Ocean	24
8c	South East Africa	56
9	South East Asia	92
10	Central and South Pacific	66
11a	North East Pacific	54
11b	North West Pacific	201
12	South West Pacific	25
13	Australia	303
Total		**1,275**

Discussion

Number of MPAs and area protected

The broad definition of the term MPA means that the number of Australian MPAs must be interpreted with some caution. Similarly, the existence of a single and very large MPA (the GBRMP) dominates the area estimates. However, the data have been analysed in such a way as to make transparent the many types of MPAs and their contribution to the assessments and conclusions.

Compared with terrestrial protected areas (TPAs), MPAs have a short history of use and acceptance. For example, Australia has 3,429 TPAs, with a total area of 501,394 square kilometres. The number of MPAs is low compared to this (303), but the total area of MPAs is only slightly less (463,200 square kilometres) because of several, very large MPAs.

Location of MPAs around Australia

Several factors contribute to the uneven distribution of MPAs around the Australian coastline. For example, the Great Barrier Reef (GBR) has received special attention from the Commonwealth and Queensland Governments and a network of complementary MPAs covers the entire GBR region.

The distribution of MPAs is also influenced by the presence of features recognised for their marine conservation significance, such as the stromatolites in Shark Bay, Ningaloo Reef and a seasonal refuge for whales in Hervey Bay in Queensland.

Since the 1960's, the fishing industry has recognised the importance of protecting breeding and nursery habitats of species of fisheries importance. This has led to the designation of many MPAs in mangrove and estuarine areas because of their importance to the life cycles of commercial and recreational fisheries species.

Most Australians live near the eastern coast. There is increasing awareness of the degradation of the marine environment, a point often brought home by a decline in recreational opportunities. This awareness has stimulated interest in marine conservation initiatives, including the establishment of MPAs and there are many small MPAs along the eastern coast of Australia. Larger MPAs tend to be located in the north away from population centres, a similar pattern as with terrestrial protected areas. Exceptions are the Solitary Islands Marine Reserve and parts of the GBRMP which exist close to population centres and encompass some areas of high use.

Optimal sizes of MPAs

The size of a MPA can be a significant factor in meeting conservation objectives. There are no prescribed size limits for MPAs and the most effective size must be determined according to the nature and purpose of the area to be protected. For example, MPAs to protect shipwrecks may be very small.

Maintenance of marine biodiversity may only be achieved by making MPAs large enough to protect all life cycle stages or to achieve adequate buffering or dilution of the impacts from human activities. The minimum viable size of a MPA is likely to be much larger than the minimum viable size of a terrestrial reserve. Management of a large area is likely to provide more scope for control and sustainable management of human activities.

Large, multiple-use MPAs are an important means for maintaining marine biodiversity. They are more acceptable to user groups, particularly the fishing industry, and have increased acceptance of MPAs as a legitimate marine conservation management tool.

It is probable that the Great Barrier Reef Marine Park, Solitary Islands, Ningaloo Marine Park Reserve, and the Coral Sea Island Reserves are of sufficient size to be independently viable and sustainable. However, even for such areas, boundary influences (particularly from mainland activities) do have an effect. It is probable that many Australian MPAs are too small to be viable in the long-term in the absence of sympathetic management outside their boundaries.

Representation

The CONCOM classification shows that while some geographic regions are very well represented in MPAs, many are not represented at all. Five of the 23 regions have MPAs that cover about 10% or more of their area while most other regions are represented at less than 1%. The total area protected is 5.2% of Australia's marine jurisdiction. Excluding the GBRMP from these estimates, the total area is about 1.3% of Australia's marine jurisdiction.

There is not yet an agreed definition for 'representation' in the marine environment, and there is no agreed method on how to identify potential MPAs that could protect representations of Australia's marine environment. Representation, in a general and non-technical sense, could be the extent to which the variety of biological, physical, and cultural features in an area typify the features of a larger region.

It will not be possible to provide an accurate or even defensible measure of the degree to which Australian marine environments are represented in MPAs until there is an agreed biogeographical framework, a definition for representation and adequate information about the biological, physical and other characteristics of the Australian marine environment. However, the information available suggests that for many of the geographic regions defined by CONCOM there are substantial gaps in the coverage of Australian MPAs.

Governments in Australia have not addressed the question as to what proportion of Australia's environment should be included in MPAs. The Brundtland Report (World Commission on Environment and Development 1987) recommended that 8% of the world's land and freshwater areas be set aside and protected. IUCN (1991) has proposed 10%, and the Canadian Wilderness Charter (an NGO) has proposed that Canada aim to have 12% of its area set aside in protected areas.

The objectives of MPAs would play a large role in any such considerations; it may be considered desirable to have a large area of Australia's marine environment under MPAs with multiple-use management and a small area set aside in highly protected MPAs.

Dangers in adopting such a single national target figure is that it does not consider details of spatial representation and other conservation objectives. Nonetheless, it is an easily understood concept and goal for the public, policy makers and governments.

Meeting the conservation objectives for established MPAs

A critical test of the status of MPAs in Australia is the extent to which they are meeting the objectives for which they were established. Success of MPAs as a marine conservation tool requires that they achieve these objectives. Such an assessment would need to consider the conservation and management objectives, the management tools used, supporting legislation, research, education, surveillance and enforcement programs, and the level of government funding and community involvement and support. It is not possible to provide an assessment at this time; each MPA would need to be assessed, a complex task covering 303 MPAs with a vast range of objectives.

International, national and jurisdictional considerations

The establishment and management of MPAs in Australia is influenced, and in some cases complicated, by international, jurisdictional and political factors.

Some international conventions impose obligations on Australia that have been met through the establishment of MPAs in particular areas. Three MPAs are listed under the World Heritage Convention: the GBRMP, Shark Bay and Kakadu National Park. The Convention requires listed sites to have management plans in place.

A number of MPAs meet international obligations to protect migratory seabirds and their habitats (including the Coral Sea Islands Reserves and Ashmore Reef Reserve), and a number protect wetlands including Kakadu (NT), Fullerton Cove and Towra Point (NSW). The intertidal component of Macquarie Island is part of a Biosphere Reserve.

The manner in which marine conservation is pursued in Australia is influenced by jurisdictional factors. Approaches to the establishment of MPAs differ both between and within jurisdictions. MPAs can be established under Commonwealth, State or Territory legislation. As a result of the Offshore Constitutional Settlement, the States establish and manage MPAs in waters out to three nautical miles and the Commonwealth in all other waters, except in exceptional circumstances where Commonwealth law can apply from the low-water mark (e.g. the GBR and External Territories).

Cooperation is required to establish and manage areas that overlap the jurisdictional boundaries between the Commonwealth and States, and between States. This may be effected through the Australia and New Zealand Environment and Conservation Council (ANZECC), but as membership of ANZECC does not include Fisheries Ministers, its effectiveness for coordinating and managing MPAs is reduced.

The most detailed cooperative arrangement exists between the Commonwealth and Queensland Governments for the management of the GBR Marine Park and World Heritage Area, and involves a joint and complementary approach to management of adjacent jurisdictions. This arrangement is overseen by the Ministerial Council, the members of which include Environment and Fisheries Ministers. Successful cooperative working arrangements have been developed between Commonwealth and State agencies for some other protected areas, for example, between the Australian Nature Conservation Agency (ANCA) and the Western Australian Department of Conservation and Land Management in Ningaloo Marine Park; and ANCA and New South Wales Fisheries in Solitary Islands and Lord Howe Island.

Within jurisdictions, various agencies with different conservation objectives can establish and manage MPAs. For example, in Commonwealth waters, MPAs have been established under the *National Parks and Wildlife Conservation Act* 1975 and *Historic Shipwrecks Protection Act* 1976 in all areas except the GBR region where the *Great Barrier Reef Marine Park Act* 1975 applies.

At the State government level, MPAs may be the responsibility of a national parks agency in one State, or a fisheries management agency in another, or both, depending on the purpose for which they are established. Such a division often also reflects policy differences in the types of MPAs that are established. Fisheries management agencies in some States tend to use MPAs primarily to protect the habitat of species of commercial or recreational fishing importance, rather than as a tool for conservation.

Other constraints to establishing MPAs

Other factors affecting the establishment and successful management of MPAs include the difficulty and cost of managing an area as vast as the Australian 200 nautical mile Exclusive Economic Zone; the limited information available on many aspects of Australia's marine environment; the high cost of research and management compared with terrestrial protected areas; and the relatively poor community (and political) understanding and support for the role of MPAs as a tool for marine biodiversity conservation and ecologically sustainable development.

Recent activities and prospects for the future

In recent years governments in Australia have been active in establishing MPAs. Factors contributing to this include community and industry concern about marine pollution (especially sewage pollution of Sydney beaches), serious oil spills overseas and in Australia, overfishing and declining recreational values in some areas.

MPAs are becoming better understood and accepted as an important marine conservation tool. The fishing industry is becoming a strong supporter for MPAs. For example, in Queensland MPAs are seen as important in protecting fisheries habitat and acting as fisheries replenishment areas.

A number of recent government and parliamentary reviews on the coastal and marine environments have emphasised the importance of large, multi-use MPAs and integrated management (e.g. 'The Injured Coastline', the 'Commonwealth Coastal Policy discussion paper', and the RAC Coastal Zone Inquiry: Chapter 1).

At the international level, the United Nations Conference on the Environment and Development and other initiatives have also promoted marine conservation (e.g. Chapter 17 of Agenda 21), and are providing impetus for the establishment and management of MPAs.

Recent initiatives provide impetus for MPAs

The Commonwealth Government's Ocean Rescue 2000 program is promoting the establishment of a national representative system of MPAs (next chapter).

The Australia and New Zealand Environment and Conservation Council (ANZECC) has also established a National Advisory Committee on MPAs to coordinate the development of a national representative system of MPAs. Membership of this committee includes conservation and fisheries management agencies.

The National Strategy for Ecologically Sustainable Development, which has been adopted by all Australian Governments, endorses the establishment of a national representative system of MPAs.

The success of these initiatives is likely to be ultimately determined by:

- community support and commitment to MPAs, (which will be influenced by community understanding of how MPAs can contribute to marine conservation and the degree of consultation in identification, selection and management);
- industry support (particularly from the fishing, tourism and mining industries), which will be influenced by the degree and nature of access to MPAs; and
- the willingness of governments to cooperate and share the costs and benefits of establishing and managing MPAs.

Summary and conclusions

1. The definition of the term 'marine protected area' (MPA) is very broad, and encompasses areas under a wide range of protective regimes and variety of marine ecosystem types.

2. MPAs have been used in Australia as a conservation tool for a wide range of purposes, including nature conservation, protection of fisheries resources, protection of cultural heritage and provision of recreation, education and research opportunities.

3. In 1992 Australia had 303 MPAs totalling an area of 463,200 square kilometres. Australia is using this tool more frequently and extensively than other countries and has a substantial proportion of all the world's MPAs.

4. The greatest use of MPAs (in terms of numbers) has been for the purpose of nature conservation. A large number of sites have also been established by fisheries agencies to protect commercial and recreational fisheries habitat. However, in terms of area, over 93% of Australia's MPAs are established on a multiple-use basis.

5. Since 1984, the number of MPAs has increased by 58% and the area in MPAs has increased 26%. The Commonwealth has increased the area protected under its jurisdiction by about 12%, while States have increased areas protected by more than 400%.

6. Most MPAs are small (more than 50% are less than 5 square kilometres) and these tend to be confined to the southern and eastern half of the continent. This is where human activity is greatest and the demand for conservation action is highest. However, the largest MPAs tend to be away from the areas of highest human activity.

7. About 5.2% of Australia's marine environment is protected in MPAs (however, a very large proportion of this, 74%, is within a single MPA, the GBRMP). Excluding the GBRMPA, about 1.3% is protected.

8. Large sections of Australia's marine environment have few or no MPAs.

9. It is not possible to provide an assessment of the degree to which MPAs are successful in meeting their objectives. It is probable that many Australian MPAs are too small to be viable in the long-term in the absence of sympathetic management outside their boundaries.

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The technical paper by C. Bleakley, A. Ivanovici and P. Ottesen was internally reviewed within the Great Barrier Reef Marine Park Authority and the Australian Nature Conservation Agency.

Chapter 68: The Ocean Rescue 2000 Marine Protected Area program[1]

... 'the Australian government has decided to work towards the expansion of Australia's marine reserve system. In association with State and Territory governments, we will investigate the establishment of a national, representative system of marine protected areas for Australia that will protect these areas, while permitting appropriate uses and promoting public education.'

The former Prime Minister, Mr Bob Hawke, at the International Union for the Conservation of Nature (IUCN) General Assembly in Perth, November 1990.

Prior to the 1960s, protected area selection was almost exclusively *ad hoc*, driven by assumptions about which biota and habitats were most threatened or endangered, which areas were most scenic, or which had the best wilderness values. Since the 1960s, ecological science has developed the concept of representative 'core' protected areas in the context of biogeography and monitoring of resource attributes.

The present status of marine protected areas in Australia has been reviewed in Chapter 67. This chapter briefly examines the history of MPAs in Australia, and describes in some detail the development of the Ocean Rescue 2000 MPA program, and possible future developments.

Background to MPA program

In 1978, an *ad hoc* Working Group on Marine Parks and Reserves prepared a report for the Council of Nature Conservation Ministers (CONCOM) Standing Committee on marine parks and reserves. This report discussed the concept of marine parks and reserves for the protection of areas for conservation, scientific, recreational and educational purposes. It also noted that the finite limit of marine resources, both commercial and cultural, had created the need for a representative system of marine parks and reserves in Australia.

In 1979, the Offshore Constitutional Settlement between the States, the Northern Territory and the Commonwealth established *inter alia* overall responsibilities for marine parks and reserves. In 1984 CONCOM endorsed selection and management principles for marine and estuarine protected areas to begin the process towards developing a representative system of marine protected areas.

However, it has only relatively recently been recognised that marine protected areas need to be located in a matrix of surrounding levels of protection, that marine ecosystems are far too dynamic and subject to external processes and pressures to be compared to terrestrial ecosystems, and that marine conservation needs to be considered within a context of integrated terrestrial and marine management.

The Ocean Rescue 2000 program

In August 1991 the former Minister for the Arts, Sport, the Environment and Territories, Mrs Ros Kelly, announced the establishment of Ocean Rescue 2000, a decade-long program to protect the marine environment.

Ocean Rescue 2000 Program

The program commenced in 1991 with three components:

- the development of a national marine conservation strategy (which will provide the basis for sustainable use of Australia's 200 nautical mile Exclusive Economic Zone and complement the national biodiversity strategy, actions arising from the ESD process, and the Offshore Exploration Strategy);
- the development of a state of the marine environment report (this report); and
- the development of a national representative system of marine protected areas (MPAs).

Since then, the program has expanded to include:

- development of a national marine education program (designed to inform and provide accurate and timely information about the Ocean Rescue 2000 program to all Australians);
- development of a national marine information system (being developed by the Environment Resource Information Network unit (ERIN) to provide a comprehensive computerised scientific information base); and
- development of a marine and coastal community network (to foster community involvement in marine conservation).

[1] Based on a paper by J.W. Muldoon, Great Barrier Reef Marine Park Authority, Canberra, Australian Capital Territory; and J. Gillies, Department of the Environment, Sport and Territories, Canberra, Australian Capital Territory.

For the first time, Ocean Rescue 2000 provides a holistic context in which to develop a national representative system of marine protected areas and allows for integration with other programs to achieve a coordinated approach to marine conservation in Australia.

Development of a network of marine protected areas in Australia

The goal ...

The goal of the national marine protected area program is to provide for the protection, restoration, wise use, understanding and enjoyment of marine heritage in perpetuity, through the creation of a national, representative system of marine protected areas and through the management in accordance with the principles of the World Conservation Strategy and the national strategy for Ecologically Sustainable Development of human activities that use or affect the marine environment.

> **Role of marine protected areas in ESD**
>
> The National Strategy for Ecologically Sustainable Development (Commonwealth of Australia 1992) has developed as an objective for nature conservation, that the challenge is:
>
> 'to establish across the nation a policy framework for the protection and management of nature conservation values, both inside and outside areas protected under legislation (i.e. protected areas), consistent with ESD principles'.

Basis of the network ...

The national system is to include marine areas chosen on the basis of representing marine biogeographic regions, ecological habitats and geographic zones and other criteria around the Australian coastline, offshore and in territorial waters. The national criteria for identification of MPAs are be established through consultation and research. There are already representative examples established and under management, including the better known Great Barrier Reef Marine Park and the Ningaloo Marine Park.

Ideally, the selection of protected areas to contribute to a nationally representative system should achieve representation of all major ecological communities and environments, including constituent species. Those areas selected for inclusion in the system must also take into account community needs, and the process should include community involvement and public understanding of all aspects of the process, because fundamentally, the management of the marine environment is the management of human use. Development of the national system is currently proceeding on the basis of cooperation between the Commonwealth and State and Territory governments. The contribution of each State and Territory in establishing its own system of marine protected areas will be the basis for the successful creation of a national system.

The Marine Protected Area Program to date

The Ocean Rescue 2000 program is jointly coordinated with two of the statutory authorities of the Department of Environment, Sport and Territories: the Australian Nature Conservation Agency (ANCA, formerly the Australian National Parks and Wildlife Service) and the Great Barrier Reef Marine Park Authority (GBRMPA). This liaison ensures a high level of technical and administrative expertise is available to the program. These agencies work collaboratively with State and Territory agencies, organisations and indigenous communities or other coordinating bodies to prepare, present, assess, evaluate and approve project proposals for funding.

In the 1991/92 financial year, the first year of the Ocean

> **Current MPA program**
>
> The current priorities in the Marine Protected Area Program are:
>
> (1) Development of a systematic approach to identifying representative marine sites for future declaration.
>
> (2) Inventory and classification of marine habitat types and natural and cultural values.
>
> (3) Declaration of marine protected areas in State/Territory waters, wherever possible in collaboration with indigenous communities, the general community and/or other agencies within the State/Territory or of adjacent States/Territory. Collaborative projects with Commonwealth and/or other State/Territory agencies, and in particular those involving indigenous communities are encouraged, in recognition that such collaboration is essential to the success of the marine protected area system, and that the inclusion of adjoining Commonwealth waters or neighbouring State/Territory jurisdictions in such declarations would be appropriate in some cases.
>
> (4) Data gathering (including biological and cultural), particularly projects specifically designed to contribute to coordinated efforts to establish a marine geographic information system (GIS) to assist with establishment, planning and management.
>
> (5) Planning, monitoring, community participation and education programs associated with establishment and promotion of marine protected areas established as a consequence of Ocean Rescue 2000 or other appropriate programs.
>
> (6) Essential management on behalf of the Commonwealth, of declared Commonwealth waters that adjoin marine protected areas in State/Territory waters.

Selected projects in MPA program

The following project descriptions provide examples of the approach adopted so far in the program.

Development of a Classification System for Development of a System of Representative MPAs (NSW Fisheries)
The project aims at developing a systematic approach for identifying areas representing diversity in coastal, marine and estuarine environments to be used as the scientific basis for the development of a system of MPAs in New South Wales waters. A hierarchical biophysical classification of coastal marine environments was developed, based on extracted empirical data related to biological and physical processes operating at different spatial and temporal scales. Progress to date has identified three biophysical regions in which initial assessment of representativeness of current MPAs shows only a small proportion of coastal environments has been covered. The project will continue to analyse biodiversity at several spatial scales.

Classification of Marine Ecosystems in Victoria Waters (Victorian Department of Conservation and Natural Resources)
The Department has developed methodology to classify marine ecosystems leading to identifying representative areas for inclusion in a representative system. The objectives of the project are to: compile existing environmental data; develop a biophysical classification system; describe significant marine features or areas; and, identify information gaps and undertake programs to address them. Progress has involved a data review to identify key data sets, to report on the condition and location of data and to identify options and resources for data handling. Nine key environmental components have been identified and summarised.

Assessment of Potential Marine Parks or Marine Nature Reserves in Western Australian Waters (WA Department of Conservation and Land Management)
This project has been underway for a number of years through the Marine Parks and Reserves Selection Working Group. The task of the Working Group is to provide a report recommending candidate areas for a representative system of nature conservation reserves in Western Australian waters. The report has been released for public comment.

Northern Territory Coastal Inventory and Selection of MPAs (Conservation Commission of the Northern Territory)
The Commission has commenced establishment of an inventory of the Northern Territory coast as the basis for selecting new candidate MPAs. The aim of the project is to identify candidate areas for selection as MPAs. Progress so far has involved: collection of biological data; development of a GIS program; integration of Darwin Harbour records; and, initial work on extending Oracle-ARC/INFO over the entire Northern Territory coast.

Marine Study for a Torres Strait Environment and Resource Strategy (MaSTERS) (Torres Strait Islander Coordinating Council with North Australian Research Unit)
In 1991 the Torres Strait Island Coordinating Council (ICC) commenced development of a marine conservation strategy for Torres Strait. The purpose of the Strategy is: to establish a comprehensive management framework which will permit optimum exploitation of the regions' limited resource base, consistent with the needs of indigenous Torres Strait Islanders, sustainable development and minimal environmental disturbance. A public discussion paper entitled 'Towards a Marine Strategy for Torres Strait (MaSTS)' has recently been released and a program of consultation undertaken with the people of Torres Strait. (Chapter 74).

Queensland Marine Conservation Strategy (Queensland Department of Environment and Heritage in conjunction with Queensland Department of Primary Industries)
This project is to develop a meaningful classification for Queensland waters for conservation planning within the framework of biogeographic regions, similar to that developed for terrestrial areas in Queensland. Initial classification is based on available data sets. Data sets were hand digitised into graphics packages to enable visual overlay and map display, resulting in a derived classification which is intuitive and based on gross physical forcing functions and geomorphology, with biogeography of selected taxa overlaid. The classification defines 18 biophysical regions. Analyses are currently underway to overlay the classification on existing MPA maps to determine levels of protection. The next step will be to develop a structured program to collect and/or collate required data, provide storage and GIS analysis and test/improve classification. More rigorous and objective analyses are proposed at a range of scales using numerical classification techniques.

Wessel Islands Marine Conservation Strategy (Northern Land Council NT)
The Northern Land Council (NLC) undertook a community consultation program with traditional Yolgnu owners in Arnhem Land about marine conservation. The central objectives of the project are to identify the values of waters adjacent to Yolgnu land, to locate specific Yolgnu groups who have responsibility for looking after these areas, establish options for management arrangements and to determine what those arrangements should be. This has so far involved a survey of Yolgnu marine protection initiatives, a detailed ethnographic survey, research into indigenous peoples' involvement in marine protected area management, community consultation and negotiations with government.

Green Paper on Potential Marine and Estuarine Protected Areas (South Australian Research and Development Institute)
South Australia's present system of MPAs is characterised by a network of small, high protection Aquatic Reserves and Netting Closures and an absence of large, multiple-use marine parks. The present MPAs represent less than 1.5% of the State's waters, the smallest percentage of area reserved as MPAs in any state. The development of the 'Green Paper' is a strategic review process which will recommend a management mechanism for new multiple-use marine parks for South Australia, including a scientific framework, methodology and time-table.

Rescue 2000 program, approximately \$0.67m was allocated to State and Territory agencies for 16 marine protected area projects in coastal waters. In the 1992/93 financial year, a total of \$0.89m was allocated toward 19 MPA proposals; in 1993/94 \$0.76m was allocated for 28 projects; and \$1.10m for 23 projects in 1994/95.

In December 1992 the former Prime Minister, Mr Paul Keating, released the 'Statement on the Environment' in which the Federal Government provided an additional \$4.8 million over the next four years to the Ocean Rescue 2000 program to 'accelerate the identification of areas of significance to marine conservation and to expand the consultative process'.

Future developments

The Marine Protected Area program has only been in progress since 1991. The initial emphasis has been the development of a broader strategic approach to identifying candidate areas, as well as funding high priority marine conservation priorities of the States. As the program progresses, the emphasis will shift to developing a more specific approach dealing with the establishment of marine protected areas.

To date, conservation efforts in the marine environment have generally not been as strong as those for the terrestrial environment. The use of an integrated approach to marine management has not yet been implemented on a scale large enough to be meaningful (with the exception of the Great Barrier Reef Marine Park). The result is that many marine areas are under threat on a number of fronts including pollution; degradation and depletion of natural resources; conflicting use of, and demand for, limited natural resources; and damage and destruction of habitat. The goal of the Ocean Rescue 2000 Marine Protected Area program is to address these and other issues.

Processes in development of a representative network

The process in developing the network will involve: (1) developing a procedure to identify an appropriate level and scale of necessary protection, including a structure which recognises the biogeographic differences within our marine environment; (2) identifying gaps in the representation of habitats and processes within such a structure; and (3) putting into place strategies and actions to fill those gaps.

There are several inter-related aspects of establishing and managing marine protected areas, with the fundamental consideration being the ability to apply the concept of ecologically sustainable use in both concept and practice. The principle objectives for marine protected areas are about protecting valued assets, sustainability of functional and viable ecosystems, sustainability of human use and the ability to monitor environmental change. These lead to difficult and complex questions for scientists, managers and administrators about how we manage for sustainable use, how multiple-use can be catered for, the number of marine protected areas required and their size, and other issues which will need to be addressed during the program.

Some progress is being made on answering these questions already in Australia in the Great Barrier Reef Marine Park, the Solitary Islands Marine Reserve and Ningaloo Marine Park, all examples of large ecosystem management for multiple-use.

The nature of the representative network

It is recognised that while they are the ideal, the opportunities for establishing large ecosystems as protected areas will be limited for a variety of political, social or economic reasons. Consequently, the established network will be made up of a large variety of areas of different sizes, declared for different purposes, with different management regimes - but all should share the same common purposes - to provide for both conservation and for opportunities for sustainable use.

The task of establishing a nationally representative system of marine protected areas will not be an easy one. The process will have to contend with political processes at a number of levels, the need for adequate funding to maintain the impetus of the program (particularly the commitment and interest of the people and departments concerned), and the knowledge that Australia is embarking on a journey which puts it at the cutting edge of marine conservation, and among the world's leaders in applying the principles of ecologically sustainable development.

Summary and conclusions

1. The national representative system of marine protected areas will provide an integral contribution to the maintenance of biodiversity, ecological functions and natural resource productivity of Australia's marine environment.

2. The success of the national program will depend on strong commitment from, and close coordination between and within, the Commonwealth, State and Territory governments.

3. Marine protected areas need to be located in a matrix of surrounding levels of protection. Marine ecosystems are more dynamic and interconnected than terrestrial ecosystems.

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Acknowledgments:
The technical paper by J. Muldoon and J. Gillies was internally reviewed in the Great Barrier Reef Marine Park Authority, the Australian Nature Conservation Agency and the Department of the Environment, Sport and Territories.

Chapter 69: The Great Barrier Reef Marine Park: the world's largest multiple-use managed area[1]

The Great Barrier Reef, consisting of around 2,900 separate reefs and extending over almost 2,000 kilometres, is the largest complex of coral reefs in the world. Almost all of the Great Barrier Reef is protected in the Great Barrier Reef Marine Park. This is the world's largest marine protected area, the largest multiple-use managed marine area, and the only large marine ecosystem which is comprehensively managed with the explicit goal of ensuring that its use is ecologically sustainable, in perpetuity.

The Great Barrier Reef Marine Park (GBRMP) covers an area of around 344,000 square kilometres, that is, larger than the area of the States of Victoria and Tasmania combined. It was established under the *Great Barrier Reef Marine Park Act* 1975, and is managed by the Commonwealth's Great Barrier Reef Marine Park Authority (GBRMPA), with the Queensland Department of Environment and Heritage (QDEH) being responsible for day-to-day management. The GBRMP, together with the Queensland Island National Parks (Chapter 76), comprises a unique land/sea system, known as the GBR World Heritage Area.

Description: geography, oceanography and ecology

The GBRMP can be divided into four sectors (far northern, northern, central and southern) based on administrative, geomorphological and biological characteristics. The latitudinal (north-south) changes are, however, less marked than the cross shelf (east-west) changes as the inner reefs are strongly affected by terrestrial inputs and periodic flooding and the outer reefs are more oceanic. Details are described in Chapter 12.

Diverse interconnected habitats and ecosystems are represented in the GBR World Heritage Area, including: shores (soft, sandy, rocky); estuaries; mangrove wetlands and seagrasses; coral reefs (platform, fringing and ribbon); sub-tidal benthos (ranging from algal- and sponge-dominated communities of the shelf, to the little-known communities of the continental edge and slope); and pelagic communities.

Coral reefs are amongst the most diverse ecosystems in the biosphere. The GBRMP supports a very rich and diverse fauna and flora, including some 400 different species of corals, 4,000 molluscs, thousands of other invertebrate species, over 1,500 fishes, 16 sea snakes, six turtles, 35 seabirds (plus 30 waders and over 150 land birds) and 23 species of marine mammals (six rorqual whales, 16 toothed whales and one dugong). Major populations of the endangered species of giant clams, turtles and dugongs are also present.

Social and cultural values

Importance to indigenous communities

The GBRMP contains many culturally important sites for Aboriginal and Torres Strait Islander peoples, including culturally significant sites and middens, and contemporary fishing grounds. Crocodiles, turtles, and dugongs have particular cultural importance, and may be hunted legally by Aboriginal people and Torres Strait Islanders according to species management plans.

Ten communities, with populations from 600 to 1,200, live adjacent to the GBRMP. The sea remains important for subsistence, cultural and spiritual reasons, although traditional hunting and gathering techniques have evolved with aluminium dinghies, outboards, modern fishing gear and 4-wheel drive vehicles now in common use. The GBRMPA recognises the importance of the involvement of Aboriginals and Torres Strait Islanders in the management of the Marine Park and employs several Liaison Officers to work with communities.

Some of the major issues for indigenous communities adjacent to the GBRMP include their strong desire for greater involvement in the planning and management process; uncertainties resulting from the 1992 'Mabo case' and the Commonwealth *Native Title Act* 1993 on coastal and customary marine tenure; and the desire of some indigenous people to hunt dugongs and turtles both within and outside customary areas.

[1]Based on a paper by Dr L. Zann, SOMER Coordinator, Great Barrier Reef Marine Park Authority, Townsville, Queensland.

Great Barrier Reef Marine Park
some facts and figures

total length (km)	2,500
total number of reefs	2,900
submerged shoals	566
patch reefs	466
crescentic reefs	254
lagoonal reefs	270
planar refs:	544
incipient fringing reefs	213
fringing reefs	545
total number of islands	940
high (rocky) islands	618
unvegetated cays	213
vegetated cays	87

GBR fisheries

commercial fisheries	
number of vessels	1,400
number of trawlers	800
number of licensed fishermen	3,700
fleet value	$200 m
catch value (pa)	$255 m
fisheries landings (t)	
prawns	4,000
lobsters etc	460
reef fish	2,828
mackerel	900
mud crabs	361
trochus	210
bêche-de-mer	40
aquarium specimens	60,000
recreational fisheries	
number of speedboats	24,000
number of charter boats	50
reef fish landings (t)	4,000

GBR tourism

GBR island resorts	**27**
Tourist beds	**7,000**
Visitors GBR & coast (pa)	2,040,000
Total visitor nights (pa)	9,498,000
Value (incl. coast) (pa)	$1,000 m
Value GBR resorts only (pa)	$300 m
Employment (people)	120,000
Tourist vessels	411
Commercial passenger vessels	100
Total SCUBA dives pa	178,000

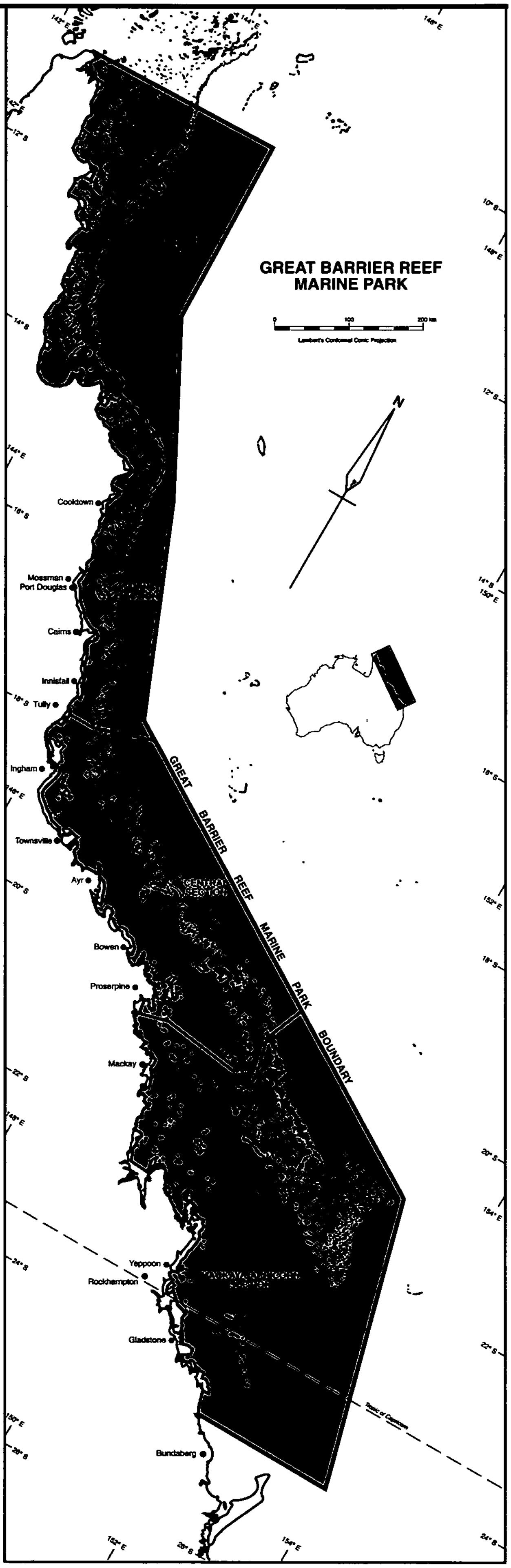

Figure 69.1: Great Barrier Reef Marine Park.

Because of the special importance of the GBRMP to Aboriginal and Torres Strait Islander communities, in 1994 the membership of Marine Park Authority was increased to five to include a member to represent the interests of indigenous people.

Importance to non-indigenous communities

The GBR is likewise very important to the cultural heritage of non-indigenous Australians. The GBR has been a trap for ships from the times of the first explorers to the present, and contains over one thousand shipwrecks, many of which are of historical significance. In 1770 Cook jettisoned the cannons and ballast stones of Endeavour when it was almost wrecked off present-day Cooktown. In 1791 *HMS Pandora* was wrecked whilst carrying some of the infamous *Bounty* mutineers back to Britain to stand trial. Other designated Historic Shipwrecks include *Morning Star* (1814), *Mermaid* (1829), *Gothenburg* (1875); *Quetta* (1890), *Foam* (1893), and *Yongala* (1911).

The GBR has a great cultural and heritage value to Australia and the world, and was the first site in Australia to be inscribed on the World Heritage List. It is a source of national pride for Australians, who commonly refer to it as the 'eighth wonder of the world', the 'jewel in nature's crown', or simply, 'the Reef'.

Australians feel strongly about the protection of the GBR. There was public outcry when plans to drill for oil and mine limestone were first raised in the 1960s, and this concern ultimately lead to the creation of the GBRMP. Australians continue to be concerned about 'the Reef'. News of a threat from crown-of-thorns starfish, or an oil spill still makes headlines around Australia.

The great social and economic value of the GBR is evident by the huge and rapidly growing tourism industry. Over two million people visited the Reef or adjacent coast each year, raising new concerns that we may be 'loving it to death'. The 'value' of the Reef measured as earnings by tourist operators and closely associated firms in the regional economy is approximately $1,000 million per annum.

Management of the GBRMP

Legislation

The Seas and Submerged Lands Act 1973 established Federal jurisdiction over, and title to, the sea-bed below low water mark outside State internal waters. The *Great Barrier Reef Marine Park Act* 1975 provides the legal basis for management of the GBR. In recognition of its outstanding universal value, the Great Barrier Reef was inscribed on the World Heritage List on 26 October 1981 as meeting all criteria set out in Article 2 of the World Heritage Convention.

Management strategy

The GBRMP is not a conventional national park, but a multi-use protected area, according to the category VIII of the World Conservation Union (IUCN). Through the use of zoning, conflicting uses are separated; some areas are provided which are suitable for particular activities, and some areas are protected from use. Levels of protection range from minimal restrictions, to complete exclusion of visitors. Special management plans are developed for more site specific controls of heavily used reefs, such as Green Island, Low Isles, and Whitsunday Islands, in cooperation with the QDEH.

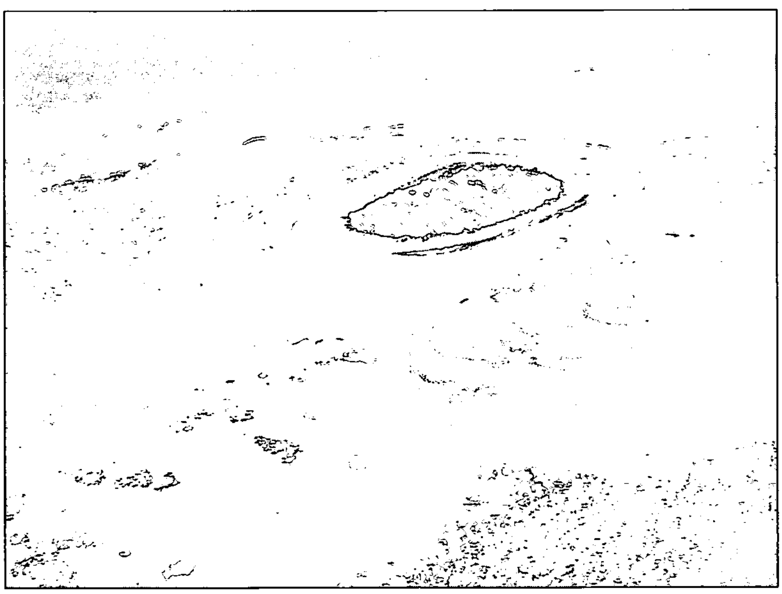
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Figure 69.2: (a) The Great Barrier Reef Marine Park includes 2,900 reefs and 940 islands. (b) Green turtle hatchlings. (c) Butterfly cod.

Many activities are regulated through a permit system, which may be subject to a comprehensive environmental impact assessment process or, if necessary, the Commonwealth *Environment Protection (Impact of Proposals) Act* 1974. These processes include provision for public comment where the amenity of an area may be affected.

The GBRMP Act requires that the GBRMP Authority involve the public in many of its decision-making processes, including zoning and formulating management plans, as this increases public acceptance and a sense of ownership, and leads to more effective planning. Input from Reef users and conservation groups occurs through the GBR Consultative Committee which comprises representatives from management, tourism, fisheries, conservation, Aboriginal communities, local government and other relevant organisations and groups.

Management framework

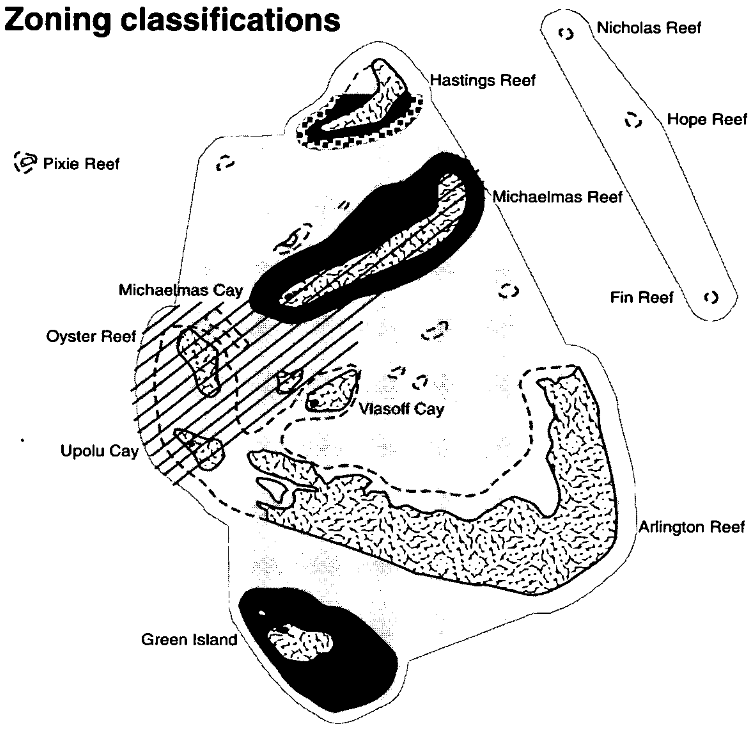
The goal of the GBRMP Authority is to provide for the protection, wise use, understanding, and enjoyment of the GBR in perpetuity through the care and development of the GBRMP. Coordination between the Commonwealth and State Governments is effected through the GBR Ministerial Council which includes two ministers from each Government.

Day-to-day management within the GBRMP is carried out largely by the QDEH, on behalf of the Authority, subject to zoning plans and policy decisions. The basis for this cooperative approach is contained in a number of agreements between the Federal and State Governments, and has been cited as a model for Commonwealth/State inter-agency cooperation. The 1993/94 allocation for day-to-day management was $7.536 million.

Surveillance of the GBRMP is carried out by sea and air by the QDEH and Coastwatch, the National Civil Surveillance Program operated by the Australian Customs Service. The users of the Marine Park also provide information on illegal activities, and on the environment such as crown-of-thorns starfish, cyclone damage and coral bleaching.

The office of the GBRMP Authority comprises units categorised as Planning and Management, Environmental Impact Management, Research and Monitoring, Administration, External Services, and Education and Information Sections, including the GBR Aquarium, the main interpretative facility. It has a staff of around 140, with offices in Townsville and Canberra.

Zoning classifications



General Use Zone
To provide areas of Marine Parks for a diverse range of recreational and commercial activities, consistent with the region's long term conservation.

Habitat Protection Zone
To provide areas of Marine Parks free from effects of trawling, while allowing for a diverse range of recreational and commercial activities.

Buffer Zone
To provide areas of Marine Parks and allow opportunities for their appreciation and enjoyment. Buffer Zones allow mackerel trolling in areas adjacent to reefs zoned National Park.

National Park Zone
To provide protected areas of Marine Parks of high conservation value, but allow public access for appreciation and enjoyment - a 'look but don't take' area.

No Structures Subzone
To provide areas of Marine Parks that remain in a natural state. This subzone is an additional condition to other Marine Park zones which allows for tourist programs to operate but ensures the area is free from structures such as pontoons and permanently moored facilities.

Figure 69.3: Example of Marine Park zoning. (Offshore Cairns region)

Uses and issues

Tourism and fishing are the major commercial uses of the Marine Park, and contribute about $1,000 million per annum. Mining and oil drilling are specifically prohibited under the GBRMP Act.

Tourism and recreation

The GBR is considered one of the most glamorous and dynamic components of Australian, and possibly world tourism, and is the most popular destination for Australians planning a holiday. It is famous for its weather, scenery, underwater coral viewing, skin and scuba diving, sailing and other water sports, and fine seafoods.

Each year, the GBR and adjacent coast receive around two million visitors who spend around $700 million. Visitations are increasing at around 10% per year, and up to 30% per year in the Cairns area. Visitors may stay on one of the resort islands, make day trips to islands or to one of the 30 offshore pontoons anchored on reefs, take extended cruises on cruise boats, or charter a 'bare boat'.

Management of GBR tourism

Complementary management of sea and land tourism is undertaken by the GBRMP Authority and the QDEH. The main mechanisms for management are: consultation with user groups; zoning plans designed for ecologically sustainable tourism development; management plans for heavily used areas; control and monitoring of tourism activities through regulations and permits; environmental impact assessment of tourism projects; scientific research and monitoring of impacts; and targeted and community-wide education.

Permits for tourism developments are assessed on effects on the environment, on ecological processes, on amenity, and on health and safety. The Environment Protection (Impact of Proposal) Act is applied where impacts could be significant. In 1992/93, 156 permits for tourist projects were issued.

User pays

As Commonwealth funding for management has significantly declined with respect to the area being managed, the GBRMP Authority introduced a permit fee system in 1990 and a fee system for commercial operators (equivalent to around $1 per visitor per day) in 1993.

Adverse effects of tourism

Negative environmental effects of intensive tourism may include: localised modification of islands, shorelines and reefs through resort and marina construction; clearing of vegetation and wetlands; siltation of coral reefs during channel and marina dredging activities; increasing levels of nutrients from sewage (causing eutrophication and coral death); pollution from run-off, antifouling paints and hydrocarbons from shipping; increasing fishing pressure; damage to corals by anchors and divers' fins; and damage to corals near pontoons as a result of shading, divers' fins and mooring chains.

While tourism can benefit by regional economies and better infrastructure, adverse social consequences of intensive tourism may include loss of cultural values for local communities, a declined experience for those visitors seeking a more natural environment, localised inflation, and increased crime. Debate on the effects of major developments has divided communities, such as in the case of the failed Magnetic Quays development on Magnetic Island off Townsville, and the proposed Port Hinchinbrook development at Oyster Point near Cardwell.

Fisheries

Around 1,400 commercial vessels fish in GBR waters. The main fisheries are trawling for penaeid prawns (six species, with scallops, slipper lobsters, sand crabs as by-catch); mackerel trolling; demersal reef fishing using bottom hand lines for coral trout, sweetlip and emperor; inshore and estuarine netting for barramundi, trevally, mullet and blue salmon; and potting for mud and sand crabs. Minor reef fisheries include aquarium fish, trochus, and bêche-de-mer.

Characteristics of recreational boat fishing in the GBR region: some facts and figures

A study of the recreational fishery, recently undertaken for GBRMPA by Blamey and Hundloe (1993), found there were around 36,000 private motor boats along the GBR coast, of which 68% were used for fishing in the Marine Park. These make a total of 210,000-270,000 fishing trips each year, and catch between 3.5 to 4.3 million kg of fish.

Catch rates

The catch per unit effort is around 0.78 kg per person per hour, and the average weight of the catch is 1.4 kg.

Who catches what?

A small proportion of fishers catch most of the fish: 25% of fishers (the serious ones!) catch 75% of the catch, while 50% of the fishers (the less serious ones!) catch only 6% of the catch.

Economic values

The capital value of the boats and other gear is around $200-$300 million. Around two-thirds of this is specifically for fishing. The annual costs for each boat is around $3,000, and the cost per trip is $80. The fleet's total annual operating costs are around $49 million.

Catch-sharing

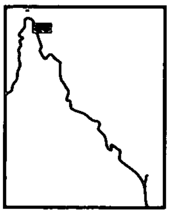
Recreational fishing is largely near the coast, and on the inner reefs. The commercial effort is largely on outer reefs, suggesting that competition between the sectors is not great.

The recreation reef fishery is large. Around 36,000 vessels are registered along the GBR coast, and the catch is equivalent to the commercial catch. A significant proportion of the recreation catch is illegally sold on the 'black market'.

Fisheries management

Under the Offshore Constitutional Settlement, the management of GBR fisheries is the responsibility of the Queensland Government through the Queensland Fish Management Authority (QFMA) and the Queensland Department of Primary Industries (QDPI). Under the GBRMP Act around 20% of the GBRMP is closed to bottom trawling, and around 5% is closed to all fishing.

Locality



Under QFMA management, the trawl fishery is limited entry, with restrictions on gear, vessel replacement and season, but the fishery is generally overcapitalised and declines in some stocks are apparent. The commercial line fishery is limited entry (maximum of 1,963 vessels), with restrictions on gear (maximum of six hooks) and numbers of tenders, and minimum sizes for the major species. Bag limits exist for recreational fishers. The aquarium, trochus and bêche-de-mer fisheries are limited entry, by licence.

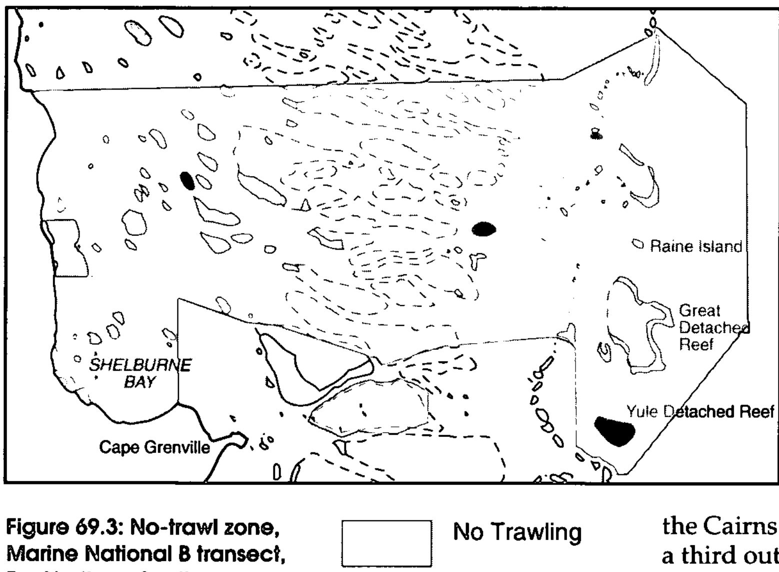


Figure 69.3: No-trawl zone, Marine National B transect, Far Northern Section.

Major environmental and management issues

Water quality

Water quality is considered a critical management issue in the GBRMP. In inshore areas elevated nutrients from soils and chemical fertilisers and sewage may stimulate the growth of algae which compete with coral for light and space, while enhanced phosphorus may weaken the coral skeleton. It is estimated that the discharge of nitrates and phosphates is between four to six times greater now than in pre-European times (Chapter 42).

Suspended sediments resulting from changing land use and port and channel dredging decrease light available for corals, inhibiting their growth and physiologically stressing the polyps. Natural disturbances such as cyclones, high temperatures and flooding, and human-induced pollutants may have serious impacts on chronically stressed reefs. A major research program on water quality in the Marine Park is currently underway.

Management responses to the problem of increasing nutrient levels include mandatory tertiary sewage treatment for all island resorts (by September 1996) and better farming practices. A consultant extension officer has been recently appointed by GBRMP Authority to advise farmers on ways of reducing nutrient run-off.

Crown-of-thorns starfish

Damage to coral reefs caused by outbreaks of crown-of-thorns starfish *(Acanthaster planci)* is one of the most serious scientific and management issues on the GBR. Over the past 30 years two outbreak episodes (commencing around 1962 and 1979) have caused serious damage to the central one-third of the GBR. In the recent episode, around 17% of the 2,900 reefs of the GBR were affected to some extent and 6% were seriously affected. During 1993 and 1994 densities of starfish began increasing once again in the Cairns to Lizard Island region, leading to fears of a third outbreak episode (Chapter 49).

As it is not known whether the outbreaks are natural or the result of human activities, controls have been limited to areas of special importance to tourism and scientific research. Trials indicate that complete eradication of the starfish is not feasible. A long-term, coordinated research program has been underway since 1985.

Effects of fishing

Evidence indicates that recreational and commercial line fishing and commercial prawn trawling may have substantial ecological effects over large areas of the GBRMP. Bottom trawling for prawns may detach or damage inter-reefal sessile benthos (organisms attached to the sea floor). Much of the by-catch, which often comprises the majority of the haul, is then discarded.

Line fishing may also be affecting stocks. Since 1980, mean fish size has declined by 30%, catch per unit effort has declined by 50%, and recreation effort has increased by 25%. Anecdotal evidence from illegal fishers suggests that catches are substantially better from reefs that are 'closed' by zoning plans than from 'open' reefs.

As most of the major fisheries are considered to be fully-exploited, measures other than the recognised input/output controls must be applied if ecologically sustainable use is to be achieved. Additional controls may include appropriately scaled harvest refugia or fishing reserves; protection of critical habitats such as spawning and nursery areas; and more selective trawling gear.

The GBRMP Authority is currently coordinating and largely funding a major, long-term research program on the effects of trawling on bottom structure and community composition and the rates of recovery after disturbance, and the effects of reef fishing. Other agencies involved include the Queensland Department of Primary Industries, CSIRO, the Australian Institute of Marine Science and James Cook University.

Oil spills, shipping accidents and sea dumping

The GBR is a major shipping route and over 2,000 ships, 10% of which are oil tankers, pass through GBR waters each year. Fortunately, there have been no major spills or strandings to date.

Because of the serious threats of oil spills to the GBR, the International Maritime Organisation has designated theGBR as a 'Particularly Sensitive Area', the world's first such listing. This enabled compulsory pilotage for all vessels over 70 metres and all loaded oil or gas tankers and chemical carriers to be introduced for certain passages. An oil spill contingency plan, REEFPLAN, exists and stockpiles of oil spill response equipment are located in Townsville and Brisbane. The reality of vast distances and logistics, and difficulties in dealing with oil spills in the open sea are such that a major spill outside of port limits would pose great problems to the GBR (Chapter 39).

Strategic planning

While the main responsibility for looking after the GBR rests with the GBRMP Authority, there are many other individuals and organisations who are involved in managing the Reef, rely on its resources and care about its future.

In 1991 - 93 the GBRMP Authority coordinated the development of a 25 Year Strategic Plan for the Great Barrier Reef World Heritage Area, involving over 60 user and interest groups and government agencies and Aboriginal and Torres Strait Islander communities. The Plan describes an agreed 25 year vision for the World Heritage Area and objectives and strategies to achieve that vision. It is anticipated that those who participated in the Plan will include relevant objectives in their own corporate plans.

The vision describes a Great Barrier Reef World Heritage Area in which in 25 years there is a healthy environment, sustainable multiple-use, maintenance and enhancement of values, integrated management, knowledge-based but cautious decision-making in the absence of full information, and an informed, involved, committed community.

Consensus agreement in multiple-use marine protected area management is essential. The Strategic Plan provides direction and guidance for

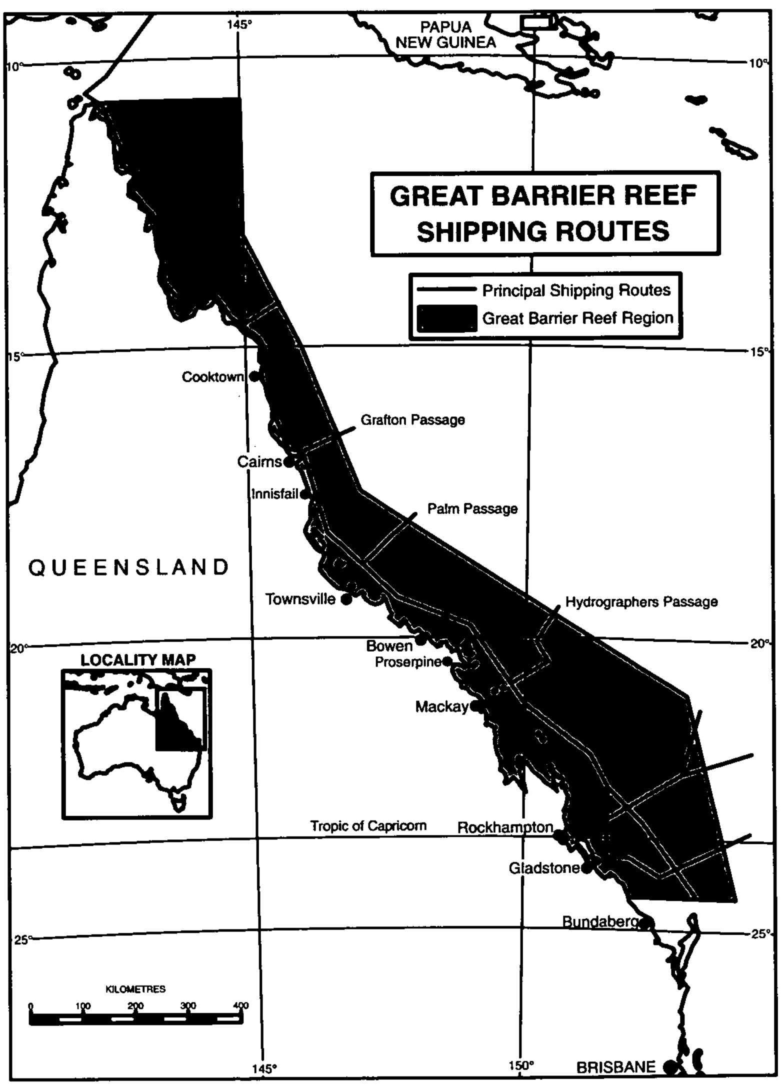


Figure 69.4: Great Barrier Reef shipping routes.

organisations, such as the Authority, in developing corporate, business and management plans.

Monitoring and marine environmental reporting

The GBR is relatively well studied because of the great scientific interest in coral reefs. Much of this research is undertaken at the Australian Institute of Marine Science (AIMS), James Cook University in Townsville, and other universities. Research stations are situated on Lizard, Orpheus, Heron and One-Tree Islands.

Around 350 research projects are undertaken on the GBR each year, representing about one third of Australia's total marine research effort. GBRMP Authority has funded over 600 different research projects since 1978, most of which were management-related. Scientists at AIMS have produced over 450 scientific papers on the GBR to date. Almost 11,000 published and unpublished reports, scientific papers and newspaper features and magazine articles on the GBR are listed in the REEF Bibliographic Database (CSIRO 1992).

Translating science into management

Because of the great size and ecological complexity of the GBR, and the *ad hoc* nature of much of this research, the majority of reefs have not been scientifically surveyed and ecological and functional aspects remain poorly understood. The translation of scientific knowledge into sound management is still a major priority.

The GBRMP Authority has generally adopted a strategic approach to research on the major issues of crown-of-thorns starfish, water quality, and effects of fishing. This involves the development of coordinated, multi-disciplinary and long-term research programs, under the direction of expert advisory committees. The establishment of the Cooperative Research Centre for the Ecologically Sustainable Development of the Great Barrier Reef has also been effective in bringing together science and industry.

Environmental monitoring program

A major monitoring program is underway on the GBRMP by the Authority and AIMS at an annual cost of around $2 million. Although environmental monitoring is currently reported on an *ad hoc* basis, systematic reporting is planned to commence in the next triennium. Problems in monitoring include the vast size of the GBR, the great cost of working at sea ($2,000-3,000 per day for field team and vessel), the great complexity of coral reefs, and a lack of standardised methodologies.

Monitoring to date has documented substantial impacts on reefs by crown-of-thorns starfish and cyclones and their recolonisation. Recent trends have found a persistent and alarming decline of coral-cover in the Capricorn Group through unknown causes.

Databases

A comprehensive database, the Island and Reef Information System (IRIS), has been established for the GBRMP's islands. This includes zoning, island type, size, elevation, climate, characteristics, vegetation, avifauna, human populations and usages etc.. The database on reefs includes zoning, size, coral cover, dominant benthic organisms, crown-of-thorns starfish densities and damage, abundance of clams etc., and human uses, including fisheries, collecting, tourism, facilities and impacts.

The detail of information is variable; some reefs have few entries, others are well known. Other databases have been established by GBRMP Authority on surveillance records, permits, human use and water quality. Data resides in ORACLE databases and work is progressing to effectively link the information to a geographic information system (GIS).

Summary and conclusions

1. The Great Barrier Reef is the world's largest complex of coral reefs, and the GBR Marine Park is the world's largest marine protected area established primarily for ecologically sustainable development.

2. Major environmental issues in the GBR Marine Park include: declining inshore water quality in inshore areas; effects of outbreaks of crown-of-thorns starfish on coral reefs; effects of trawling on shelf benthos; effects of line fishing on reefs; and threat of oil spills from shipping. These are being addressed by research and management programs.

3. Major management issues include: involving indigenous communities in management; maintaining opportunities and uses; increasing public commitment; and use of scientific information in planning and management.

4. The GBR Marine Park is relatively well studied and a basic monitoring program is in place. However, research and management remains constrained by its great size and complexity.

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Chapter 70: Ningaloo Marine Park[1]

Ningaloo Reef is a unique, long fringing and barrier reef system along the arid north-western coastline of Western Australia, and is one of Australia's most significant coral reef systems. It boasts a high diversity of corals and other species, and significant populations of turtles and dugongs. Humpback whales pass the reef during their annual migrations and whale sharks form unique aggregations offshore. Although the reef is remote from large population centres and the adjacent coast is virtually uninhabited, outbreaks of coral-eating snails, a large recreational fishery and an offshore shipping and petroleum industry pose significant management challenges.

Ningaloo Marine Park is located approximately 1,200 kilometres north of Perth. It extends along 260 kilometres of coast from Bundegi Reef in Exmouth Gulf, northwards beyond North West Cape, then south to Amherst Point. Ningaloo Marine Park includes a narrow coastal land component and both State and Commonwealth waters with a total area of 4,572 square kilometres. For much of its length it is contiguous with Cape Range National Park with which it is managed in an integrated manner. The coastline is sparsely inhabited; the town of Exmouth lies just out of the north-eastern boundary.

Description: geography, oceanography, ecology

Geography and geomorphology

Ningaloo Reef is the longest tract of coral reef in Western Australia. Believed to be a veneer over a Pleistocene basement, the present reef crest lies between 200 metres and seven kilometres offshore, creating a shallow lagoon with occasional 'bommies' or coral patches. The foreshore consists mainly of steep sand or pebble beaches, and limestone beach rock, fossil reef platforms and low cliffs. At low spring tides, gently sloping rock platforms and mud and sand flats are exposed up to 500 metres from the shore. One sheltered lagoon supports a mangrove community. Much of the adjacent coast is characterised by fragile Holocene dunes, and dry salt flat communities.

Ningaloo lies in an arid region with an average annual rainfall of 250-300 mm (evaporation is 2,700 mm). It lies within the cyclone belt; between 10-15 cyclones pass within 100 kilometres of the coast in a 10 year period. Prevailing winds are from the south and south-east in the morning, followed by a stronger sea breeze in the afternoon, and are generally strongest during spring.

Oceanography

The continental shelf between North West Cape and Point Cloates is only about 10 kilometres in width and is strongly influenced by the warm Leeuwin Current. Circulation within the reef is mainly driven by waves breaking over the reef crest; currents run parallel to the coast and exit via reef passages. Tides are semidiurnal, with a range of up to two metres. Temperatures at well flushed locations within the lagoon range from 22 to 26°C.

Ecology

North West Cape is a significant ecological boundary. Ningaloo Reef lies in relatively clear waters on the western side of the Cape while the Pilbara coast to the east is turbid and muddy. The fauna is largely Indo-Pacific in origin. Around 217 species of hermatypic (reef-building) species of coral, 500 species of fish, 90 species of echinoderms and over 600 species of molluscs have been identified to date but these numbers are conservative as research has been limited because of the area's remoteness.

Reef crests largely consist of algal pavement. Back reefs are dominated by *Acropora* corals, and lagoon patches by *Acropora* and massive *Porites*. Coral cover has been significantly reduced by outbreaks of the coral-eating snail *Drupella cornus* over the past decade (Chapter 50). Inshore soft bottoms are dominated by macroalgal and seagrass beds, with clusters of stunted mangroves (three species) in sheltered pockets. Preliminary investigations suggest that offshore bottoms support a rich benthos.

Threatened species include humpback whales which pass through Ningaloo during their annual migration. Dugongs are also present in the Park, and green, loggerhead and hawksbill turtles which nest in summer. Uniquely large numbers of giant whale sharks visit Ningaloo waters at certain times each year and are the focus for a growing dive-tourism industry. Shorebirds and waders stop over during their annual migrations to and from Asia.

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[1]Based on a paper by Dr S. Osborne, Department of Conservation and Land Management, Exmouth, Western Australia.

(Source: CALM)

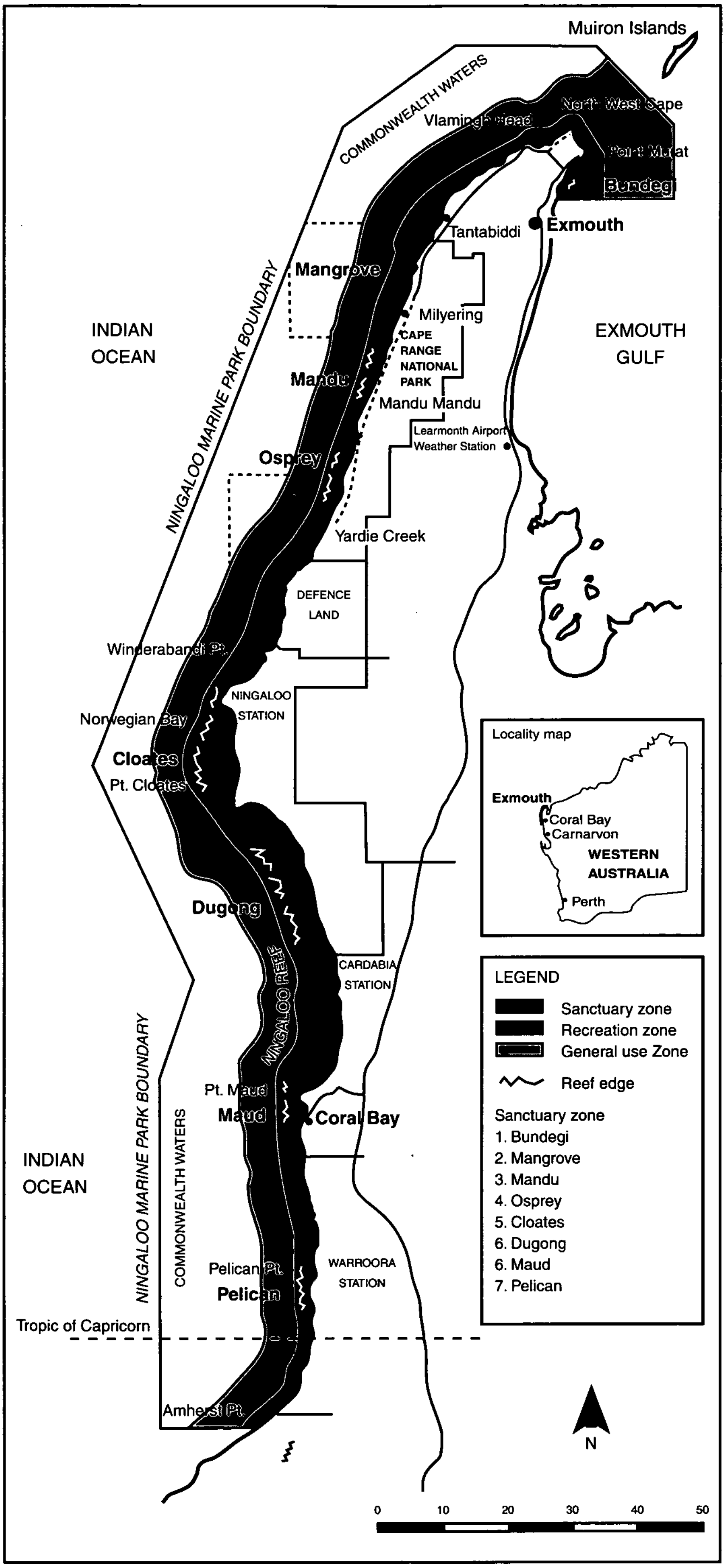

Figure 70.1: Ningaloo Reef Marine Park.

Social and cultural values

Although Aboriginal people no longer live along the coast, there is substantial archaeological evidence of intermittent occupation from at least 33,000 years ago. Little is known of the customs and mythology of the now-dispersed Aboriginals; one account by shipwrecked sailors in 1875 describes their use of coastal and marine resources in a harsh, nomadic existence.

The first European visitors were from the Dutch vessel *Mauritius* in 1618. Eleven years later Commandeur Pelsaert from the *Batavia* which had been wrecked in the Abrolhos Islands came ashore at Yardie Creek. Over the years, at least 20 vessels have been wrecked by the rough seas and treacherous reefs. Because of the navigation hazards two lighthouses were commissioned early this century.

A Norwegian factory ship commenced whaling for humpbacks off Ningaloo in 1912, and a whaling station operated intermittently at Norwegian Bay. A turtle industry also operated at Ningaloo until the early 1970s.

Management of Ningaloo Marine Park

Ningaloo was first recommended as a marine reserve by the Australian Marine Sciences Association in 1972. In 1978 a Marine Working Group was convened to develop the proposal and in 1983 their report recommended the present boundaries. In 1987 the State marine portion was gazetted under the Western Australia *Conservation and Land Management Act* 1984 (CALM Act), and the land portion was reserved under the *Land Act* 1933. Commonwealth waters off Ningaloo Marine Park were gazetted in 1987 under the Commonwealth *National Parks and Wildlife Conservation Act* 1975.

(Source: CALM)

Figure 70.2: Ningaloo Reef is a large fringing and barrier reef system.

Management strategy

A multiple-use management plan for the State component of Ningaloo was prepared with the assistance of a Ningaloo Marine Park Advisory Committee and was opened for public comment in 1988. This was approved by the Minister for the Department of Conservation and Land Management (CALM) in 1989 with a ten year life span. Management zones were gazetted in 1991 under the CALM Act . Complementary legislation has been made under the Fisheries Act.

Zoning categories

General use zone: provides for commercial and recreational uses consistent with conservation of natural resources. It is based on recreational and commercial uses not in conflict with other uses or protection of conservation values.

Recreational zone: provides for recreational uses. Commercial fishing is prohibited. It is based on attractiveness and accessibility for recreation.

Sanctuary zone: provides for protection. 'Look but don't touch'. It is based on representativeness of the reef system for biological diversity and structural variability.

Offshore areas beyond the reef are zoned for general use, and the reef and lagoon for recreation and sanctuary zones. As Ningaloo is a transition area between tropical and temperate species, sanctuary zones are distributed along the north/south axis. Unique areas of seagrass, mangroves and corals are also protected.

Management framework

The Department of CALM is the primary management agency for Ningaloo Marine Park, while fishing and fisheries management is the responsibility of the Western Australia Fisheries Department. Close liaison is maintained between these departments and the Australian Nature Conservation Agency which is responsible for administering the Commonwealth waters.

Direct government funding for the Marine Park provides for employment of a local Marine Park manager and two rangers. The Fisheries Department also provides most of the time of two Fisheries officers in Exmouth, and part of the time of three from Carnarvon.

Public contact

The major thrust of the Park's education program has centred on the development of management operations and effects on visitors. Visitors were encouraged to input into the management plan and fisheries regulations. The Milyering Visitor Centre was established, signs and moorings deployed, brochures were produced, patrols regularly undertaken to maximise visitor contact and a State-wide media campaign was conducted. A recent survey found that 76% of Park visitors were aware of zoning and fisheries regulations before arrival, and 97% of those within the Park were adequately informed.

Surveillance and enforcement

Patrols are undertaken to educate visitors, to detect and deter infringements, and to monitor visitor usage and the environment. They are conducted by boat and vehicle, and in close liaison with Fisheries Department officers. During the winter tourist season each sanctuary zone is patrolled at least once a week. While education is the primary emphasis and no prosecutions have been pursued to date, 73 formal warnings were issued in the 1992 season.

Research and monitoring

Local management staff monitor human usage, public awareness, infringements and the abundance of *Drupella* snails. Research programs include the biology of *Drupella*, tagging of nesting turtles, and studies on the biology of the snappers or lethrinids.

Human uses and issues

Recreation and tourism

Small resorts and commercial caravan sites are situated in and around the townships of Exmouth and Coral Bay. In 1992 around 55,000 tourists visited Ningaloo Marine Park, double that in 1989. Around 80% of visitors stay in the caravans parks. Ningaloo has traditionally attracted retired people who camp in winter; around 64% of tourists are repeat visitors (43% more than five times). The average stay is 35.6 nights. The increasing numbers of campers are disturbing the fragile dunes, taking timber for firewood and introducing feral animals.

Most visitors come to fish (84% cite fishing as the highest priority activity). Whereas many once came just to take a freezer full of fish fillets back to Perth, non-extractive activities like sight-seeing, diving, snorkelling, surfing etc. are increasing. Fifteen commercial charter boats also take fishing and diving tours in the Park. Tours concentrating on diving with whale sharks are an increasing attraction. Regulations under the CALM Act require operators to acquire a licence and pay a fee.

Fisheries management

Many campers fish in Ningaloo lagoon in dinghies and many of these (73%) operate fish freezers. The major catch are snappers, small reef cod, and mackerel. The management of the recreational and commercial fisheries within the Park is the responsibility of the Fisheries Department which consults with CALM and key user groups. Because of the increasing fishing pressure the daily bag is seven fish and four spiny lobsters (size limits apply), while the possession limit is 10 kilograms of fillets and seven whole fish or a total of 17 kilograms of fish. Spearing with compressed air, and spearing cods and wrasses are banned. Large predatory species such as potato cod and Queensland groper are protected.

The Exmouth prawn fishery of 16 vessels overlaps the Park in the north, and a small trap fishery operates within the general use zone. Commercial fishing is not permitted in recreational areas.

Petroleum exploration and production

Prior to the gazettal of Commonwealth waters in the Park in 1987 there were three petroleum permits totalling 700 square kilometres in area. These were excised from the boundaries as under the *National Parks and Wildlife Conservation Act* 1975 reserves cannot be established in areas of pre-existing interest.

Three offshore permits also existed within State waters. Since the establishment of the Park in 1987 there have been seismic surveys in the north and a lateral well has been drilled from outside the boundary in the Exmouth Gulf underneath the seabed of the Park.

In July 1994 the Western Australian Government announced a ban on drilling for petroleum in the State waters of the Park.

Major environmental and management issues

Drupella outbreaks

Outbreaks of the coral-eating snail *Drupella cornus* have made a significant impact on the coral reef communities Ningaloo since 1980. Live coral cover on back reefs has been reduced by more than 50%, and some areas have been reduced to rubble. While overfishing of natural predators such as snapper has been proposed, the cause of the outbreak is not known (Chapter 50).

Effects of tourism

The rapid growth of tourism in the Park has raised concerns on littering, taking of undersized fish, over fishing, disturbances to sand dunes and fauna and flora, damage by off-road vehicles, anchor damage to corals and localised water pollution. The recent rapid growth of the whale shark watching industry has necessitated controls. Residents and tourists support low key development in the region (72% polled) rather than marinas (29%) or resorts (17%).

Effects of fishing

The annual recreational catch in the Park is estimated to be around 100 tonnes of fillet, or 150-200 tonnes of whole fish. According to long-term residents, the quality of fishing has declined, although scientific evidence for this is lacking. Of concern is the slow growth of the target species of snappers and rock cod (around 4 years to maturity).

Pollution

As the coastline is largely deserted pollution is minimal. Shipping is a potential hazard as around 730 ships, primarily bulk carriers, cargo and container ships, pass the North West Cape each year. In 1988 the Park was affected by an oil slick from the wreck of the *Korean Star* to the south. The development of an off-shore petroleum industry would increase shipping and hazards.

Monitoring and environmental reporting

While the remoteness of Ningaloo has minimised human impacts, it has also hindered scientific research in the Park. The ecology and biota of Ningaloo are poorly known and listings of fish, corals and other invertebrates are incomplete. Limited research is currently underway on the biology and effects of the *Drupella* snail but resources are limited compared with the similar crown-of-thorns starfish research program on the Great Barrier Reef. Catch and effort of the recreational fisheries are being monitored and studies are underway on the biology of the major species. It is hoped that the establishment of an Australian Institute of Marine Science facility and a university research institute in Exmouth will increase scientific understanding of the area.

Summary and conclusions

1. Ningaloo Reef is an ecologically unique and valuable area. It contains significant populations of dugongs, humpback whales, shorebirds, turtles, and whale sharks. It is also an important recreational area.

2. The Ningaloo Marine Park, Australia's second largest Marine Park, was reserved in 1987. It is managed for multiple-use using three zones: General Use, Recreation and Sanctuary.

3. Major environmental and management issues are loss of coral caused by outbreaks of *Drupella* snails; increasing tourism; and risk of pollution from offshore oil production and shipping.

4. Informed management is constrained by lack of scientific knowledge of the ecology, the resources, the uses and effects of these. Day-to-day management is constrained by the great size of the Park, its accessibility to the mainland and camping areas, and limited resources for management.

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Acknowledgments:
The technical paper by S. Osborne was reviewed internally in the Department of Conservation and Land Management.

Chapter 71: The Solitary Islands Marine Reserve[1]

Lying north of the fast growing northern New South Wales city of Coffs Harbour is the 75 kilometre long Solitary Islands Marine Reserve. This is a unique area containing diverse tropical and temperate habitats such as coral reefs, mangrove estuaries, rock platforms and rocky reefs, as well as picturesque islands and long ocean beaches. The reserve, New South Wales' largest, was established largely as a result of local community action to save a fast changing coastline and now enjoys strong community support.

The Solitary Islands Marine Reserve in northern New South Wales extends from Muttonbird Island near Coffs Harbour, northwards to Plover Island, adjacent to the mouth of the Sandon River, and out to the 50 metre depth contour or three nautical miles around the outer islands. The western boundary follows the mean high water mark and includes eight estuaries. The Marine Reserve has an area of around 100,000 hectares, 85,000 hectares in State waters, and 15,000 hectares in Commonwealth waters.

Description: geography, oceanography and ecology

The Solitary Islands group are remnants of a north-south outcrop of marine rocks of Carboniferous age. The inner shelf, beaches and dunes are of silica sands, which migrate in a northerly direction under the southerly swells and inshore currents.

The distinctive mix of tropical and temperate biota results from the warm, southwards flowing East Australia Current which brings tropical larvae to the seaward islands, and a colder, northwards flowing coastal current.

The wide range of marine habitats include open waters, continental shelf floor, coral reefs, rocky reefs and headlands, sandy beaches, estuaries, tidal mud flats, seagrass, mangroves, and saltmarsh. Island habitats include low scrub lands, grass leans, shallow soils and bare rock.

Biodiversity

The biological diversity of the area is high, and has both tropical and temperate affinities. Offshore areas tend to be more tropical, whilst inshore areas are more warm-temperate because of prevailing currents. Around 200 species of algae have been identified, including tropical forms such as *Halimeda, Valonia* and *Galaxaura*, and temperate *Ecklonia* (kelp) and *Hormosira* (Neptune's necklace). There are six species of mangroves and the area includes the southernmost stands of some species.

Although the coral reefs are among the southernmost in the world, they have a very high species diversity and 92 species have been identified to date. One species, *Acropora solitaryensis*, was first described from the area. Coral cover is locally high, and may locally reach 100% off South West Solitary. Coral communities are particularly affected by currents and wave action. Giant sea anemones and their attendant anemonefish are particularly abundant around North Solitary Island; Anemone Bay at North Solitary is considered to have the densest population of anemones and anemonefish in the world. A range of tropical and temperate bryozoans, molluscs, crustaceans and echinoderms (including the notorious crown-of-thorns starfish) have also been described.

The Reserve contains at least 280 species of fish belonging to 65 different families; 80% are tropical in origin, the remainder temperate. Loggerhead and green turtles are common and may be resident. Hawksbills and leatherbacks are occasional. A number of seabird and shorebird species frequent the area, and the islands are important shearwater rookeries. Pods of migrating humpback whales move through the reserve between June and October on their northern migration. Dugongs and leopard seals, stragglers from distant northern and southern populations respectively, are occasionally reported.

Management

The Solitary Islands Marine Reserve was established in May 1991, and in February 1993 an extra 135,000 hectares of Commonwealth waters were added. The Reserve is managed by the New South Wales Fisheries from Coffs Harbour, while the Australian Nature Conservation Agency is responsible for Commonwealth waters.

[1]Based on Solitary Isands Marine Reserve Plan of Management, NSW Fisheries; and a paper by C. Ashdown, Coffs Harbour, New South Wales.

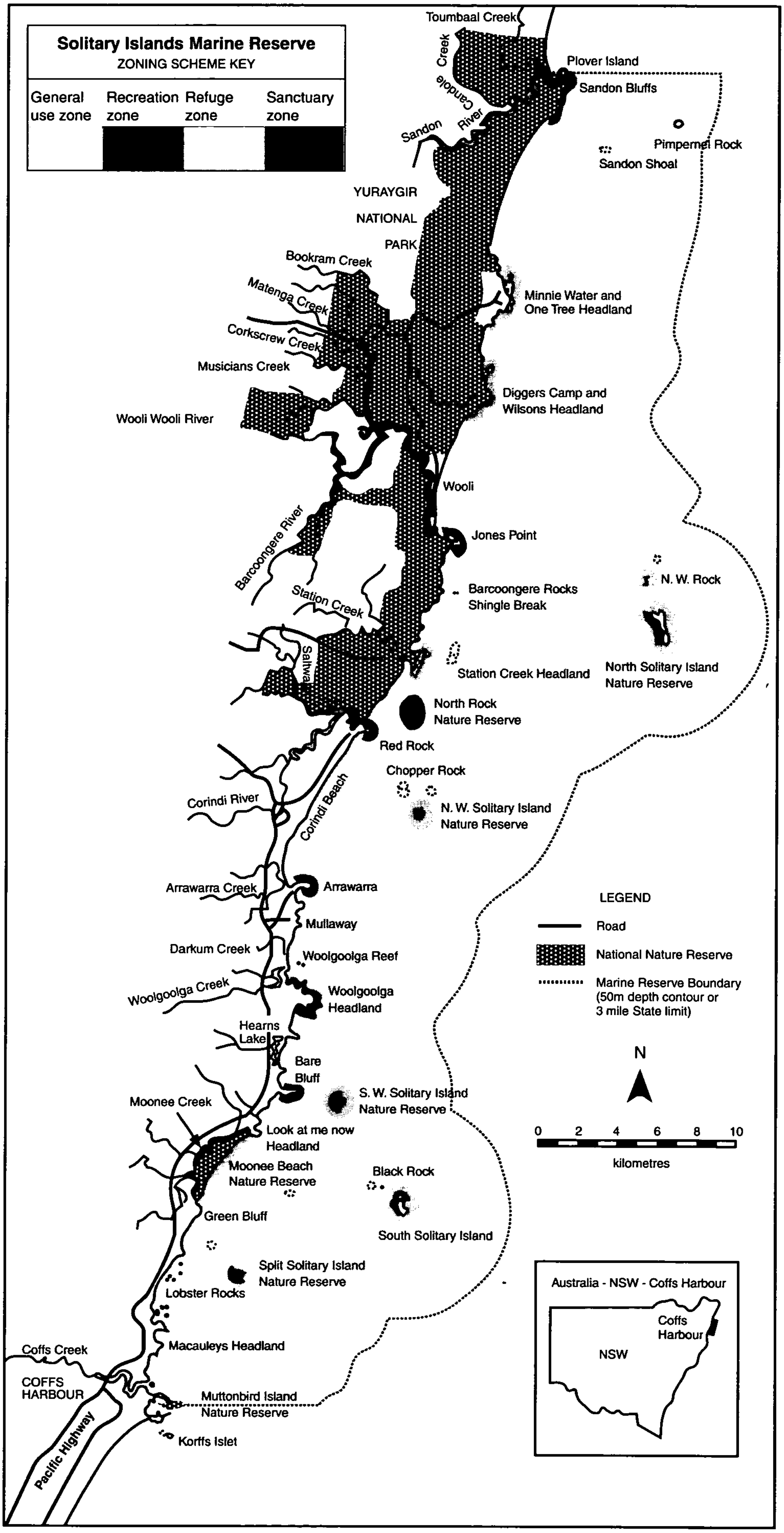
Zones in Solitary Islands Marine Reserve

General use zone
This is the largest and least restrictive zone which allows most commercial and recreational uses to continue under licence or permit. Licenced commercial fishers may operate in this zone. Permits are required for all commercial tourist activities and are also issued for natural history excursions, aquarium collection, scientific research and fishing competitions. The collection of corals, destruction of marine plants and mining in shallow and sensitive areas is prohibited.

Recreational zone
This zone allows for more recreational uses than commercial uses to occur. Commercial fishing is restricted in this area and recreational collecting is limited to bait animals and finfish. The removal of plants is prohibited.

Refuge zone
This zone is placed around each of the islands in the reserve and protects the upper reaches of some estuaries and headland areas. These areas act as buffer zones around the sanctuary zones and prohibit the removal of marine plants and finfish, except finfish by line fishing and selected fish by spearfishing.

Sanctuary zone
This zone provides total protection to sensitive fish habitat. They are 'look but don't touch' areas where the removal of any marine life is prohibited. Anchoring is also prohibited in this zone; boats must use the moorings provided.



(Source: NSW Fisheries)

Figure 71.1: The Solitary Islands Marine Reserve.

Community input, always strong, is achieved through the Solitary Islands Marine Reserve Advisory Committee which includes representatives from the Coffs Harbour City and Ulmarra Shire Councils, commercial and recreational fishers, divers, conservation interests, educators and scientists.

The key management strategy used to manage the Reserve is a multiple use zoning scheme. The zoning scheme and boundaries are detailed in the Fisheries and Oyster Farms (Solitary Islands Marine Reserve) Regulation 1991. Zones have been derived from the consideration of the natural and conservation values of the area and their capability to withstand use from both the current and future commercial and recreational uses.

Human uses and impacts

The Marine Reserve is the focus for Coffs Harbour city and coastal townships north to Grafton. It is therefore subject to a wide range of human uses.

Commercial fishing

Prawn trawl, trap and line fisheries are undertaken within the Reserve as permitted. Around 924 tonnes of fish, molluscs and crustaceans were taken in 1992/93. This catch, landed in Coffs Harbour, was valued at $5 million in 1991/92. Around 70% is taken from Commonwealth waters and 30% from coastal waters controlled by the State. Possible environmental impacts include destruction of bottom communities by trawls as minimal areas of shelf are prohibited to trawling.

Recreational fishing

Fishing is an important pastime for residents and visitors. Popular methods include handling, trolling, beach fishing and underwater spearfishing. Spanish and spotted mackerel, northern bluefin tuna, striped and mackerel tuna are taken in summer and autumn; tailor are taken in winter; and kingfish are taken in spring. Snappers and other reef species are taken year-round.

Investment in boats, tackle, bait, fuel and associated accommodation makes this pastime a major revenue earner for the area. Recreational fisheries are of considerable importance in New South Wales and may have a significant impact on fish stocks in coastal and inshore areas.

Diving

Skin and scuba diving are also major activities as the Solitary Islands are easily accessible from Coffs Harbour. The sport is increasing at around 5% per annum and around 5,000 divers used local commercial dive operators in 1993.

Boating, surfing and swimming

Coffs Harbour is home port to a large number of power boats and yachts. Many smaller speedboats,

(Source: Coffs Harbour Visitors Bureau)

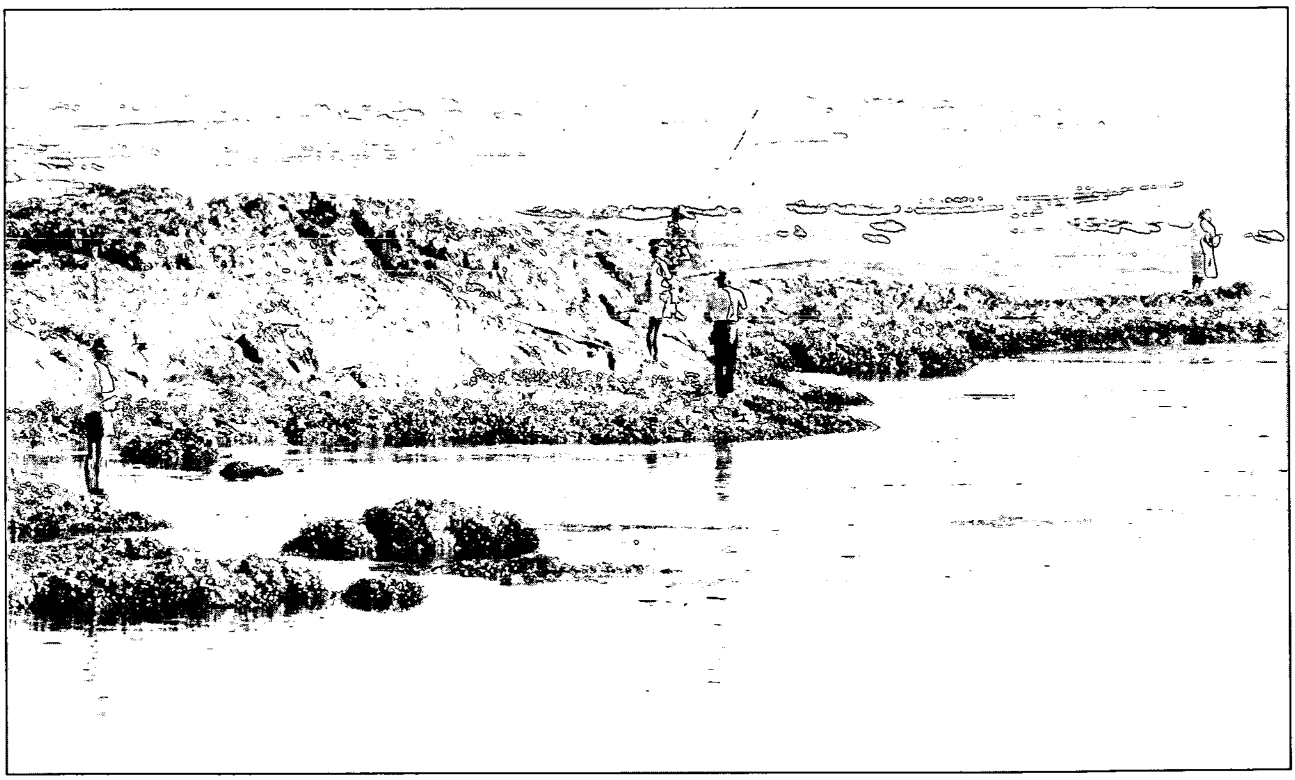


Figure 71.2: Solitary Islands Marine Reserve includes estuaries, beaches, rocky shores, islands and coral reefs, mangroves and other communities.

canoes, sailboards, skis and other craft use waters in the Reserve. Ocean beaches are also very popular for bathing and surfing.

Collecting

In the region marine life is collected for bait (e.g. worms, molluscs and crustaceans), food (e.g. sea urchins, shellfish), ornaments (sea shells) and aquarium specimens (fish and invertebrates). Eight recreational aquarium collecting permits were issued to local residents in 1992. Recreational aquarium collectors must have a permit from New South Wales Fisheries to collect in New South Wales waters.

Research, environmental education

The Reserve is important for research and marine education. Research is undertaken in the Reserve by scientists from the Southern Cross University and University of New England, and amateur groups such as the Coffs Harbour-based Solitary Islands Underwater Research Group (SURG). The Reserve's headlands and rock pools are used for marine education for schools. The Marine Education Society of Australasia (MESA) has a local chapter in this area.

Issues and concerns

Management resources

New South Wales Fisheries currently employs a project officer to manage the Reserve. The project officer is assisted by local fisheries officers who are responsible for enforcing the zoning scheme. Corporate sponsors are funding a range of educational resources to allow better management of the Reserve. While the goodwill of the local community has been an asset, a concerted education and management effort is essential because of high usage levels and potential conflicts in the Reserve.

Education

New South Wales Fisheries is currently raising the profile of the Reserve and zoning scheme with regular news ad education items in the local print, radio and television media to increase community awareness in the reserve. An annual conference is held to allow the local community to learn about the research programs in the Reserve. Over 500 attended the inaugural conference in 1994.

Research

Information on most marine biota in the Reserve is limited. Fish are not well documented, and most other groups have been studied on an *ad hoc* basis. A Monitoring and Research Plan is has been established and a habitat inventory is being compiled.

Research effort is needed to establish oceanographic and ecological processes within the Reserve, the natural variation of species over time, and to assess the effectiveness of the Reserve's management.

Monitoring and environmental reporting

The Monitoring and Research Plan currently underway will help New South Wales Fisheries in assessing the environmental status of the Reserve. Coordinated programs to monitor water quality will be undertaken by schools and community groups, and pollution studies will be undertaken by the University of New England and Southern Cross University.

All tourist operators and scientific researchers operating within the Reserve are required to submit a yearly permit of their activities. Tourist operators must provide details on the number of customers, areas visited and the activities undertaken at each destination within the Reserve. All registered fishing clubs operating within the Reserve must submit a report after each competition outing to allow New South Wales Fisheries to monitor recreational catch rates within the reserve. All these data are stored on an educational public access database on the Reserve.

Summary and conclusions

1. The Solitary Islands Marine Reserve contains a diverse and dynamic mix of tropical and warm temperate species and habitats of both local and national importance.

2. Its marine biodiversity is high, and has been moderately well described, but its environmental status, threats and issues, and levels of usage are not well known.

3. The Marine Reserve enjoys considerable local support but currently lacks an appropriate management infrastructure.

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Acknowledgments:
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Chapter 72. Jervis Bay National Park[1]

Jervis Bay, located 200 kilometres south of Sydney, is the only major embayment in south-eastern Australia which has remained relatively undeveloped, and both the marine environment and its terrestrial catchments are in a relatively pristine condition. Jervis Bay National Park, lying in the Commonwealth's Jervis Bay Territory, covers an area of 6,312 hectares, which includes 840 hectares of marine environment. New South Wales Fisheries is currently preparing a plan of management for a Marine Reserve over the remaining waters of Jervis Bay (93% of the Bay), in recognition of their outstanding natural and recreational values.

The Jervis Bay Nature Reserve, Bowen Island Nature Reserve, and additional Commonwealth lands and waters of Jervis Bay Territory were proclaimed a National Park in 1992, and are managed by the Australian Nature Conservation Agency (ANCA). In 1994 it was announced that title of Jervis Bay National Park will be vested in the Wreck Bay Aboriginal Community Council.

Some of the issues discussed in this paper are to be considered in the Jervis Bay National Park management plan, and will not be resolved until the plan has undergone public scrutiny and comment and comes into effect. The suggested prescriptions are subject to review.

Description: geography, oceanography, ecology

Terrestrial component

Jervis Bay National Park covers the bulk of the Bherwerre Peninsula, the southern-most peninsula of Jervis Bay. The Peninsula is underlain with Permian sandstones, siltstone and conglomerates of marine origin which are part of the southern-most extent of the Sydney basin sedimentary rocks. The Peninsula is overcapped by dunes and sandy soils which restrict bedrock outcrops to the exposed cliffs, marine platforms and minor exposures in creeks and dune areas. A number of freshwater dune lakes and waterholes are on the Peninsula. Lake Windemere and Lake McKenzie have been formed as a result of streams being blocked by dunes. Lake Windemere provides water to the surrounding settlements of Wreck Bay, Jervis Bay, and HMAS *Creswell.*

Grazing pressure and fires in the late 19th and early 20th century reduced vegetation on the Bherwerre Beach sand dunes to the point where they became mobile. Stabilisation of the dunes commenced in 1959 and grazing was halted completely in 1965. Unfortunately South African bitou bush, *Chrysanthemoides monilifera,* was included in the planting program in 1969 and despite control measures, soon became a major weed. Dune stabilisation and planting programs were completed by 1980, but weed control continues.

Marine component

Geography

The waters of the Jervis Bay Territory are approximately 840 hectares in area, and comprise 7% of the total Jervis Bay area. They lie to the south of a line between Captains Point and the northern tip of Bowen Island, and encompass some 56 kilometres of bay and oceanic shoreline. The proposed New South Wales Fisheries Marine Reserve will cover the remaining waters of Jervis Bay. A cooperative approach to the management of the marine resources of the Bay has been undertaken by Commonwealth and State, although a number of issues are yet to be resolved.

Oceanography

The clear waters of Jervis Bay are oceanic in character. There are no major rivers flow into the Bay and the entrance is flanked by rocky coast, with few beaches. Most of the catchment is covered by native vegetation and is relatively well protected. No heavy industry is present in the catchment and urban development and run-off is limited.

Ecology

Jervis Bay has a high representation of marine environments of the south-eastern temperate region of Australia. Many species present in the marine environment are at the northern and southern limits of their ranges. The littoral and sublittoral plant communities of the Bay are of both local and state-wide significance .

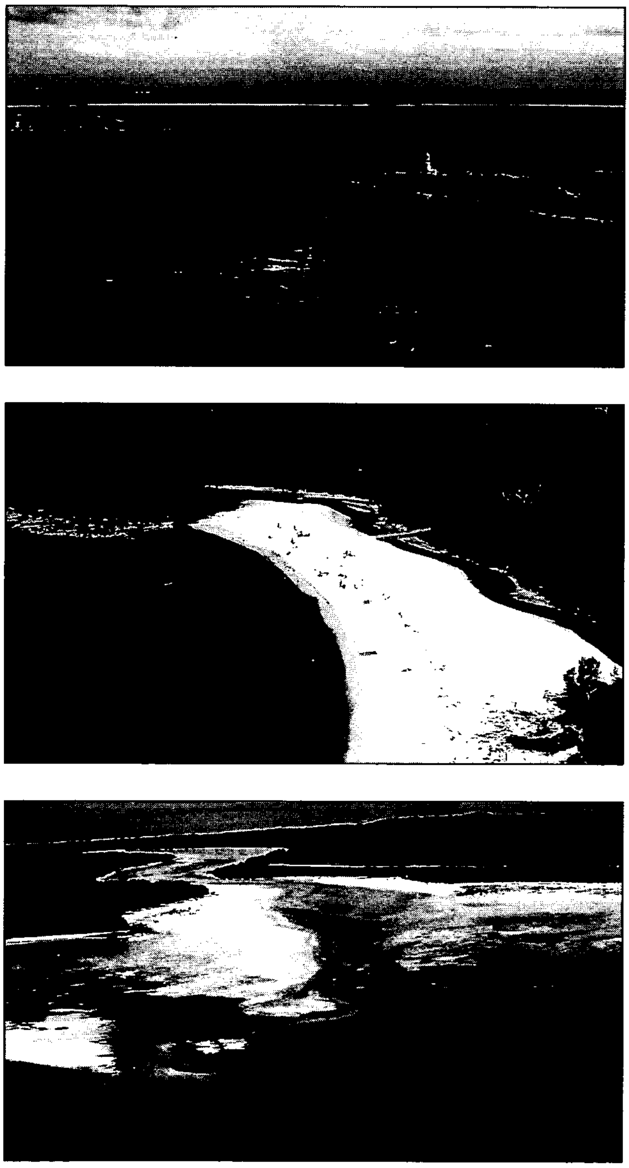
The marine environment is characterised by a wide range of tidal and subtidal habitats, including shallow rock reefs and sand zones, seagrass meadows, deeper silty-sand flats and deep water rocky reefs, cliffs, platforms, blocks, boulders and

[1]Based on a paper by M. Fortescue and F. Kristo, Australian Nature Conservation Agency, Jervis Bay National Park, Jervis Bay, New South Wales.

caves. Features of special interest include a sand delta (comprising a concave sand bank a short distance inside the channel between Bowen Island and Governor Head), shallow rock platforms with associated algal communities and extensive seagrass beds.

The intertidal rock platforms of Bowen Island are particularly significant as they harbour a great variety of intertidal organisms including large numbers and varieties of sea urchins, crabs, abalone, oysters and other organisms depleted elsewhere by human collection and foraging. There are few if any other areas where such a diversity of marine habitats and biota occur in such a small and easily accessible area, situated close to major population areas.

(Source: K. McClymont)



a

b

c

Figure 72.1: (a) Jervis Bay opening. (b) Greenpatch Beach. (c) Seagrass beds at Hare Bay.

Seagrasses, comprising *Posidonia*, *Zostera* and *Halophila*, are well developed. Due to the clarity of the Bay's waters and deeper penetration of light some seagrass occur at greater depths than expected. These areas provide habitat for a diversity and abundance of fish and macro invertebrates. Subtidal and intertidal platforms support a diversity of rocky reef algae with *Hormosira*, *Ecklonia*, *Sargassum*, *Phyllospora* and *Cystophora* being the dominant genera.

Bowen Island is of high conservation significance as it supports a substantial colony of the little penguin *Eudyptula mino*r, and breeding colonies of three species of shearwater, all protected by the international Japan Australia Migratory Birds Agreement and China Australia Migratory Birds Agreement (JAMBA and CAMBA).

Conservation value

The significance of the Park is attributable mainly to its rich natural and cultural heritage, the inclusion of a land-seascape interface as a protected area, and its location. Within a national context the Park has a significant role in the protection of temperate and coastal environments. Since initial protection in 1971, there has been considerable scientific and environmental interest in the area. Its significance has been recognised with the inclusion of the area on the Register of the National Estate.

The Park meets international standards for the protection of its natural resources and is listed in the IUCN List of National Parks and Equivalent Reserves. The marine waters also meet IUCN criteria for marine protected areas (MPAs).

The Park forms the basis for the development of a regional framework for the protection of natural and cultural heritage, including the establishment of an extensive habitat corridor system. This concept compliments the cooperative regional planning approach adopted by New South Wales State and Local Government authorities in the area, and allows for protection of the marine environment through management of catchments.

Social and cultural values

Aboriginal heritage

Aboriginal people are known to have lived along the coast of New South Wales for more than 20,000 years. Evidence suggests that occupancy of the area of the Park commenced approximately 1,200 years ago.

Aboriginal cultural sites in the park are mainly undisturbed and are potentially important sources of information. Over time, shell middens associated with exploitation of the littoral environment have formed and scattered camp hearths; flaking sites and artefacts are also present.

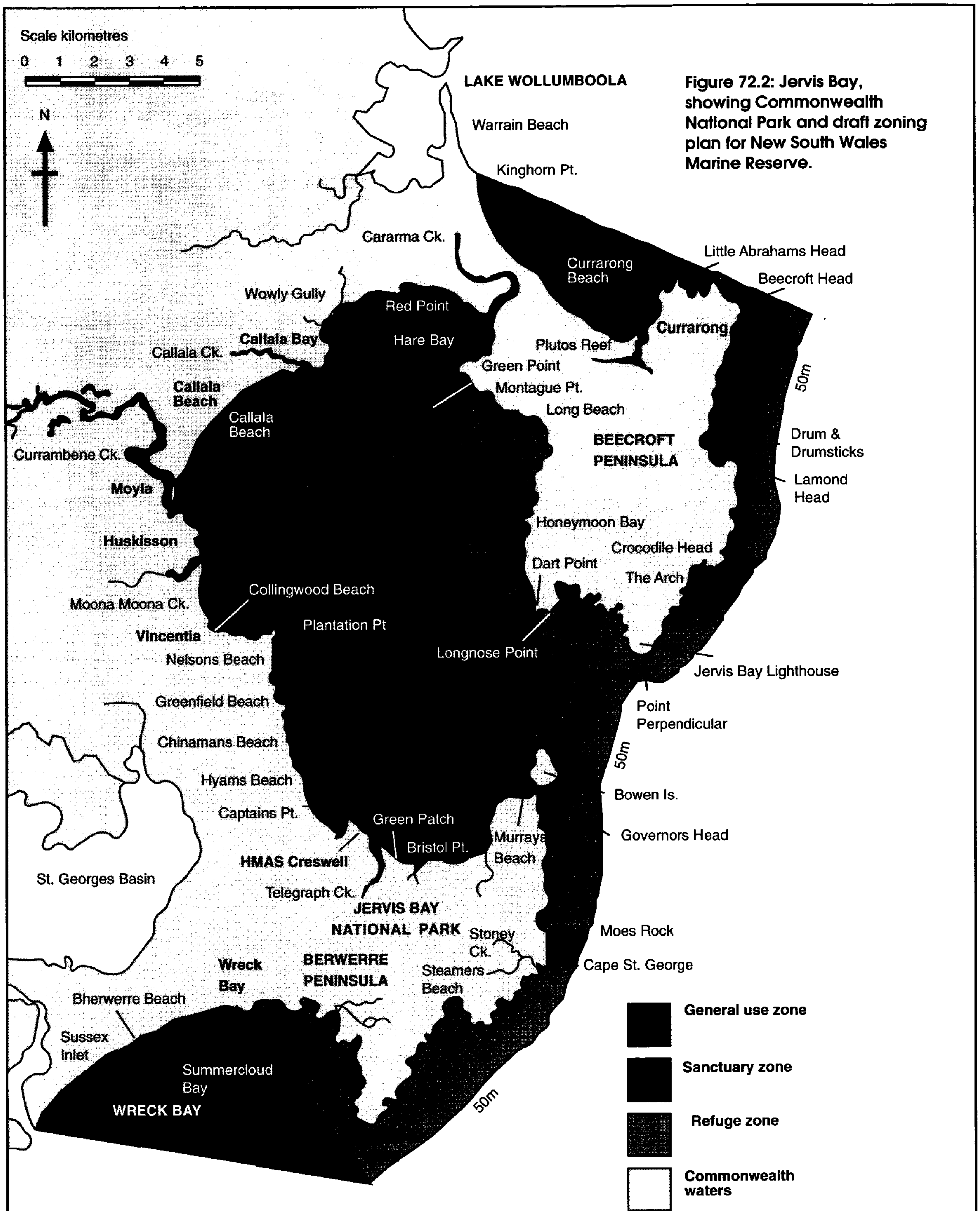


Figure 72.2: Jervis Bay, showing Commonwealth National Park and draft zoning plan for New South Wales Marine Reserve.

New South Wales Jervis Bay Marine Reserve draft management plan: public submissions

In a four-month public review period of the Draft Management Plan in 1994 over 9,000 questionnaires and zoning summaries and over 3,500 copies of the Management Plan were distributed and many individuals, organisations and government departments were consulted.

Of the 326 written submissions received, 86% were in support of the Marine Reserve, 9.5% disagreed with the proposal and 4.5% did not indicate their preferences. Of the 632 natural features of the Bay specified in these returns, the most commonly mentioned were: water quality (175); diversity of marine life (87); beauty and amenity (64); sheltered and safe waters (45); beaches (41); undeveloped foreshores (40); diversity of habitats (36); natural values and features (36); undisturbed marine environment (29); unique fauna and flora (28); seagrasses (26); and conservation values (25).The suggestions and comments in many of the submissions are being taken up in the final management plan.

(Source: K. McClymont, NSW Fisheries)

Management of Aboriginal cultural heritage to date has been *ad hoc*. There has been informal consultation with local Aboriginal people in regard to park development proposals. Dune stabilisation works on Bherwerre Beach during the 1960s and 1970s are known to have destroyed a number of significant middens and hearth sites.

As title of Jervis Bay National Park will be vested in the Wreck Bay Aboriginal Community Council, a Board of Management will be overseeing the preparation of a Plan of Management for the Park which addresses issues of cultural heritage management.

Non-aboriginal heritage

The historic, non-aboriginal exploitation and occupancy of the area includes fishing, whaling, grazing, tourism, timber getting and plantation forestry. Significant European heritage in the Park is land based, as distinct from marine sites. Cultural sites are principally protected through physical barriers or zoning.

The ruin of Cape St George lighthouse is perhaps the most significant European site in the park. The ruin, an example of colonial maritime technology, was listed on the National Estate Register in 1981 in recognition of the ruin's important setting, stonework and as a relic of early European occupation. It is closed to the public. A conservation plan for the lighthouse ruin has been prepared.

The wreck of the convict ship *Hive* and associated camp is located on Bherwerre Beach. The *Hive* is the only convict ship to have been wrecked on mainland Australia, and was located only in 1995. The New South Wales Department of Planning and Heritage is currently preparing a conservation plan for the site. A number of other documented wrecks occur in New South Wales waters in the Wreck Bay area.

Amongst the recommended objectives in the management of European heritage are: to conserve places of historical significance; to conserve European historical knowledge of the area; to cooperate with and support park neighbours in the effective management of European heritage; to foster visitor and community awareness and appreciation of local European heritage; and to undertake or encourage research and monitoring to improve the management of European heritage in the Park.

Uses and issues

Activities undertaken in the waters of Jervis Bay National Park include commercial fishing operations, recreational activities, naval activities, commercial tourism operations, scientific research and educational activities.

Commercial fishing operations

There are eight licences (four of which are generally active) for local commercial fishers to beach seine in the National Park. Their historical use of these waters predates management for nature conservation as a primary objective, and they will be allowed to continue.

There are three commercial baitfishers in the National Park. Jervis Bay is one of several baitfish grounds in the region. It is the only embayment fished, and is therefore particularly attractive as it provides protection from the wind. The size of the domestic longline baitfish catch is unknown.

The southern bluefin tuna pole-and-line fleet use the waters of Jervis Bay National Park. The Park waters provide protection, particularly in southerly winds, in the lee of Bowen Island. At present, commercial pilchard fishing is not permitted in Park waters, although some quantity is taken by boats from other fisheries.

Amongst the recommended objectives regarding professional fishing in Jervis Bay National Park are: that the existing licensed small scale beach seining operations be allowed to continue until licenses are not renewed; that careful consideration be given to the live bait fishery with a view to prohibiting the taking of baitfish from Park waters; and that commercial taking of baitfish continue to be prohibited from Park waters.

Recreation and tourism

The diversity of landforms, habitats, fauna, scenic locations and cultural sites in Jervis Bay National Park offers a wide variety of opportunities for nature and culture appreciation activities. It is important to recognise that the marine component of the park is part of a much wider opportunities spectrum.

Jervis Bay National Park receives over 700,000 visitors per year. The Park offers camping facilities with the number of camper nights being approximately 70,000 per year. The major visitor uses of the Park are beach oriented day use and picnicking.

The activities pursued in the park include: fauna and flora appreciation; bushwalking; boating; rock, beach, and boat fishing; snorkel and scuba diving; swimming, surfing and other beach oriented activities; scenic driving; terrestrial and underwater photography; painting; and history and culture appreciation.

The physical underwater features, diversity of habitats and water quality of Jervis Bay provide the opportunity for high quality diving experiences. Several commercial dive operators offering charters and tuition are based in Jervis Bay. In 1989 approximately 30,000 scuba divers used the Bay. Snorkelling is also a popular activity. A recreational survey is currently being conducted to allow more detailed analysis of visitor use patterns and visitor profiles.

Commercial tourism operators are required to hold a permit issued by the ANCA in order to use the park. The permit system allows management to monitor and control the levels of commercial use; deny access for inappropriate activities; and ensure adequate insurance cover is available for operators' clients.

Indigenous use

In 1986 an area of 382 hectares of the Jervis Bay Nature Reserve was excised under the *Aboriginal Land Grant (Jervis Bay Territory) Act* 1986 and freehold title granted to the Wreck Bay Aboriginal Community Council.

In October 1994, the Minister for the Environment, Sport and Territories and the Minister for Aboriginal Affairs announced that title of Jervis Bay National Park and the Botanic Gardens be granted to the Wreck Bay Community Council. Legislative amendments to allow this are being prepared. The Council will provide input to the management of the Park through a Board of Management, in a model based on that successfully applied to the Uluru and Kakudu National Parks in the Northern Territory.

Shipping and Defence

The waters around Jervis Bay experience high levels of maritime traffic. However, use of the park waters by large vessels is restricted to naval vessel anchorage and those engaged in operational trials (around 600 vessel movements per year).

Jervis Bay National Park is committed to participation in the National Plan to Combat Pollution of the Sea by Oil developed by the Australian Maritime Safety Authority (AMSA) and is developing a local marine oil spill contingency plan. Liaison with HMAS *Creswell* with respect to an oil spill emergency is ongoing.

Scientific research

The Park has been used extensively for external research as it offers opportunities in a relatively undisturbed natural coastal environment. In some cases the opportunities exist for habitats to be used as scientific precincts or reference areas, or as a pristine control for comparative experimentation in the environmental sciences. Integrated terrestrial/marine research is possible within the well protected catchments in the Park. The Park has considerable intrinsic scientific value, containing overlapping bioregions in both the marine and terrestrial environments, and many species at the northern and southern limit of their distribution. All research activities within the Park require permits.

The Park is relatively close to a number of major research institutions in Canberra, Wollongong and Sydney who use the Park as a field resource. The University of Canberra's field station in the Jervis Bay Territory provides accommodation in a highly desirable location and is used by many universities. CSIRO has conducted baseline studies in relation to environmental impact assessment for the east coast naval fleet base and ammunition wharf and depots.

Education, interpretation and information

Jervis Bay National Park has enormous potential for the development of comprehensive and innovative interpretive, education and information services. Geographically, Jervis Bay National Park is ideally placed within the visitor catchment areas of Sydney, Canberra and Wollongong.

An Interpretation Plan has been developed for Jervis Bay National Park which will provide guidelines for the development of interpretation, education, promotion, liaison and information programs over a five year period. It also recognises the need for integration and closer liaison with the Wreck Bay community and Jervis Bay Botanic Gardens to achieve communications goals.

Management of the Jervis Bay National Park

The Jervis Bay Territory was acquired from New South Wales in 1915 under the *Jervis Bay Territory Acceptance Act* 1915, for Defence purposes. Two thirds of the Territory (4,470 hectares) was declared a public park, Jervis Bay Nature Reserve, in 1971. In 1975 the House of Representatives Standing Committee on Environment and Conservation recommended that the Jervis Bay Nature Reserve be extended to include all areas of the Jervis Bay Territory not reserved for use by the Department of Defence.

In 1986 an area of 382 hectares of the reserve was excised under the *Aboriginal Land Grant (Jervis Bay Territory) Act* 1986 and freehold title granted to the Wreck Bay Aboriginal Community Council. In 1995 it is expected that legislative amendments to enable the title of the Park to be granted to the Wreck Bay Aboriginal Community Council will be completed.

Legislation

The *National Parks and Wildlife Conservation Act* 1975 (NPWC Act) is the primary statutory authority guiding management of the Park. The NPWC Act and Regulations override legislation and ordinances that previously applied to the area of the Park. All of the waters of Jervis Bay Territory are reserved and protected under the Act. Other Acts of the Commonwealth, for example the *ACT Fishing Act*, can be applied in Jervis Bay Territory. Special purpose Commonwealth legislation, for example the *Whale Protection Act* 1980, also apply.

Defence use

The *Control of Naval Waters Act* 1918 applies to the waters for Defence use of Jervis Bay and the ocean waters off the Bay are official naval exercise areas. Naval manoeuvres, marine exercises and fleet visits are common. The waters of the Park contain 14 specified naval anchorages. Occasional serious beach pollution by sewage, and damage to marine animal resources from explosives used in naval exercises do occur. Minor oil spills have occurred constituting a risk to the marine environment.

Planning and management

A management plan for Jervis Bay National Park is yet to be prepared pursuant to the NPWC Act which requires the preparation of a plan of management. Cooperative management between Commonwealth, State and Local Government bodies is essential and joint management and cross-authorisation of officers for enforcement purposes will be considered.

Major environmental and management Issues

The foreshores of Jervis Bay National Park are generally in a natural condition. Developments include recreational access points; the naval training college HMAS *Creswell* (which includes a sewerage outfall); and a small breakwater and boat launching ramp near Murrays Beach.

Nutrients

Waste water is currently generated by HMAS *Creswell*, Jervis Bay Village, the Jervis Bay Range Facility (naval fire fighting installation), and Greenpatch picnic and camping area (discharging into the HMAS *Creswell* sewage treatment plant). The permanent population of the Jervis Bay Territory is in the order of 600 people.

Waste water from the *Creswell* treatment plant is currently discharged into the sea at Captains Beach, inside the Bay. Plans have commenced to dispose of the treated effluent from this plant on land, and link Wreck Bay to this system. A water balance model has been developed to determine the minimum storage and irrigation site area required for development of the effluent irrigation scheme. No waste water will be discharged into the sea from Jervis Bay Territory on completion of these works.

Urban run-off is not well managed. Run-off from HMAS *Creswell* and Jervis Bay Village flows into a natural lagoon which is periodically opened to the sea after heavy rainfall events. Some level of monitoring for nutrients in the lagoon is to be undertaken but it is thought that nutrient input into the marine environment from Jervis Bay Territory is likely to be small.

A major bloom of the alga *Gephrocapsia oceania* occurred throughout the Bay in 1992 but the causes of this remain unknown (Chapter 14).

Tourism and recreational use

Problems arising from land-based recreation which can impact on the marine environment principally relate to catchment management. These include the maintenance of foreshore vegetation, marine catchment monitoring, effluent and run-off management from park facilities.

Overcrowding is evident during seasonal peaks (summer holidays and Easter) when high levels of use exceed the current capacity of some facilities. Visitors with varying expectations (e.g. campers, picnickers, swimmers, scuba divers, snorkellers, anglers, tour groups, sightseers) are concentrated in relatively small areas. While many of the activities themselves are compatible, the need to share limited resources such as parking and boat launching facilities leads to some site impact and visitor conflict through overcrowding.

Anchoring of boats within seagrass meadows has the potential to seriously damage the community, which may take decades to recover.

There has been a growing use of power boats for water skiing and the use of jet skis. These activities constitute a risk to public safety and diminish the quality of other visitors' recreational experience.

Tourism may be singly the most significant cause of environmental degradation in the Park, especially with regards to the catchment. Around 250,000 visitors a year utilise the two camp grounds situated on the shores of the Bay, Greenpatch and Bristol Point.

Some of the known impacts include:

- Inappropriate practices within the catchment (deliberate or accidental fire, abuse of waterways, clearing of vegetation cover), and overcrowding within potentially sensitive areas.
- Inappropriate or illegal collection of intertidal and subtidal organisms, including collecting on scuba, spear fishing particularly of bottom-living species, and collection of shellfish such as scallops, abalone and mud oysters.
- Littering into and pollution of the marine environment.

Monitoring and marine environmental reporting

There has been little environmental marine monitoring in the Park. A working group, formed in 1992 in the wake of an extensive algal bloom and consisting of representatives from the New South Wales EPA, Shoalhaven City Council, New South Wales Public Works Department, Department of Defence, CSIRO and ANCA agreed that joint monitoring of the waters of Jervis Bay was necessary. The monitoring is to include point-source monitoring of known human inputs and early warning monitoring to alert management of likely environmental imbalances and assist in causal assessment.

Monthly point-source monitoring of nutrients at effluent discharge points (HMAS *Creswell*, Plantation Point, Moona Moona Creek) is conducted by the Commonwealth Environmental Protection Agency and the Shoalhaven City Council, as required for licensing.

The use of remote submersible telemetry equipment, measuring perhaps water temperature, salinity and light levels at strategic locations, is being investigated. The purpose of such a system would be primarily for early warning of environmental change, for example, through an influx of warm tropical waters. The data would greatly assist in causal assessment of environmental perturbation.

Summary and conclusions

1. Jervis Bay and its catchments are generally in a near pristine condition.

2. The declaration of a National Park over the Bherwerre Peninsula and southern waters of the Bay, the imminent declaration of a marine reserve over the New South Wales waters and declaration of key catchment areas as Parks managed by New South Wales National Parks and Wildlife Service, and the proposed inclusion of the Beecroft Peninsula as the second stage of Jervis Bay National Park all contribute to the protection of Jervis Bay.

3. Jervis Bay and its catchment could be a model in cooperative management to achieve integrated protection of a coastal environment.

4. Major issues include disposal of sewage effluent, maintenance of indigenous interests, and regional planning incorporating catchment management.

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Acknowledgments
The paper by M. Fortescue and F. Kristo was reviewed internally in the Australian Nature Conservation Agency, and reviewed externally by Dr C. Jacoby, CSIRO.

Chapter 73: National Nature Reserves[1]

Many marine protected areas have been established in Australian waters in response to adverse human impacts. There are, however, some marine reserves, called National Nature Reserves, which have been established in offshore waters seldom visited by humans.

National Nature Reserves are managed primarily as scientific reference areas - the principal management objectives being to protect natural communities and species and to maintain and protect natural processes in an undisturbed state. Although visitors to the Reserves are welcome, management for human enjoyment is a secondary consideration.

This chapter describes five marine National Nature Reserves: Coringa-Herald National Nature Reserve; Lihou Reef National Nature Reserve; Ashmore Reef National Nature Reserve; Elizabeth and Middleton Reefs Marine National Nature Reserve; and Mermaid Reef National Nature Reserve.

Description: geography, oceanography, ecology

Coringa-Herald and Lihou Reef National Nature Reserves

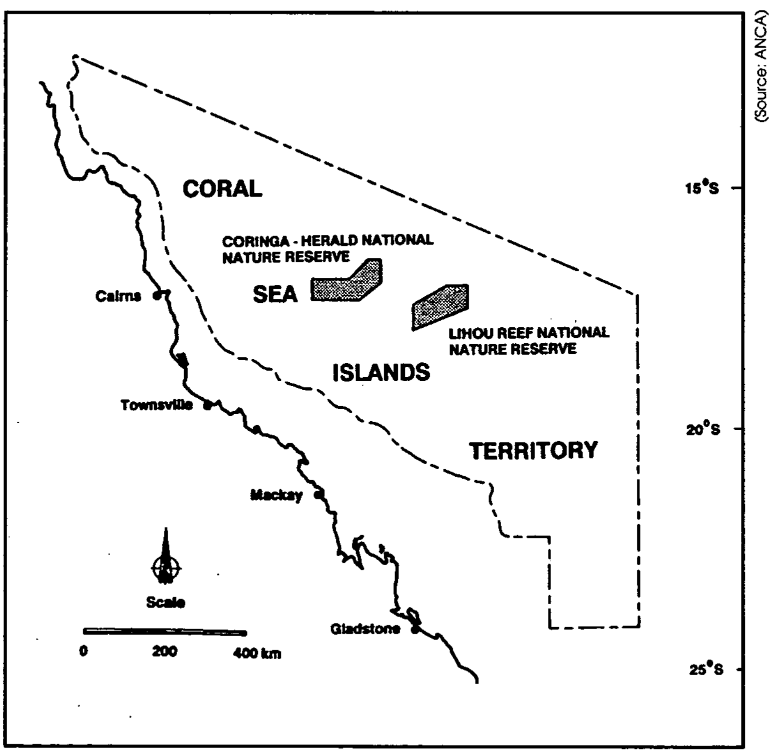
The Coral Sea, as its name implies, is characterised by its great development of coral reefs which has occurred on the Coral Sea Plateau, and the clear oceanic waters from the South Equatorial Current.

The Australian Nature Conservation Agency (ANCA) manages two Reserves in the Coral Sea: Coringa-Herald National Nature Reserve and Lihou Reef National Nature Reserve. These Reserves have important island and reef ecosystems, as well as shallow and deepwater habitats characteristic of the central region of the Coral Sea Islands Territory. Lihou Reef is the largest reef structure in the Coral Sea; the islands of the Coringa-Herald National Nature Reserve include the only forested cays in the Coral Sea Islands Territory. Both Reserves include spectacular and unusual underwater topography and reef structures which are thought to be unique to the Coral Sea.

The two Reserves have a rich and diverse marine biota, including an interesting and distinct fish fauna. They provide important breeding and feeding habitat for marine turtles. The major invertebrate groups present include a variety of sponges, soft and hard corals, starfish, sea urchins and holothurians. Sponges form an important part of the reefs' fauna and, in marked contrast to the Great Barrier Reef, are often more abundant than coral, in places forming extensive sponge 'gardens'. At the Coringa-Herald National Nature Reserve, the marine algae are diverse and are the most dominant group of encrusting organisms in most reefal habitats.

The islands of the Reserves are critical for the survival of seabirds which come to them from an extensive oceanic 'catchment'. At most times there are high concentrations of nesting seabirds. Many of the bird species are migratory and breed on small isolated islands. Fifteen of the 24 species of birds recorded from Lihou Reef, and 17 of the 23 species of birds recorded from Coringa-Herald are included in the bilateral agreements which Australia has entered into with Japan and the People's Republic of China to protect migratory birds and their environments.

Figure 73.1: Location of Coringa-Herald National Nature Reserve.



[1]Based on a paper by M. Griffin, The Australian Nature Conservation Agency, Canberra, Australian Capital Territory.

(Source: ANCA)

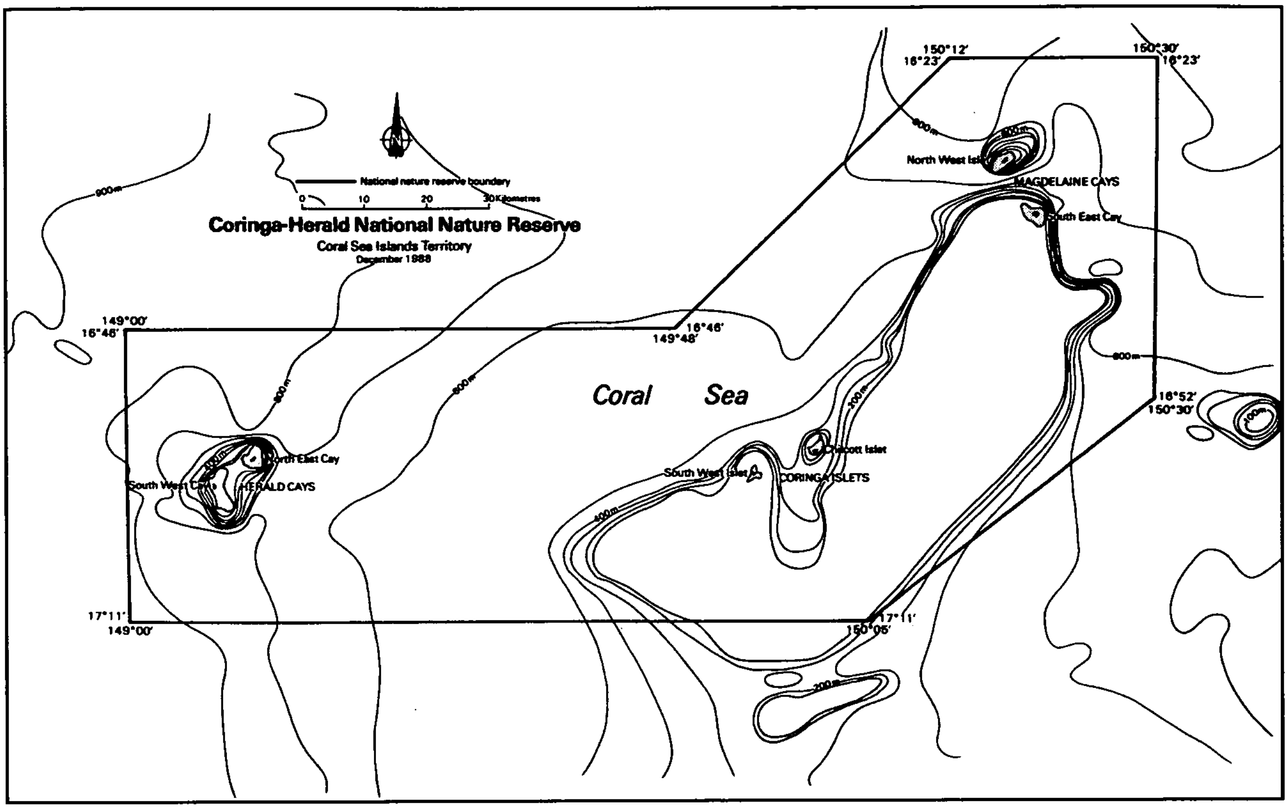


Figure 73.2: Location of Coringa-Herald and Lihou Reefs National Nature Reserves.

(Source: ANCA)

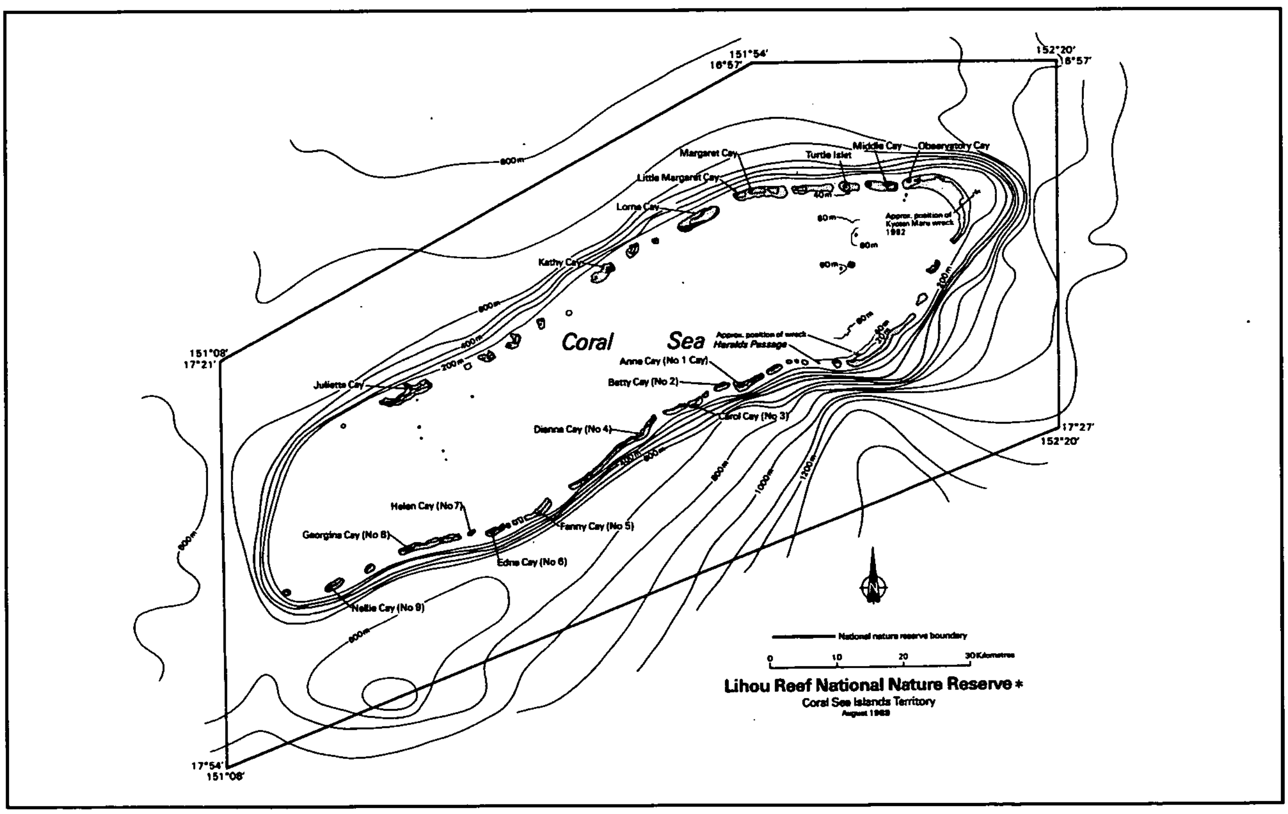


Figure 73.3: Lihou Reef National Nature Reserve.

Ashmore Reef National Nature Reserve

Ashmore Reef is located in the Timor Sea about 840 kilometres west of Darwin and 610 kilometres north of Broome. It is part of the Territory of Ashmore and Cartier Islands.
The Ashmore Reef National Nature Reserve covers 583 square kilometres encompassing three islands, reef shelf and surrounding waters to the 50 metres bathymetric contour. The islands and waters of the Reserve support extremely high concentrations of breeding seabirds and provide an important staging point for birds migrating between Australia and the northern hemisphere.

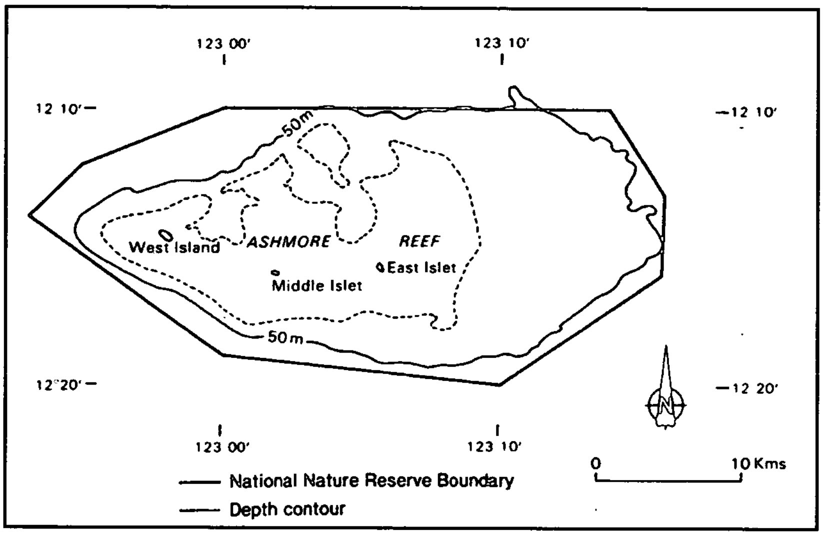
The Reserve has a rich and diverse marine life with a degree of endemism - the sea snake fauna in particular is notable. The Reserve also provides important breeding and feeding habitat for marine turtles and dugong.

Elizabeth and Middleton Reefs Marine National Nature Reserve

The Australian Nature Conservation Agency also manages the Elizabeth and Middleton Reefs Marine National Nature Reserve, located some 600 kilometres east of Coffs Harbour. These isolated oceanic reefs are influenced by both tropical and temperate ocean currents and are the most southerly coral atolls in the world (Chapter 12).

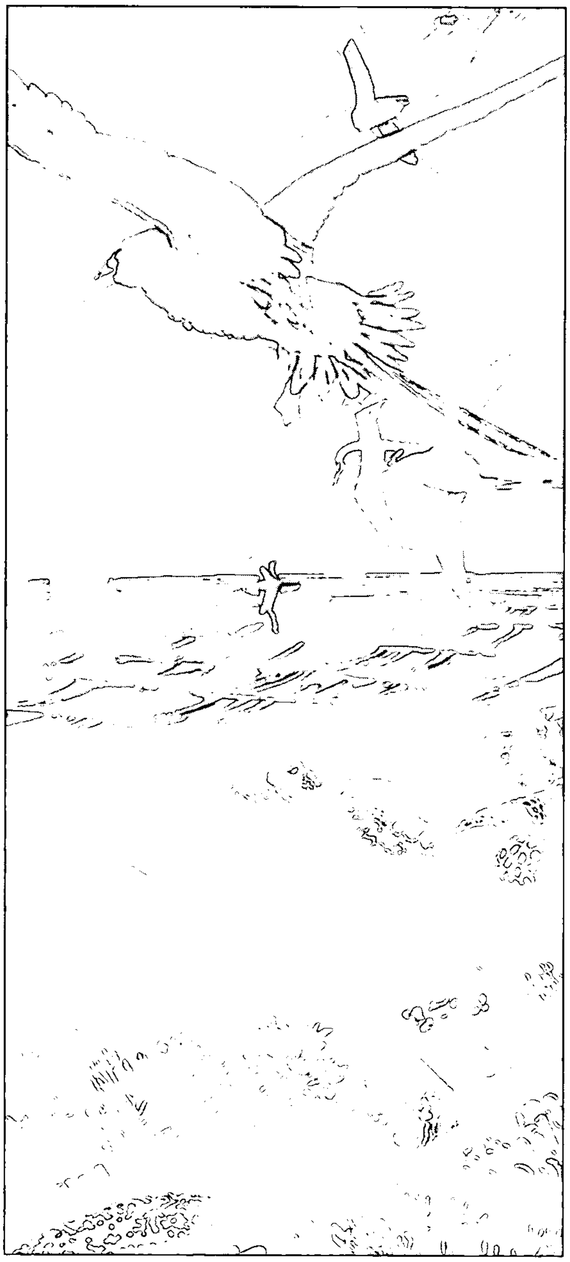
The combination of isolation and high latitude has given rise to an unusual and scientifically interesting marine fauna that includes a number of endemic species. The isolation of the reefs has also made them the last secure refuge in Australia for the black cod, a species once common along the New South Wales coast.

The reefs and their surrounding waters are used as feeding grounds by a number of species of seabirds and by green turtles. Many ships, dating back to the earliest years of European settlement in Australia, have been wrecked on the reefs, making the area of considerable marine archaeological significance.



(Source: ANCA)

Figure 73.4: Ashmore Reef National Nature Reserve.



(Source: ANCA)

Figure 73.5: Ashmore Reef is a rich, shelf-edge atoll off the North West Shelf. The reef supports a great variety of marine life, including three species of turtles, dugongs and sea snakes. Eighty three species of birds have been recorded on the islands. Ashmore Reef was declared a National Nature Reserve in 1983 because of concerns of the effects of Indonesian fishers harvesting fish, molluscs and turtles. A Memorandum of Understanding with the Indonesian Government allows restricted access for Indonesian fishers.

(Source: ANCA)

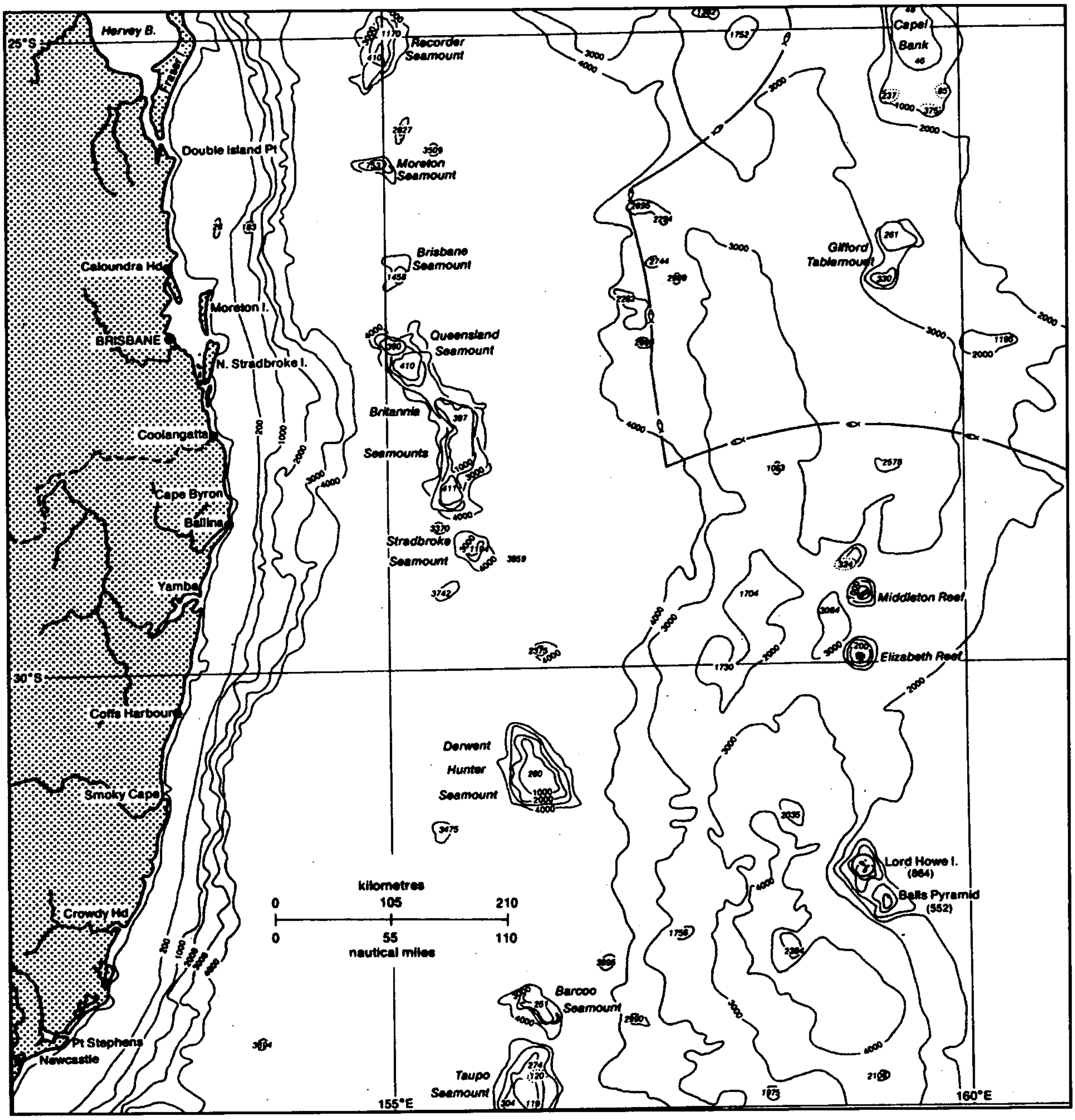
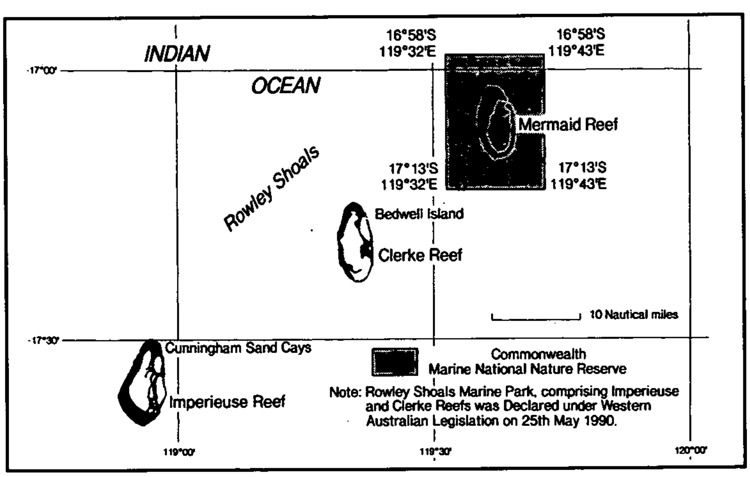


Figure 73.6: Elizabeth and Middleton Reefs Marine National Nature Reserve.

(Source: ANCA)



Mermaid Reef Marine National Nature Reserve

Mermaid Reef National Nature Reserve lies approximately 280 kilometres to the west of Broome, Western Australia. Mermaid Reef is one of three offshore shelf atolls which together form the Rowley Shoals (Chapter 12). The two southerly atolls, Clerke and Imperieuse Reefs, were declared under Western Australian legislation on 25 May 1990 as the Rowley Shoals Marine Park (Chapter 81).

Figure 73.7: Mermaid Reef Marine National Nature Reserve.

Mermaid Reef is 16 kilometres long and approximately 7.7 kilometres wide at its widest point. It has a single, deep lagoon with a maximum recorded depth of approximately 20 metres at high tide. A single passage, about 35 metres wide, enters the lagoon on the north-east side. There is no permanent land on Mermaid Reef, but, at the northern tip of the Reef, a large sand cay is exposed at low tide.

The Rowley Shoals are considered to be good morphological examples of shelf atolls, which makes them suitable for the study of the origin and dynamics of these reefs. They experience a large tidal range, which, with an estimated five metre tidal range at spring tide, is thought to be the largest in the world for shelf atolls. This tidal range influences the height and structure of the reefs and faunal zonation. The isolation of the reefs from continental faunas has given rise to a high degree of endemism.

Legislation, planning and management

Legislation

The National Nature Reserves were proclaimed under the *National Parks and Wildlife Conservation Act* 1975 between 1982 and 1991.

Shipwrecks which are older than 75 years (which exist at Coringa-Herald, Lihou, Elizabeth and Middleton Reefs) are protected under the *Historic Shipwrecks Act* 1976.

Planning and management

The *National Parks and Wildlife Conservation Act* 1975 provides that Reserves proclaimed under the Act must be managed in accordance with the provisions of a Plan of Management for the Reserve, prepared in accordance with the Act. The Act specifies a public consultation process which must be followed during the preparation of management plans.

Management Plans have been prepared for Lihou Reef, Coringa-Herald, Ashmore Reef and Elizabeth and Middleton Reefs Marine National Nature Reserve. A plan has yet to be drafted for Mermaid Reef Marine National Nature Reserve.

The Reserves are managed by ANCA. Wardens appointed under the National Parks and Wildlife Conservation Act undertake patrols to the Reserves aboard Royal Australian Navy and Australian Customs Service vessels; Coastwatch and military aircraft provide an aerial surveillance service. The continued assistance of the Royal Australian Navy, Australian Customs Service and Coastwatch in the management of these Reserves is greatly appreciated.

Human uses

Each of these National Nature Reserves is remote from human settlement and centres of activity. There has, therefore, been relatively little human impact on the Reserves' ecosystems, compared with areas closer to the mainland.

People visiting the Reserves do so by surface vessels, with the occasional charter flight over the Reserves. Mermaid Reef, together with the other reefs of the Rowley Shoals, has become a tourist destination for recreational divers, with nine tour vessels operating intermittent trips from Broome. Pleasure craft also visit the other Reserves, although the level of usage is considered to be low.

Most of Ashmore Reef National Nature Reserve is closed to public access. Public access is permitted only to West Island and the lagoon adjacent to it. Indonesian fishermen have traditionally used the resources of Ashmore Reef, and this use continues in the areas open to public access in accordance with a Memorandum of Understanding between the governments of Indonesia and Australia. Fishing, including the taking of sedentary species, is not permitted on the reef platform itself.

Some fishing activity, mostly recreational, is known to occur in each of the Reserves; commercial fishing is prohibited.

People also visit the Reserves on organised tours catering for special interest groups, including diving enthusiasts, ornithologists and people seeking wilderness adventures.

Major environmental and management issues

Indonesian fishermen are known to have used the resources of Ashmore Reef from before the time of the first European settlements in northern Australia. The Australian Government recognises this use as being traditional and allows the practice to continue in accordance with a Memorandum of Understanding between the governments of Indonesia and Australia. The Memorandum and guidelines for its implementation specify the activities which are considered to be traditional, the areas in which these activities may take place and prohibitions on taking certain protected wildlife such as turtles and giant clams.

The diversity and abundance of marine life at these remote Reserves may attract poachers for either market or the aquarium trade, particularly as reefs closer to the mainland become degraded or overexploited, or have access restrictions placed on them. All native species in the Reserves are protected from commercial exploitation. Provision is made, however, for traditional subsistence fishing at Ashmore Reef by Indonesians (as indicated above) and for recreational fishing, with restrictions imposed at Elizabeth and Middleton Reefs to protect the black cod population.

Despite modern navigational aids, the potential for shipwrecks to occur at the Reserves does still exist. The vessels most likely to become wrecked on the Reserves are pleasure craft or fishing vessels which either lack sophisticated navigational equipment or do not have a continuous watch set on that equipment. The principal management objective in the case of a shipwreck in the Reserves is to prevent loss of life. Prevention of damage to the ecology of the Reserves, particularly through oil pollution is an important secondary consideration.

Oil exploration and drilling activity is increasing in the Timor Sea. Should a major oil pollution incident occur at any of the Reserves it is unlikely that a spill could be contained or treated as the Reserves are too remote and exposed. It would generally be impractical and possibly dangerous to try and contain surface oil by booms, and the reefs are outside the effective operational range of most aircraft capable of carrying and applying dispersants. An appropriate response plan to an incident would have to be formulated on a case-by-case basis, taking into account the weather conditions at the time and the nature of the incident.

The difficulty of eradicating pests such as rats from these remote islands, and the damage that these predators can inflict on nesting seabirds makes continued vigilance critically important for the protection of the seabird rookeries. The black rat *(Rattus rattus)* occurred at South West (Coringa) Islet until successfully eradicated by ANCA in 1991.

The crown-of-thorns starfish *(Acanthaster planci)* has been observed at both Elizabeth and Middleton Reefs, and is thought to have caused, or be causing, significant coral death. The population and size classes of the starfish at the Reefs indicate that the species is breeding at the Reefs or is being supported by larval recruitment. There is no evidence to suggest that the presence or abundance of *A. planci* at the Reefs has been influenced by anthropogenic factors. Control of the species, if considered to be desirable, would be logistically difficult, if not impossible, using technology which is currently available (Chapter 49).

Cyclones occur frequently in the Coral Sea Territory and the Timor Sea. These events can have a massive impact on the flora and fauna and structure of reefs, cays and islets in the Reserves.

The remoteness of each of these Reserves and resource constraints make management and surveillance difficult.

Information base, monitoring and reporting

Because of their isolation, the National Nature Reserves are not well known scientifically and are not regularly monitored. Scientific parties visited many of the islands and reefs in the Coral Seas Islands Territory in 1960, 1961 and 1964 aboard Naval vessel and further studies have been either commissioned by ANCA or conducted by ANCA staff. The geology, bathymetry and oceanography of the Coral Sea reefs have been described. The Bureau of Meteorology maintains several automatic weather stations in the Coral Sea Islands Territory, and a staffed outpost at Willis Island.

Much of the information about the biota of the Ashmore Reef National Nature Reserve has been obtained by ANCA Wardens and by research commissioned by ANCA. The most recent scientific expeditions to the Reserves were conducted in 1986 by the Northern Territory Museum and the Western Australian Museum. The results of these expeditions have yet to be published.

Elizabeth and Middleton Reefs fish and corals have been described by the Australian Museum and the Australian Institute of Marine Science mounted an expedition to the Reefs.

In 1982 the Western Australian Museum conducted a comprehensive biological survey of the Rowley Shoals, including Mermaid Reef.

Summary and conclusions

1. The remoteness of these National Nature Reserves has saved them from many of the influences which have had such a serious impact on areas closer to human settlement.

2. As representative samples of natural marine ecosystems which have suffered comparatively little from human influences, these Reserves are of scientific interest and wilderness value.

3. The remoteness of the Reserves, however, also makes management and surveillance of the Reserves difficult.

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Acknowledgments:
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Chapter 74: The Torres Strait Protected Zone [1]

Torres Strait, the meeting place of two oceans, is ecologically very rich and highly productive. It is strewn with coral reefs, including the northern extreme of the Great Barrier Reef, has large areas of mangrove wetlands, and some of the most extensive seagrass beds in the world. Its dugong population and turtle and seabird rookeries are of world significance. Torres Strait supports important prawn, lobster, mackerel and pearl fisheries, and is a strategic ,international shipping lane. The islands are inhabited by indigenous Torres Strait Islanders, a people of Melanesian origin.

Torres Strait poses a plethora of management challenges: a complex, shared international border; conflicting interests in fisheries sectors; potential pollution risks from heavy metals from Papua New Guinea; oil spills from shipping; and, in particular, the maintenance of the interests of the indigenous inhabitants. To this end, the area north of 10°50'S latitude has been declared a Protected Zone under the Torres Strait Treaty ratified between Australia and Papua New Guinea in 1985.

Description: geography, oceanography and ecology

Torres Strait is a 150 kilometre wide, shallow passage between Cape York and Papua New Guinea (PNG). It contains over 100 islands, islets, reefs and cays. Sixteen islands, with a total population of 6,300, are inhabited by Torres Strait Islanders, a maritime people (Chapter 22).

Oceanography

Oceanographically, Torres Strait is part of the Pacific Ocean. Eastern and south-eastern reefs are influenced by waters of the Great Barrier Reef, including

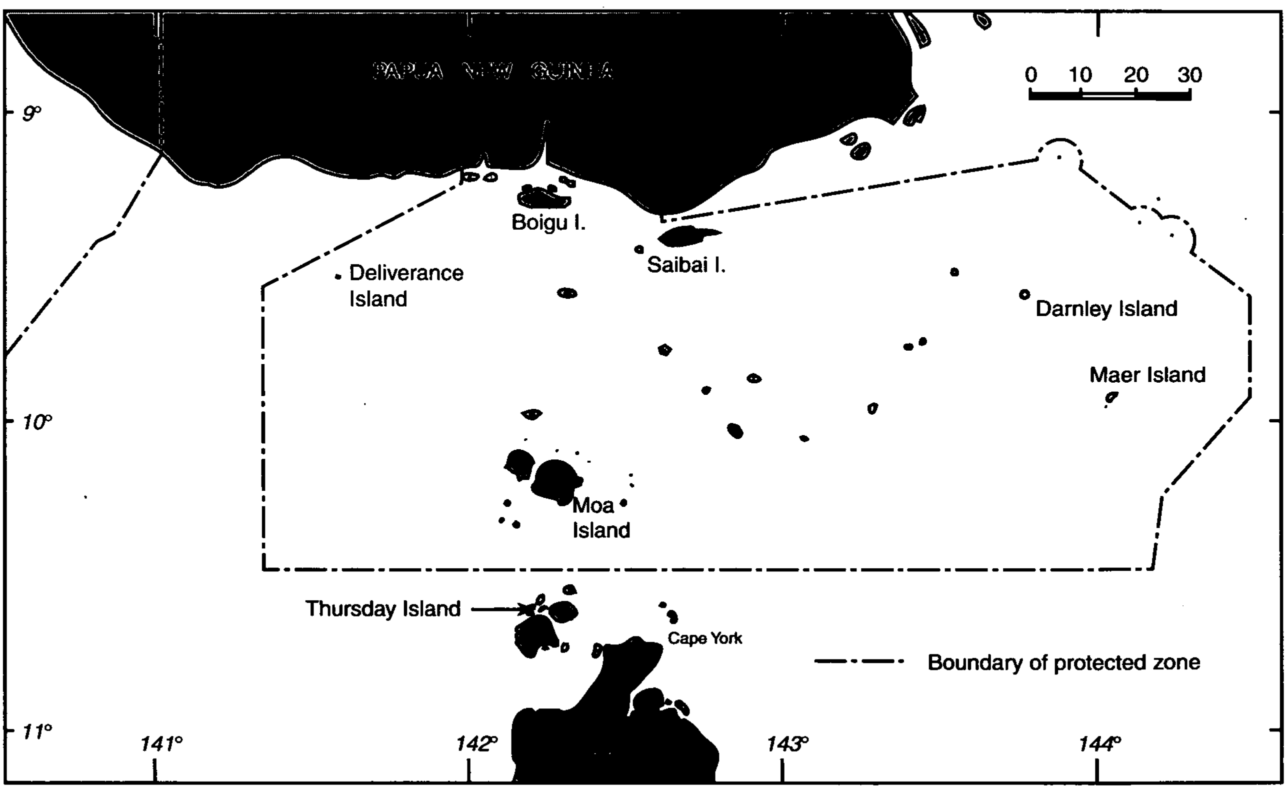


Figure 74.1: Torres Strait, showing major islands, borders and the Protected Zone.

[1]Based on a paper by Dr D. Lawrence and Dr W. Gladstone, Great Barrier Reef Marine Park Authority, Townsville, Queensland; with contributions by Dr L. Zann, SOMER coordinator.

upwellings. Very strong tidal currents move Coral Sea and Arafura Sea waters back-and-forth through the Strait. Major freshwater inputs into Torres Strait are discharges from PNG (especially the Fly River) and Irian Jaya.

Marine ecology

Biogeographically, Torres Strait is part of the Indo-West Pacific region and has a very high diversity of marine habitats and species. Major coral reef habitats include fringing coral reefs (around continental and volcanic islands, mud banks and macroalgal reefs); platform coral reefs and associated coral cays; and deltaic and dissected coral reefs on the Great Barrier Reef. Other habitats include soft and hard shores; estuaries; mangrove wetlands; subtidal seagrass beds; and inter-reefal benthos dominated by sponges, soft corals, seawhips, hard corals and gorgonians.

Based on reef types, there are six biogeographic areas: Western Reefs (shallow reefs, shoals, fringing reefs, mud banks and seagrasses, dugongs, lobsters and flatback turtles abundant); Northern Reefs (shallow sand banks and shoals, turbid, low mangrove islands); Western inter-reef (shallow, sandy bottom, sparse algal beds); Warrior Reefs (shallow shoals, reefs separated by deep channels, turbid, algal dominated); Central Reefs (many platform reefs, sand cays (some vegetated), clear water, sandy bottom benthos (disturbed by trawling), giant clams, sea snakes and turtles common, dugongs uncommon, trochus fisheries, major prawning grounds); Eastern Reefs (many platform reefs, dissected Northern Great Barrier Reef, sand cays (some vegetated), turtles and sea snakes common, green turtle rookeries, seabird rookeries, humpback whales occasional, important spiny lobster breeding grounds) (Figure 74.1). Torres Strait contains major seabird rookeries (Chapter 17) and populations of dugongs and turtles (Chapter 18) of world significance.

Fisheries

The Torres Strait commercial fisheries for prawns, rock lobsters, pearls and mackerel are valued at $20-30 million per year. The reef fisheries are of major subsistence importance for Torres Strait Islanders.

Prawns

Prawning commenced in 1968 but grew rapidly in the 1980s with the introduction of mother ships, fuel barges and electronic fish finding equipment. Major species are tiger prawns *(Penaeus esculetus)*, endeavour prawns *(Metapenaeus endeavouri)* and red

(Source: GBRMPA)

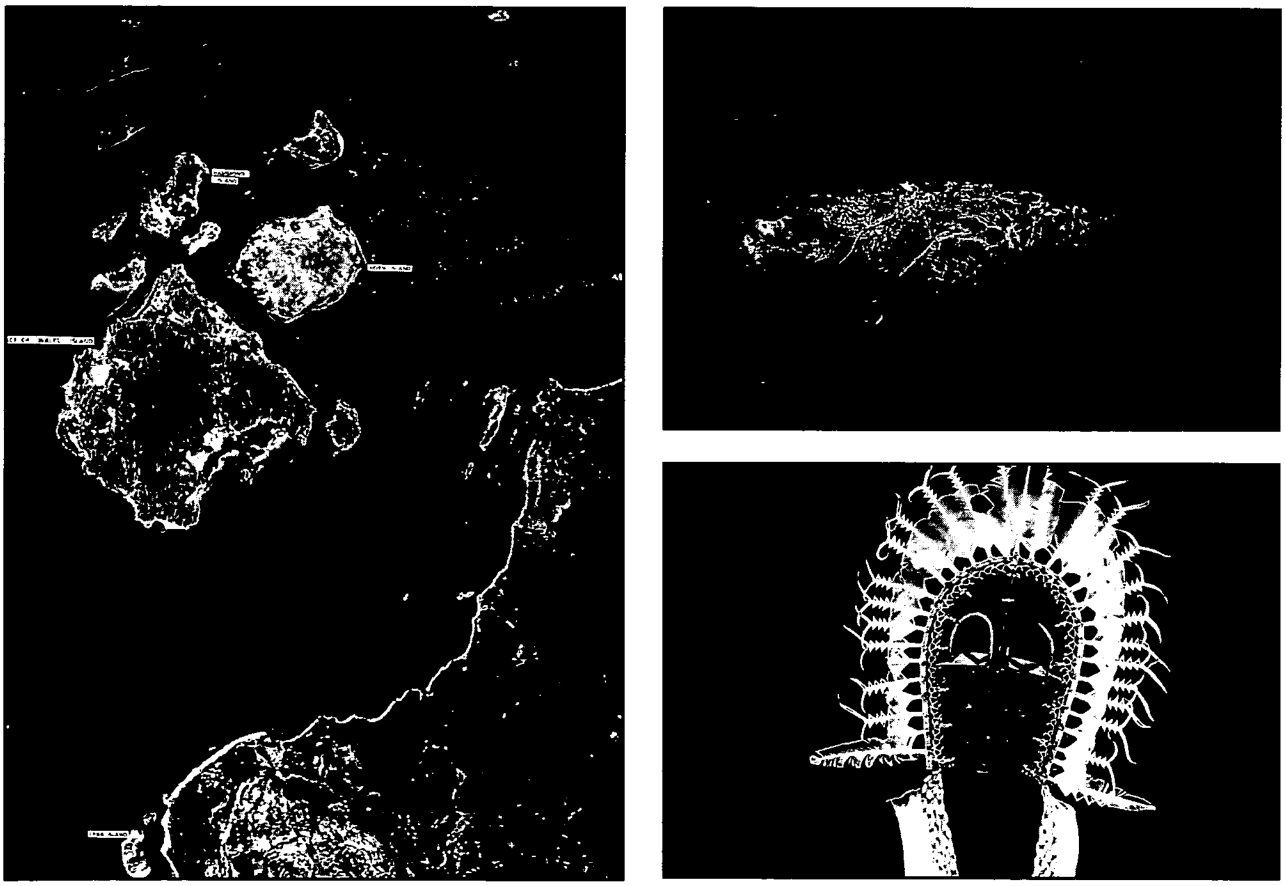


Figure 74.2: (a) Torres Strait (Western Group, LANDSAT). (b) Dugong. (c) Torres Strait Islander.

spot king prawns *(Penaeus longistylus)*. The current catch is around 800 tonnes per year.

The fishery is managed under Article 22 of the Torres Strait Treaty by limitations on vessels, equipment and seasonal and area closures. There is minimal involvement of Torres Strait Islanders in the prawn fishery because of the high capital investment and technological requirements of the fishery.

Mackerel

Centred in eastern Torres Strait, the Spanish mackerel troll fishery is seasonal (Oct-Nov), with landings averaging around 100 tonnes per year. The fishery is undertaken from small dories based on mother ships with freezers, or land-based freezers run by Islanders.

Rock lobsters

The ornate rock lobster *(Panulirus ornatus)* is taken by divers using spears and sold to freezers on mother ships and islands. The major grounds are from Thursday Island to Warrior Reef, and the catch is around 185 tonnes (1990). Lobster trawling is banned and the fishery is managed under Article 22 of the Treaty to encourage Islander participation.

Pearls

Pearling began in 1868 and by 1883 Torres Strait was the world's largest mother-of-pearl fishery involving 33 pearling stations and 206 licensed vessels. The industry slumped after WW II with the advent of plastics but revived with the advent of cultured pearls. Current activity involves the supply of live shell to a small number of predominantly Japanese-owned pearl farms. According to anecdotal information, a major epidemic which decimated stocks in the 1970s was caused by detergents used in the *Oceanic Grandeur* oil spill in 1970. There is no scientific evidence to support this.

Other fisheries

Bêche-de-mer (Holothuroidea, various species) and trochus snails *(Trochus niloticus)* have been fished intermittently for over a century. The current high prices have lead to a recent revival in a fishery based at Daru in Papua New Guinea. Under the Treaty these fisheries are exclusively Islander fisheries.

Shipping

The Torres Strait is a major shipping route between the eastern Australian states and South East Asia, and for international 'through' shipping. It is an international strait under international law. The *Oceanic Grandeur* oil spill in 1970 was one of Australia's largest spills, but environmental damage was not considered great.

The major channels of Adolphus, Prince of Wales and Great North East Channels were used by around 1,772 vessels in 1989.

Environmental issues

The range of environmental issues facing Torres Strait includes pollution from heavy metals, oil spills from shipping, catch-sharing in fisheries, effects of sea level rise on islands and conservation of endangered species.

Heavy metals

The possibility of heavy metal contamination of the Torres Strait commercial fisheries, and in particular of endangered species such as turtles and dugong, and of the seafood consumed by Torres Strait Islanders has been a major concern. Tailings from the Ok Tedi gold and copper mine and Porgera and Mt Kare gold mines enter the Strickland/Fly River system which discharges into the Gulf of Papua east of Torres Strait. A small gold mine also operated on Horne Island in 1988-89.

On Horn Island tailings from an abandoned gold mine have caused statistically significant elevations in the concentrations of cadmium, lead, copper and manganese in mangrove cockles around Spring Creek. A monitoring and rehabilitation program is underway.

Commercial fisheries

Major issues include the effects of trawling on the benthos and on juvenile fish of commercial and subsistence importance, the lack of economic benefits to the Islanders from the fishery, and their limited control over its management.

Oil spills

Oil spills are a constant threat because of the large number of vessels using Torres Strait, increasing tanker traffic, the development of the Kutubu oil fields and shore oil terminal near Cape Blackwood in Papua New Guinea, the lack of an oil spill contigency plan in Papua New Guinea, and problems of instituting compulsory pilotage through the Strait because of its designation as an international strait. Globally important populations of dugongs, turtles, sea snakes and seabirds could potentially be affected by a major oil spill.

Sea level rise

Effects of a rise in sea level would be very severe in the cays of the Central Group and in the northern mangrove islands where erosion is already a severe problem.

Local issues

The terrestrial environment of inhabited cays has been damaged by construction of airstrips, barge landings, garbage dumps, sea walls and other infrastructure. Dredging of barge channels has caused local damage to coral reefs.

Torres Strait baseline study

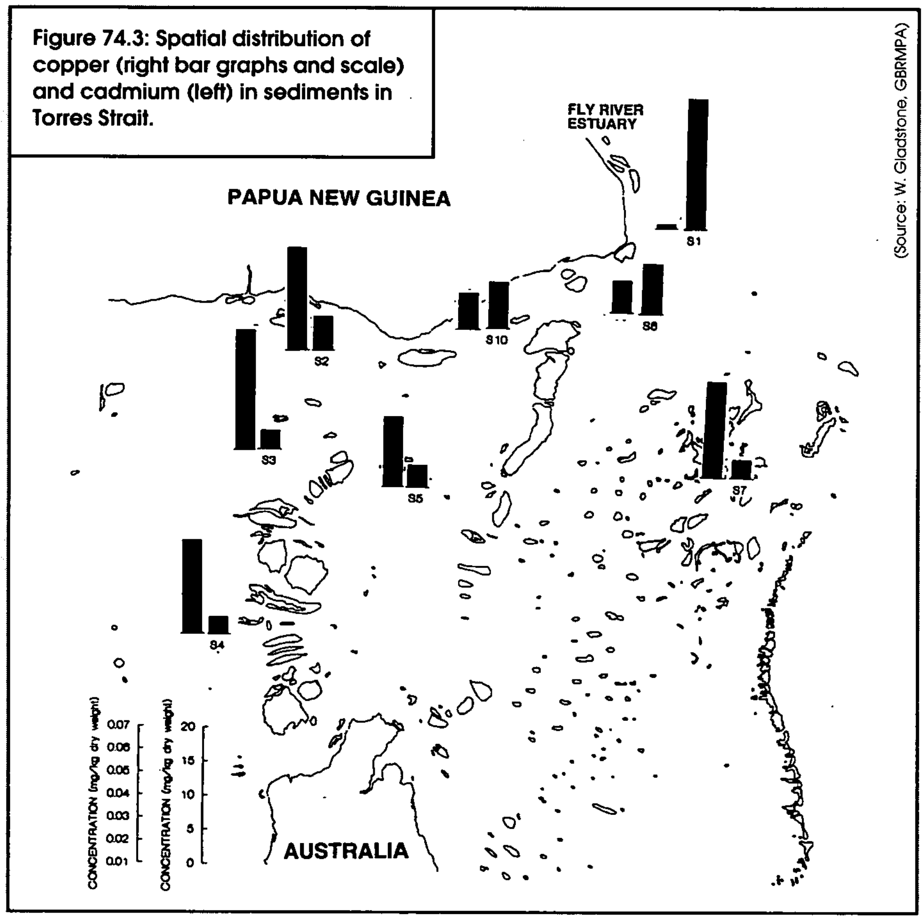
A major study, coordinated by the Great Barrier Reef Marine Park Authority, has been undertaken to establish trace metal levels in the sediments, water and selected marine animal and plant species, and investigate important transport, geo-chemical and trophic pathways of trace metals in the marine environment of Torres Strait.

The 1993 pilot survey results found that the Fly River was a major source of fine-grained sediments containing a number of major and trace metals (i.e. aluminium, chromium, copper, iron, manganese, nickel, lead, silica and zinc) to the northern Strait. Arsenic, cadmium, magnesium, mercury and solenium were not primarily associated with terrigenous sediments and are unlikely to be significantly influenced by the Fly River discharge.

Concentrations of cadmium in various mollusc tissues (e.g. clams, cockles, pearl oysters, strombs) are higher than on the Great Barrier Reef but those of copper, mercury, nickel, lead and zinc are similar. However, the concentrations of arsenic, cadmium and solenium in the edible portions of food consumed by Islanders (e.g. Murray Island sardines (*Harengula ovalis*), green turtle (*Chelonia mydas*), and dugong (*Dugong dugon*)) were close to or above the National Health and Medical Research Council's Maximum Permitted Concentrations for seafood. (Levels in turtle livers were many times the maximum for cadmium). Further studies on Island diet were suggested.

The pilot study also identified appropriate indicators for trace metals (the burrowing clam *(Tridacna crocea)* and mangrove cockle *(Polymesoda erosa)*) and refined the sampling program for the major study, which is now approaching completion. The pilot study demonstrated the very high costs of marine surveys in such isolated areas, and the very high analytical costs for trace metals.

Figure 74.3: Spatial distribution of copper (right bar graphs and scale) and cadmium (left) in sediments in Torres Strait.



Endangered species

Dugong is a valued subsistence and ceremonial food in both the Torres Strait and coastal Papua. Despite legal regulations, dugong is sold from the Daru market. Turtles are taken in large numbers in the region. Until accurate catch numbers are collected from both sides of the border, dugong and turtles should be regarded as potentially threatened species.

Management

The Torres Strait Protected Zone

The Torres Strait Treaty was negotiated with Papua New Guinea in 1978 to clearly establish the border of sovereignty and jurisdiction following PNG's independence in 1975. The Treaty established the Maritime Boundaries, the Sea Bed Jurisdiction and the Fisheries Jurisdiction, and aims to protect the traditional way of life of both the Torres Strait Islanders and the Papuan coastal people. It serves to protect the marine environment, provides freedom of access for vessels, and determines the catch-sharing arrangements for fisheries resources and certain mineral resources.

A Marine Strategy for Torres Strait

Concerns by the Torres Strait Islanders on the future of their marine environment led to a statement 'Principles and Objectives for the Future of Torres Strait' by the Torres Strait Island Coordinating Council in 1991. The advocated a comprehensive conservation and sustainable development strategy, of which the Marine Strategy for Torres Strait (MaSTS) would be a major part.

MaSTS, funded under the Ocean Rescue 2000 program, aims to establish a comprehensive management framework which will permit optimum exploitation of the region's resource base, consistent with the needs of indigenous Torres Strait Islanders, sustainable development and minimal environmental disturbance.

Principles of MaSTS

- a need to protect the marine environment and its resources today and for future generations;
- a leading role by communities in management;
- Torres Strait Islanders to remain the principal users of the marine environment;
- an economy based on marine resources;
- coordination of marine policies;
- greater education for Torres Strait Islanders on marine management; and
- preferential employment of Torres Strait Islanders in training, management.

Monitoring and marine environmental reporting

Torres Strait has been relatively well studied. Monitoring programs include the Torres Strait Baseline Study for heavy metals (Great Barrier Reef Marine Park Authority); dugong populations (Great Barrier Reef Marine Park Authority); and commercial and subsistence fisheries landings (CSIRO; Bureau of Resource Sciences). Despite the relatively large number of individual studies undertaken in the region, these have not been synthesised.

Summary and conclusions

1. Torres Strait has a highly productive and diverse marine environment. It is inhabited by the Torres Strait Islanders, an indigenous maritime people of Melanesian origin.

2. Torres Strait contains very large areas of seagrass and coral reefs and important populations of dugongs, turtles and seabirds.

3. Major environmental issues include the possibility of heavy metals contamination from Papua New Guinea mines, threats of oil spills from shipping and offshore wells, effects of prawn trawling, and resource sharing with Papua New Guinea.

4. A marine strategy MaSTS is being prepared under the Ocean Rescue 2000 program.

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The technical paper by Drs Lawrence and Gladstone was reviewed by Getano Lui (Jr), Chairman, Island Co-ordinating Council, Torres Strait; and Dr R.E. Johannes, CSIRO Marine Laboratories, Hobart, Tasmania.

Chapter 75: Australia's Antarctic Territory[1]

Antarctica is the world's last great wilderness and abounds with wildlife. Whales, seals, penguins and other organisms gorge on the vast seasonal swarms of crustaceans, Antarctic krill. Australia's Antarctic Territory is very large (around 6 million square kilometres, or three quarters of the size of the Australian mainland) and Australia has a major international role in its management.

Despite its remoteness, some serious environmental issues face Antarctica in the 21st century: stocks of the great whales have been greatly reduced and food chains have been altered; fishing for krill may increase; global warming may have a major effect on the dynamics of the sea ice and the world's deep-ocean water masses; and depleted ozone over the continent may increase ultraviolet radiation levels and could lead to decreased phytoplankton populations.

Description: geography, oceanography and ecology

Geologically, Antarctica was once connected to Australia and India in the supercontinent of Gondwana. The sea floor between Australia and Antarctica, created by the spreading of the Indian-Australian and Antarctic tectonic plates over the past 54 million years, is around 4-4.5 kilometres deep.

Oceanography

The Southern Ocean plays a major role in the global ocean circulation and climate systems. The major current, the Antarctic Circumpolar Current, connects the world's ocean basins. The major oceanographic features include the Antarctic Convergence (around 58°S) which forms the northern boundary of the Antarctic environment, and the Antarctic Divergence which brings upwellings of nutrient-rich deep water around the continent.

The freezing of the sea surface in winter to form sea ice results in a doubling of the Southern Hemisphere's ice covered area (to 34 million square kilometres) and has a major effect on the world's oceans and climate. The freshwater sea ice insulates the warmer sea (-1.8°C) from the cold air (-20 to -30°C). The cold, residual salty water sinks to become the major source of the world's current masses. An understanding of these processes is considered essential in predicting potential world climate change.

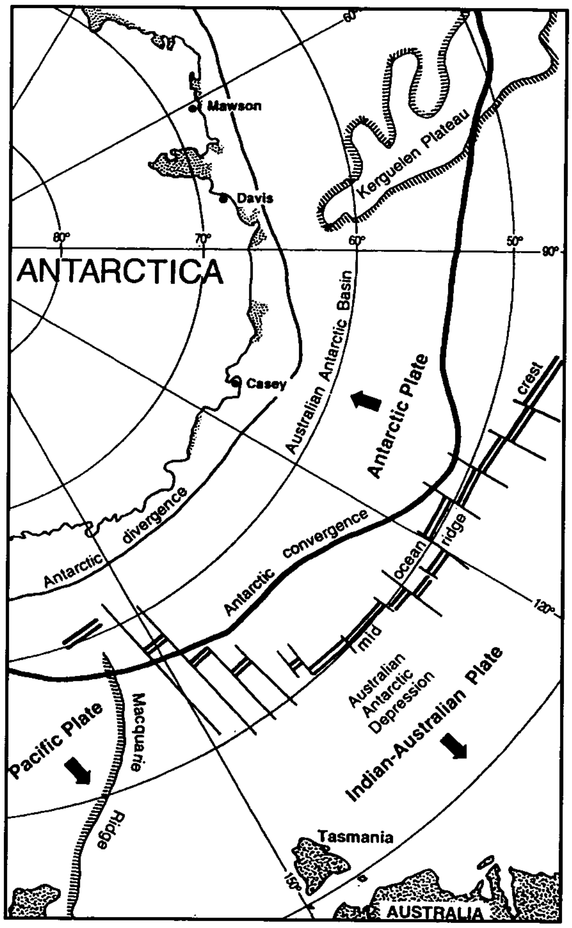

Figure 75.1: Australia's Antarctic Territory: geological and oceanographic features.

Ecology

The 'Antarctic ecosystem', generally defined as that area south of the Antarctic Convergence, moves seasonally with the advance and retreat of the pack-ice. It includes oceanic, neritic (and intermediate regimes), and pack-ice and marginal ice edge communities.

[1]Based on a paper by Dr P.G. Quilty, Assistant Director, Science, Australian Antarctic Division, Hobart, Tasmania and other sources.

Life in the permanent pack-ice is characterised by a short period of intense primary productivity, providing energy for specialised planktonic suspension feeders and detrital feeders on the sea floor. A rich and complex food web exists within brine channels and other habitats in the sea ice.

While seals and birds spend a considerable time onshore, the source of their food is entirely the marine realm. Here the food chain, while more complex than thought a few years ago, is basically simple, from phytoplankton, through zooplankton and krill to the consumers.

Plankton, krill

Pelagic, unicellular algae dominate Antarctic seas. Around 100 species of diatoms and 60 species of dinoflagellates have been identified. The pelagic community is characterised by vast swarms of swimming crustaceans, the krill. *Euphausia crystallarophias* dominates the coastal community and is important in the diet of many fish and some land-based vertebrates. The larger *E. superba* which dominates offshore waters is consumed by fish, seals, seabirds and the great whales, and is also the target of the region's major commercial fishery. Standing stocks are estimated to be in the order of 500 million tonnes.

Birds

The Antarctic bird fauna consists of some 40 species, of which penguins are the most important, and best known. Penguins comprise 90% of the avian biomass, and consume an estimated 130 million tonnes of krill each year. Petrels and albatrosses make up most of the remainder. Issues include possible changes in population dynamics induced by the greater availability of krill caused by whaling, and the significant mortality of albatrosses which take baits from fishing longlines north of the convergence.

Seals

Fur seals and elephant seals breed on the subantarctic islands. Populations were greatly reduced by a fur and blubber industry but populations of fur seals are now rapidly expanding. Elephant seals are declining in the Indian and Pacific sectors, but not in the Atlantic. The causes are not understood as their biologies, like those of other seals, are poorly known for they spend most of their time at sea.

Crabeater and leopard seals inhabit the ice edge area. Populations of the crabeater, believed to be a major consumer of krill, are the most abundant seal species on earth. Ross and Weddell seals inhabit the more permanent pack-ice; Weddell seals consume fish, squid and benthos, and Ross seals consume squid.

(Source: CSIRO Oceanography)

a

(Source: P. Quilty)

b

Figure 75.2: (a) Remote sensed image showing formation of pack-ice. (b) Helicopter over pack-ice.

Whales

Baleen and toothed whales are found in Antarctic waters. Baleen whales migrate into Antarctica to feed, building up blubber to last their tropical breeding cycle. Populations of the larger whales were greatly reduced by hunting, with progressively smaller species targeted as stocks declined. The international moratorium on whaling agreed in 1982, come into effect in Antarctica in the 1987-88 season.

It is estimated that the baleen whales now consume around 43 million tonnes of krill per year, a decline from around 190 million tonnes of pre-hunting times. The population of the minke whales is large, around 760,000.

Other organisms

The biota of Antarctica is not well known. The fish (around 100 species, mainly of Nototheniiformes) are slow moving, slow growing, have a low fecundity, and are consequently prone to overfishing. Stocks of species of commercial importance have been seriously overfished, particularly in the South Atlantic.

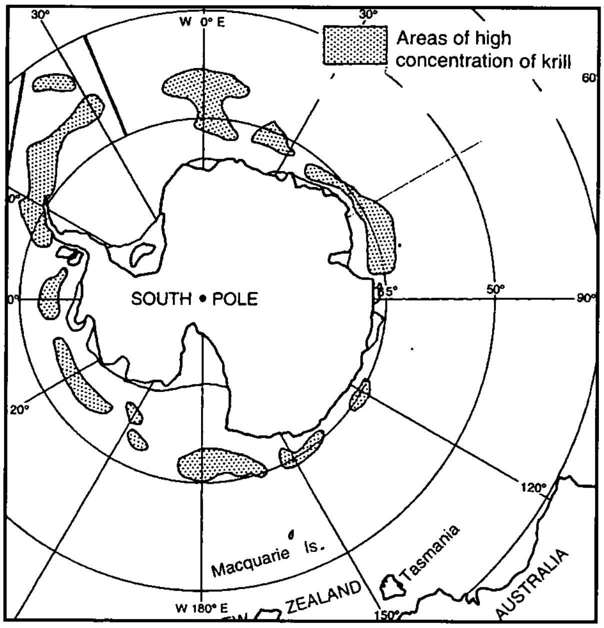

Figure 75.3: Antarctica and the Southern Ocean, including krill concentrations and areas of heavy fishing.

Use of marine resources, and issues

The resources of the Southern Ocean have been exploited for almost 200 years, with dramatic reductions to populations of the great whales and seals, and persisting effects on the krill centred food chain. These are now controlled by three international conventions (see management, below). At present the only significant fisheries are based on krill, finfish and to a lesser extent, crabs.

Fisheries

The Antarctic krill fishery is the largest crustacean fishery in the world. It reached a peak of 530,000 tonnes in 1981-82, but declined to 88,000 tonnes in 1992-93. Japan is currently the dominant fishing nation but most of the catch in the 1970s and 1980s was by the then USSR.

Under the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), the Southern Ocean krill fishery is to be managed at an 'ecosystem level' rather than at a traditional single stock level. A precautionary catch limit of 1.5 million tonnes was set in 1991 in one fishing area, the South Atlantic, allowing scope for the development of integrated management plans in advance of fisheries development. A further precautionary limit of 390,000 tonnes was set in 1992 for the area of the South Indian Ocean to the west of Prydz Bay.

A range of fish, under the generic name of 'Antarctic cod' and 'icefish' are taken. The finfish fisheries began before any international governing mechanisms came into being. CCAMLR has formulated total allowable catches and nominated closed areas for certain species but many species have been overfished. Management is still undertaken using single stock models and much information will be required before the ecosystem approach is realised in fisheries.

Scientific research

Scientific research on climate and wildlife is the primary function of the shore stations. The population of the continent is 4,000 in summer and around 1,500 over winter. As a result, the direct impacts of humans on Antarctica are small and localised, and it is an ideal place to monitor global pollution.

Tourism

Tourism is a developing Antarctic industry, with around 6,000 visitors per year, mostly departing by ship from Chile or Argentina. In some years two voyages, each with up to 160 passengers, have departed from Hobart for the Ross Sea region, including a brief stopover at Macquarie Island. Planned destinations have included the Australian continental stations.

Icebergs as future water sources?

There has long been speculation on the potential of icebergs as freshwater sources for dry urban areas such as Perth and Adelaide. As towing of small icebergs is technically feasible but would result in a high loss by melting, transport of 'quarried' ice or insulation of icebergs in plastics has been suggested.

Pollution in the Antarctic

A study by the United Nations Environmental Program (Stromberg et al. 1990) concluded that

Antarctica is the least contaminated area of the world. Concentrations of pesticides and other chlorinated compounds are several orders of magnitude lower than in the Northern Hemisphere. Low levels of contamination were found in hydrocarbons, probably mainly from natural sources, but with some local contamination from research stations and supply vessels. Penguins were found to be very vulnerable to oiling, and in toxicological experiments, krill proved to be especially sensitive to oil pollution.

The organochlorine insecticide DDT was first found in Antarctic biota in the 1960s, and together with other chlorinated compounds was detected in sea water and the atmosphere in the 1980s. DDT has been detected in fish (around 3 ppb), krill (4-65 ng/g), penguins (to 0.4 µg/g), and seals (to 170 ng/g). DDT, chlordane, dieldrin and other manufactured chlorinated compounds are concentrated in the blubber of seals and fat storage of birds, although levels are generally two to three orders of magnitude lower than in mammals elsewhere in the world.

Data on heavy metals are scarce and in some instances may reflect uptake outside the Antarctic. Relatively high levels of copper and cadmium have been detected in all the Antarctic seals but the significance of this is unknown. Radioactive polonium and lead have been detected in phytoplankton at similar levels to other localities.

Debris from human activity is largely associated with research stations and shipping. Plastic and other floating litter have been detected in the Ross Sea and an increase in fishing litter is expected with large scale fisheries.

Management

Jurisdiction

An Imperial Order in Council in 1933 placed under Australian authority lands and islets south of 60°S latitude, and between 45° and 160°E longitude, excluding the French Terre Adelie (subsequently defined by France in 1938 as south of 60°S and between 136°E and 142°E longitudes). The Order was proclaimed by the Governor-General in 1936. The Antarctic Territory Acceptance Act of 1954 declared all laws of the Australian Capital Territory and Commonwealth to apply to the Antarctic Territory. Australia currently maintains three permanent stations on the continent (Mawson, Davis and Casey), and a fourth on subantarctic Macquarie Island.

International treaties

Antarctica is unique politically, for despite territorial claims by a number of countries, it is largely governed by international treaties. The Antarctic Treaty came into effect in 1961 following the success of the International Geophysical Year of 1957-58. It covers the important role of scientific research, the free exchange of information, declaration of the continent as a zone of peace (with bans on military activity and nuclear testing and dumping of waste material), a consensus decision-making process, and, as the treaty has evolved, the care of the environment. At present there are 40 acceding nations, and 26 consultative parties to the treaty.

Important subsequent agreements include the Convention for the Conservation of the Antarctic Marine Living Resources (CCAMLR), the Convention on the Conservation of Antarctic Seals and the Protocol to the Antarctic Treaty on Environmental Protection. The Agreed Measures for the Conservation of Antarctic Fauna and Flora which came into effect in 1964 prohibits the killing or wounding or capturing of native mammals and birds without a permit; designated 'Specially Protected Areas'; regulates the import of non-indigenous species; and established an exchange of information process. There are currently 25 Specially Protected Areas and 35 Sites of Special Scientific Interest around Antarctica.

The Convention on the Conservation of Antarctic Seals specifically prohibits the taking of elephant and Ross seals, and fixes conservative limits on the taking of crabeater, leopard and Weddell seals. No seal industry on these has yet emerged. Whales are specifically managed by the International Whaling Commission.

CCAMLR has as its centrepiece the 'ecosystem approach' to management. Management of krill stocks is a major objective because of their importance to baleen whales, penguins, and some seals. CCAMLR has its headquarters in Hobart, and is the only such international body to have its head office in Australia.

The Protocol on Environmental Protection to the Antarctic Treaty specifically prohibits mining, established a Committee for Environmental Protection, and covers waste management and fuel conservation on shore stations. A key recommendation is a new nomenclature for protected areas: Antarctic Specially Protected Areas for wildlife, and Antarctic Specially Managed Areas for areas of human activity.

Management of Australia's subantarctic islands

Fisheries in Australia's subantarctic territories are administered by the Commonwealth of Australia under the Fisheries Management Act 1991. Macquarie Island is part of the Shire of Esperance in Tasmania and is a State Nature Reserve under the Tasmanian *National Parks and Wildlife Act* 1970. Both Heard and Macquarie Islands have been nominated by Australia for World Heritage Listing. A marine reserve has been proposed for Macquarie Island as part of the Ocean Rescue 2000 Program.

Major environmental issues

In addition to the conservation of whales, seals and bird life, and fisheries management (discussed above), many issues face the Antarctic marine environment.

Global issues

The impact of global climate change is a major issue and an important area of research. Of particular importance is the importance of sea ice in the equation of global sea level rise, and in turn, the effects of a reduction in sea ice on the ecology of the Southern Sea, on global albedo (reflectivity of light and heat into space), and reduction of Antarctic Bottom Water entering the world ocean.

The Antarctic is especially vulnerable to increased ultraviolet B radiation resulting from stratospheric ozone depletion. Increased UV-B may have fundamental effects on the composition and biomass of phytoplankton. It is feared that a reduction of phytoplankton biomass would not only affect food chains but may also have some effect on the production of the atmospheric sulphate aerosols which may be the major source of cloud condensation nuclei over the oceans.

Local environmental effects

Localised impacts on wildlife from the Antarctic stations' buildings and airstrips, rubbish disposal, fuel oil spills and tourism are a growing concern. These will be subject to Environmental Impact Assessment under the Protocol on Environmental Protection.

Monitoring and marine environmental reporting

A fundamental problem is the lack of knowledge of the Antarctic. It is a vast, inhospitable place where observations are possible for a few months of the year, with limited shipping and transport. Remote sensing is proving important for gathering surface data and new ships are being designed for the Antarctic environment (e.g. Australia's RSV *Aurora Australis*). Major advances are being made in oceanographic research through the recent international World Ocean Circulation Experiment, and the Joint Global Ocean Flux Studies.

The gathering of scientific information and its free exchange are major aspects of the Antarctic Treaty. The CCAMLR Ecosystem Monitoring Program is currently evolving and should generate a major database to monitor the 'health' of the Antarctic ecosystem.

Summary and conclusions

1. Antarctica has the least polluted environment of any place on earth.

2. The major environmental impact has been overhunting of the great whales. This has increased the available krill biomass, which may have allowed populations of other species to expand.

3. Threats include overfishing of krill and midwater fish, tourism and localised pollution from research stations.

4. Global warming and ozone depletion could have disastrous consequences as the Antarctic plays a major role in the dynamics of the world atmosphere and oceans.

5. The Antarctic environment is uniquely managed by international treaties and conventions.

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Acknowledgments:
The technical paper by Dr Quilty was internally reviewed by Drs S. Nicol, I.Church and others, and externally by Dr G. Ross, Australian Biological Resources Study, Canberra, Australian Capital Territory.

Chapter 76: Marine conservation and marine protected areas in Queensland[1]

Queensland has a very long coastline (around 6,000 kilometres of mainland coastline and 7,400 kilometres including that of its major islands), a wide continental shelf, and well over 1,000 continental, coral and barrier sand islands. It has very rich and diverse marine ecosystems: coral reefs (including the Great Barrier Reef, the world's largest reef complex), soft and hard shores, extensive mangrove wetlands and tropical and subtropical seagrass beds. Major marine bioregions include the Gulf of Carpentaria, Torres Strait, the Great Barrier Reef, the protected tropical mainland coastline, subtropical bays and barrier islands, and the open coastline in the south-east. Reflecting this great diversity of marine habitats and ecosystems, and an active marine conservation program, Queensland has by far the largest number and area of marine protected areas in Australia.

As in most Australian States, Queensland's major cities and towns are situated on the coast. More than 70% of Queenslanders live within 40 kilometres of the coast. The largest population centre of around 1.8 million is in south Queensland where the capital Brisbane on Moreton Bay almost merges with the second largest urban centre, the Gold Coast, to the south and with the Sunshine Coast to the north. Major provincial centres on the north Queensland coast are Townsville-Thuringowa (116,000) and Cairns (98,000) and on the central coast Mackay, Rockhampton and Gladstone (53,000, 63,000 and 32,000 respectively). The beaches, bays, islands and estuaries in the south are subject to heavy use, as are inshore areas of the Great Barrier Reef adjacent to population centres, necessitating marine environmental conservation.

Legislation and responsibilities in the marine environment

In Queensland the statutory powers to manage the marine environment are spread over a number of agencies. No single agency has a mandate for managing the resources as a whole and each is generally responsible for achieving a single objective, such as port development or fisheries protection. Because most statutory powers apply above or below high-water mark, management across this boundary is extremely difficult. Recent initiatives have addressed the need for integrated management of complex issues, including preparation of the Coastal Protection Strategy and subsequent development of the Coastal Protection Bill.

To date, conservation of the marine environment has been achieved primarily through the marine parks, national parks and fisheries legislation. Many other pieces of legislation may also affect coastal management in Queensland; some 50 pieces of legislation relating to coastal management are listed in the Coastal Protection Strategy.

Queensland's *Nature Conservation Act* 1992 and the Environmental Protection Bill and the Coastal Protection Bill have been developed to end the fragmented approach to managing environmental issues. The Environmental Protection Bill will replace the current *Clean Air, Clean Waters and Noise Abatement Acts* and will provide Government departments with a mechanism to incorporate environmental factors into their decision-making. The legislation will enable the proclamation of subordinate legislation in the form of legally-binding Environmental Protection Policies (EPPs). These will provide the specific standards and criteria for particular environmental problems. Policies can cover the State or an area such as a catchment. The first EPPs will address management of air, water, noise and waste. Each EPP must go through two rounds of public consultation to ensure the strategies are practical, environmentally effective and economically efficient.

Major pieces of legislation which currently provide for marine protected areas in Queensland include: *Marine Parks Act* 1982-88 (for conservation of marine areas and declaration of zoned marine parks for their sustained use and protection); *National Parks and Wildlife Act* 1975 (for management of national parks, including some coastal areas and islands); *Fauna Conservation Act* 1992 (for conservation of fauna in its habitats and declaration of fauna sanctuaries, refuges and reserves); and the *Fisheries Act* 1994 and *Fishing Industry Organisation and Marketing Act* (for management of and research into the commercial,

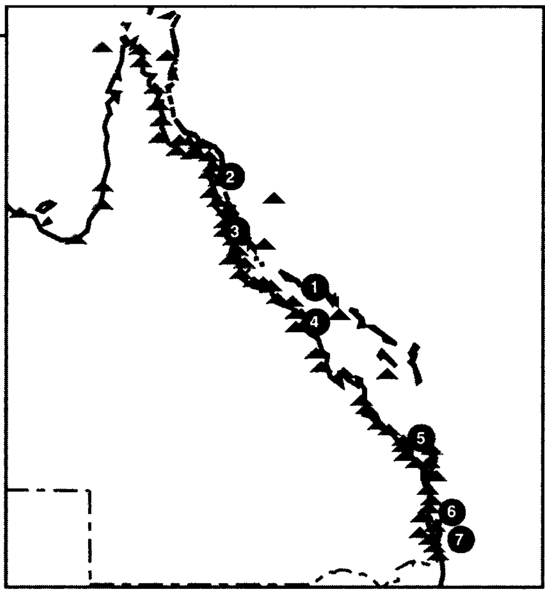
[1]Based on a paper by E. Eager, Queensland Department of the Environment and Heritage, Brisbane, Queensland and J. Campbell, Great Barrier Reef Marine Park Authority, Townsville, Queensland.

industrial and conservation aspects of the fishing industry, fisheries resources and habitats).

Relevant Commonwealth Acts include: the *Great Barrier Reef Marine Park Act* 1975 (for zoned marine park planning and management); and the *Historic Shipwrecks Act* 1994 (for protection of historic shipwrecks and relics in Commonwealth waters).

A plethora of other legislation affects the marine environment to some degree. These include: *Harbours Act 1995* (for protection of foreshores; construction of works below high-water mark; reclamation; management of land below high-water mark); *Queensland Marine (Sea Dumping) Act* 1985 (to regulate the dumping into the sea of wastes and other matter); and *Beach Protection Act* 1968 (to control coastal land use and development).

(Source: QDEH)



Queensland has a well developed system of State MPAs as well as the Commonwealth's Great Barrier Reef Marine Park (1). Seven MPAs have been declared under the Marine Parks Act 1982, with a total of 39,024 sq km: Cairns (2), Townsville/Whitsunday (3), Mackay/Capricorn (4), Hervey Bay (5), Woongarra, Pumicestone Passage (6) and Moreton Bay (7) Marine Parks. Some 83 MPAs with a total area of 6,028 sq km have been declared under the Fisheries Act 1976; these comprise 48 Fish Habitat Reserves, 29 Wetland Reserves and six Fish Sanctuaries. There are also 30 national parks and six environmental parks along the coast with a total intertidal area of 820 sq km. Five protected zones have been declared for shipwrecks.

Figure 76.1: Queensland has a long coastline and very diverse tropical and subtropical marine ecosystems. The major marine bioregions are the Gulf of Carpentaria, Torres Strait, Great Barrier Reef, tropical mainland coastal waters, and the south-east bays and exposed coastlines.

Overview of marine protected areas

Over a period of many years Queensland has established and managed a large number of 'marine protected areas' (Table 76.1). This record has been enhanced in more recent times, for example, by the complementary approach with the Commonwealth in the area of the development of marine parks.

Areas of MPAs

Queensland has seven MPAs declared under the Marine Parks Act with a total area of 39,024 square kilometres: Cairns, Townsville/Whitsunday, Mackay/Capricorn, Hervey Bay, Woongarra, Pumicestone Passage and Moreton Bay Marine Parks. Under the Fisheries Act, there are 83 MPAs with a total area of 1931 square kilometres comprising 48 Fish Habitat Reserves, 29 Wetland Reserves and six Fish Sanctuaries. There are also 30 national parks and six environmental parks along the coast with a total area of 823 square kilometres. Seven protected zones of two square kilometres or less have been declared for shipwrecks in waters off Queensland.

The Great Barrier Reef Marine Park declared under Commonwealth legislation covers 345,000 square kilometres and extends along about 2,000 kilometres of the Queensland coast. There are two other Commonwealth MPAs in the Coral Sea off Queensland: the Coringa-Herald and Lihou Reef National Nature Reserves (17,292 square kilometres).

MPAs established under the Marine Parks Act

Queensland's Marine Parks are mainly multiple-use areas encompassing some areas of total protection. Marine Parks are declared for the protection of marine resources and allow for the management of use of those resources. Owing to their multiple-use nature, Marine Parks are generally very large in size. At June 1994, seven marine parks had been declared with a total area of 39,024 square kilometres: Cairns, Townsville/Whitsunday, Mackay/Capricorn, Hervey Bay, Woongarra, Pumicestone Passage and Moreton Bay Marine Parks. The Commonwealth Great Barrier Reef Marine Park is discussed in Chapter 69.

Ecologically sustainable, multiple-use management is achieved through zoning which allows for differing uses of defined locations. The different zones may thus be considered as equivalent to designation of reserve type under other legislation. Zoning provides for spatial separation of conflicting uses and results in a balanced approach to resource use and protection. For example, in a National Park Zone, no extractive use of natural resources is permitted, whereas in a General Use Zone, most uses are allowable. Those uses which may cause a negative impact are controlled through regulations or specific environmental assessment and approval processes. The type pf protection of an area is generally indicated in the name of the zone (e.g. Conservation Park Zone, Estuarine Protection Zone, Buffer Zone).

A zoning plan which defines the various zones and their uses is developed in conjunction with extensive public consultation. The zoning plan is then released as sub-ordinate legislation of the Queensland Government. The objectives for each zone within a marine park and the activities which are allowed within the zone or require a permit, are identified in the zoning plan for the park.

Legislation

The Marine Parks Act provides for the setting apart of tidal lands and tidal waters as marine parks. A marine park includes the airspace above, the subsoil below and all marine products within a specified boundary. The Act requires the Government to consider public submissions in relation to the area of interest for a marine park and also provides for the preparation of a zoning plan for each marine park. Revocation of all or part of a Marine Park may occur only through an Order in Council subsequent to Parliamentary approval.

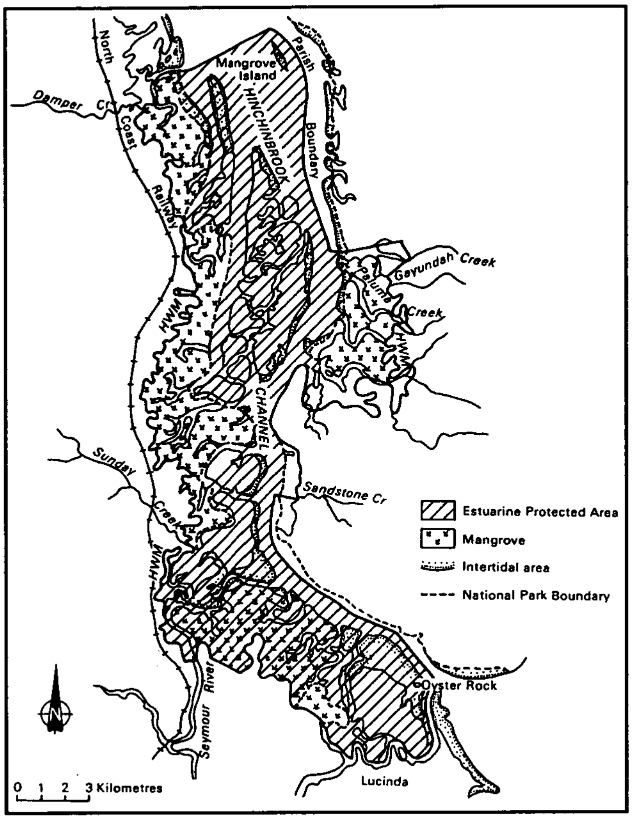
In relation to the Great Barrier Reef Region, complementary Queensland Marine Parks are established to ensure adequate protection of the intertidal areas adjacent to and Queensland waters which overlap with the Great Barrier Reef Marine Park (GBRMP) established under Commonwealth legislation. Day-to-day management of the GBRMP is primarily the responsibility of the Department of Environment and Heritage under formal intergovernmental agreements (Chapter 69).

Managing authority

The Department of Environment and Heritage is responsible for environmental management and conservation of Queensland's natural and cultural resources. The Marine Parks section of the Department lies within the Division of Conservation. The Director of National Parks and Wildlife as appointed under the National Parks and Wildlife Act, is responsible for the administration of the Marine Parks Act subject to the Minister for Environment and Heritage. Under the Nature Conservation Act, the Director-General of the Department of Environment and Heritage is responsible for administration of the Marine Parks Act.

Enforcement agency

Enforcement of the Marine Parks Act and Regulations is undertaken by Inspectors appointed under the Marine Parks Regulations 1990. Nominated Marine Parks officers of the Department of Environment and Heritage and the Boating and Fisheries Patrol within the Department of Primary Industries are currently appointed as Inspectors.



(Source: I. Ivanovici 1984)

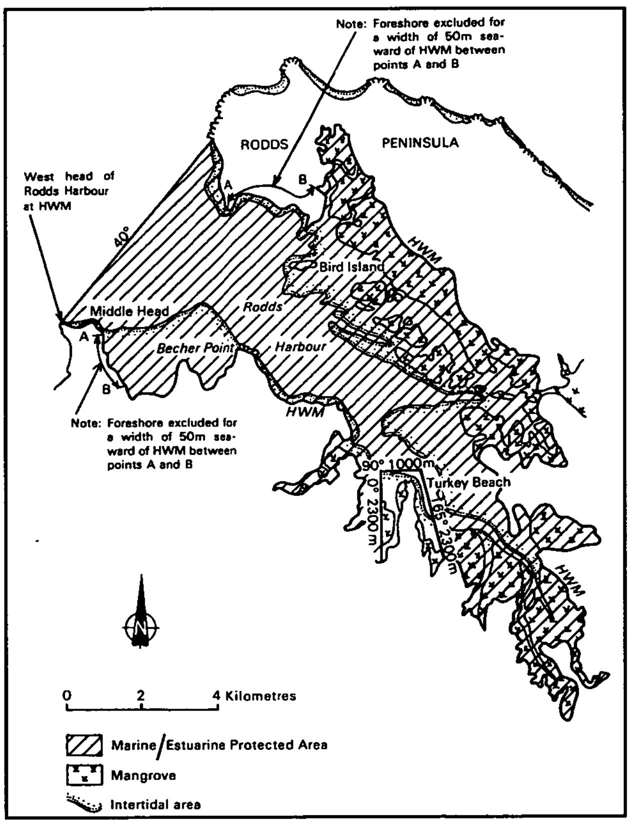


Figure 76.2: Queensland has a very large number of MPAs. Space prevents illustration of all but a sample. Above: Hinchinbrook estuarine protected area, north of Ingham, North Queensland. Below: Rodds Harbour marine protected area, south of Gladstone, Central Queensland.

Case study:

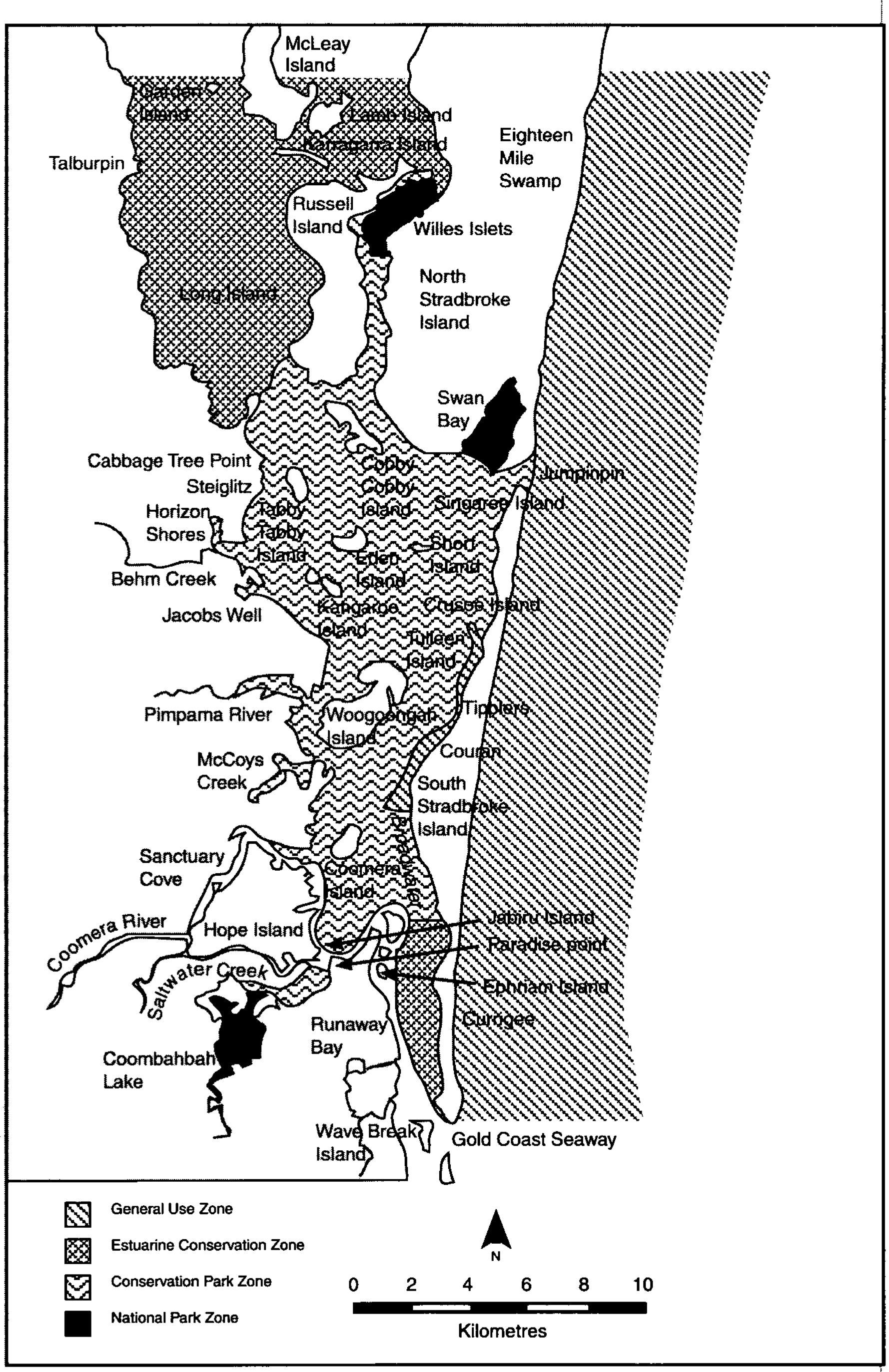
Moreton Bay Marine Park

Moreton Bay Marine Park represents the first effort in Australia to establish a major marine protected area adjacent to a large metropolis.

Moreton Bay Marine Park covers all tidal lands and tidal waters of Moreton Bay from the Caloundra Bar to just north of the Gold Coast Seaway, and seawards to the limit of Queensland waters, generally three nautical miles off the coastline. The areas included are those with environmental value or where management of an area is essential to control impacts on an adjacent area of environmental value. It has a total area of 336,609 hectares.

Purposes
Moreton Bay Marine Park was declared in February 1993 in response to general community support for a park expressed during preparation of the Moreton Bay Strategic Plan. The Strategic Plan is part of the Queensland Government's pledge to protect the Queensland coast, specifically to provide for ecologically sustainable use of Moreton Bay and to protect its natural, recreational, cultural heritage and amenity values. This goal has been adopted as the 'intent' of the draft zoning plan for the Marine Park.

Features
Moreton Bay is a diverse and important conservation area, despite some degradation. Its proximity to the city of Brisbane ensures its high recreational and educational values. Moreton Bay is one of only two large estuarine bays in Australia enclosed by barrier islands of vegetated sand dunes. Mangrove communities, saltmarsh and saltpan areas, benthic communities, seagrass meadows, rocky shore environments and coral reef communities are represented. Flinders Reef, north of Moreton Island, has been proposed as marine park for more than 20 years. It is recognised as being of very high importance to marine conservation due to its unusual and diverse assemblage of tropical and subtropical marine life.



(Source: QDEH)

Figure 76.3: Draft zoning plan for southern part of Moreton Bay Marine Park shows around 20% of the park.

Humpback whales regularly pass the Bay on their migrations. Parts of the Bay represent an internationally significant habitat for dugong. Green and loggerhead turtles are abundant in Moreton Bay while hawksbills occur rarely. The region is one of only four recognised sites of significance to wintering migratory wading birds along the eastern Australian coast. Significant populations of Indo-Pacific and bottlenose dolphins are also found in the Bay as are a diversity of pelagic and estuarine fish species.

Significant cultural heritage sites occur throughout the Moreton Bay area. Aboriginal heritage sites include bora rings, middens, fish traps, artefact scatters, quarries and scarred trees.

Moreton Bay is also of considerable economic significance, both regionally and State-wide. Major activities are recreational fishing ($160m annually); port operations ($127m); commercial fishing ($61m); recreational boating ($25m); and extractive industries ($7m).

The resources of Moreton Bay are under increasing pressure from a rapidly growing population in its catchment. Currently more than 1.5 million people live in the vicinity of the Bay. Potential effects of this growing population include:

- land clearing for housing, roads and industry which result in loss of marine and freshwater wetlands;
- increased need for sewage disposal;
- increased demands for mineral extraction from the Bay (sand and coral);
- increasing port activities with potential loss of wetlands and threat of an oil spill; and
- increasing demands for recreational access to the Bay resulting in more boats on the Bay.

Status
The zoning plan for Moreton Bay Marine Park is being prepared taking into consideration public comment on a draft plan developed from the broader Strategic Plan. Approval of the zoning plan is expected in late 1994. When the final zoning plan is approved, Pumicestone Passage Marine Park will be amalgamated with Moreton Bay Marine Park.

The zoning process and issues for management
The Moreton Bay Strategic Plan guided development of a draft zoning plan for the Marine Park. This is the first time in Queensland a broader-scale plan has been available to assist the zoning process of a marine area. It has enabled effort to be concentrated on obtaining community input into the issues considered most complex in drafting the plan. Some 800 groups and key individuals were targeted resulting in about 210 submissions from a wide range of groups.

Although the response compares favourably with the 250 submissions received during preparation of the Strategic Plan, the Marine Park zoning plan covers issues at a level directly affecting thousands of recreational users of the area. Planners consider a better response could have been achieved if funding extended to television advertising to increase awareness of the Marine Park.

Issues raised frequently in community response to the plan related to the general problem of integrating the zoning plan with local government jurisdictions and town plans for foreshore control, for example, how mosquito and midge problems are to be managed and water quality issues. A cooperative approach is needed to resolve these issues and efforts are being put into plans for integrated development such as the South-eastern Queensland 2001 regional planning project which aims to develop a framework for growth management in south-east Queensland.

Other major issues developed around local hot spots such as Russell Island which has unsettled claims from purchasers of 'submerged' land during the 1970s, and Green Island where there is conflict between recreational fishing interests and future rights for limestone extraction. Further consultation is the preferred way to resolve these issues even though it will involve delays to the planning process.

With such a large number of users, there are major administrative aspects to consider in the development and implementation of a zoning plan. Budget constraints require realistic assessment of what should be managed and how. The approach is likely to be one of developing guidelines to allow responsibilities to be devolved to existing administrative systems rather than setting up a new regulatory system.

MPAs established under the *Fisheries Act*

Three categories of protected areas can be established under the Fisheries Act for managing fisheries resources: Fish Habitat Reserves, Wetland Reserves and Fish Sanctuaries. A complete listing of these is found in Table 76.1.

Fish Habitat Reserves are declared to help ensure that productive recreational and commercial fishing continue in Queensland. At June 1994, there were 48 Fish Habitat reserves. Wetland Reserves protect wetland habitat areas on which fish depend. A June 1994, there were 29 Wetland Reserves.

As well as helping ensure ecological sustainability of resources, Fish Sanctuaries may also be declared around special facilities such as underwater observatories. Two of the six sanctuaries declared to date are in this category and involve small areas of about five hectares. The total area included in sanctuaries is about 3,350 hectares.

MPAs established under the National Parks and Wildlife Act

There are 30 coastal national parks and six coastal environmental parks with a total area of 823 square kilometres (Table 76.1). Their primary purpose is nature conservation.

MPAs established under the Historic Shipwrecks Act

Historic Shipwreck Protected Zones are declared to protect Queensland's marine cultural heritage and usually involve small areas. Seven protected zones of two square kilometres or less have been declared for shipwrecks in waters off Queensland (Table 76.1).

Table 76.1: Marine Protected Areas in Queensland as at 30 June 1994

Name	Locality	Gazettal Date	Management Plan Approved
Marine Park			
Cairns	South of Jeannie River to Mission Beach/Dunk Island	18-02-89 Extended July 1992	February 1989 Revised July 1992
Townsville-Whitsunday	South of Mission Beach/ Dunk Island to Repulse Bay	03-10-87	October 1987
Mackay-Capricorn	South of Repulse Bay to Broadwater Creek	27-08-88	August 1988
Hervey Bay	West of Fraser Island	16-09-89	September 1989
Woongarra	Between Burnett R. and Elliot R.	14-12-91	14-12-91
Pumicestone Passage	Caloundra in north to southern end of Bribie Island	30-01-86	January 1986 Managed by QDPI
Moreton Bay	North of Bribie Island to south of South Stradbroke Island	February 1993	Draft zoning plan December 1993
Fish Habitat Reserve			
Eight Mile Creek	Gulf of Carpentaria	17-05-90	
Morning Inlet-Bynoe River	Gulf of Carpentaria	17-05-90	
Staaten-Gilbert	Gulf of Carpentaria	17-05-90	
Nassau River	Gulf of Carpentaria	17-05-90	
Escape River	Cape York	19-11-83	
Temple Bay	Temple Bay	19-11-83	
Silver Plains	Princess Charlotte Bay	19-11-83	
Princess Charlotte Bay	Princess Charlotte Bay	19-11-83	
Admiralty Island	Cairns	23-09-89	
Hull River	Rockingham Bay	19-11-83	
Murray River	Rockingham Bay	19-11-83	
Tully River	Rockingham Bay	19-11-83	
Dallachy Creek	Rockingham Bay	19-11-83	
Wreck Creek	Rockingham Bay	19-11-83	
Meunga Creek	Cardwell	19-11-83	
Hinchinbrook	Lucinda	19-11-83	
Bowling Green Bay	Ayr	25-11-89	
Repulse Bay	Proserpine	19-11-83	
Repulse	Mackay	10-05-86	
Sand Bay	Mackay	10-05-86	
Cape Palmerston	Mackay	22-11-86	
West Hill	Mackay	22-11-86	
Broad Sound	Mackay	22-11-86	
Corio Bay	Yeppoon	19-11-83	
Colosseum	Colosseum Inlet	19-11-83	
Innes	Seven Mile Creek	19-11-83	
Rodds Harbour	Rodds Harbour	19-11-83	
Bustard	Middle Island	19-11-83	
Eurimbula	Bustard Bay	19-11-83	
Round Hill	Bustard Bay	19-11-83	
Burrum-Isis	Burrum River	10-05-86	
Beelbi	Hervey Bay	10-05-86	
Susan River	Great Sandy Strait	10-05-91	
Maaroom	Great Sandy Strait	19-11-83	
Kauri Creek	Tin Can Inlet	19-11-83	
Tin Can Inlet	Tin Can Inlet	19-11-83	
Noosa River	Noosa River	19-11-83	
Weyba	Noosa River	19-11-83	
Maroochy	Maroochy River	19-11-83	
Pumicestone Passage	Bribie Island	19-11-83	
Deception Bay	Deception Bay	19-11-83	

Kippa Ring	Deception Bay	19-11-83
Hay's Inlet	Bramble Bay	19-11-83
Moreton Banks	Moreton Bay	19-11-83
Myora	Nth Stradbroke Island	19-11-83
Myora Extension	Nth Stradbroke Island	15-05-92
Peel Island	Moreton Bay	19-11-83
Jumpinpin-Broadwater	Moreton Bay	19-11-83
Wetland Reserves		
Half Moon Creek	Cairns	19-11-83
Yorkey's Creek	Cairns	19-11-83
Barr Creek	Cairns	19-11-83
Trinity Inlet	Cairns	23-09-89
Halifax	Halifax	19-11-83
Palm Creek	Halifax Bay	19-11-83
Cattle Creek	Halifax Bay	19-11-83
Bohle River	Townsville	19-11-83
Midge	Mackay	10-05-86
Rocky Dam	Mackay	22-11-86
Marion	Mackay	22-11-86
Carmila	Mackay	22-11-86
Wild Cattle	Tannum Sands	19-11-83
Boyne creek	Hummock Hill Island	19-11-83
Turkey	Turkey Beach	19-11-83
Seventeen Seventy	Town of Seventeen Seventy	19-11-83
Kolan River	Bundaberg	19-11-83
Gregory	Burrum River	10-05-86
Cherwell-Burrum	Burrum River	10-05-86
Burrum-Toogoom	Hervey Bay	10-05-86
Fraser Island	Fraser Island	19-11-83
Doonella Lake	Noosa	19-11-83
Maroochy	Maroochy River	19-11-83
Bribie Island	Bribie Island	19-11-83
Pimpana	Woogoompah I.	19-11-83
Coomera	Coomera Island	19-11-83
Coombabah	Coombabah	19-11-83
Tallebudgera Creek	Tallebudgera Creek	19-11-83
Currumbin Creek	Currumbin Creek	19-11-83
Fish sanctuaries		
German Bar	Princess Charlotte Bay	19-11-83
Centenary Lakes	Cairns	19-11-83
Hook Island	Hook Island	19-11-83
Middle Island	Middle Island	19-11-83
Swan Bay	Jumpinpin-Moreton Bay	19-11-83
Coombabah Lake	Coombabah	19-11-83

Notes:
All of Queensland's Marine Parks fall within IUCN's Category V - Protected land/seascapes.
1. The figures for 'area' provided for Queensland Marine Parks are approximate and include the area of islands within the boundaries, hence the figure should be used with caution and considered indicative of scale only. Note also that many parts of the Great Barrier Reef Marine Park and the complementary Queensland Marine Parks are overlapping.

Summary and conclusions

1. Queensland has a very long coastline, a wide continental shelf, and over 1,000 continental, coral and barrier sand islands. It has very rich and diverse marine ecosystems including coral reefs and extensive mangrove wetlands and tropical and subtropical seagrass beds.

2. Reflecting this great diversity of marine habitats and ecosystems, and an active marine conservation program, Queensland has by far the largest number and area of marine protected areas in Australia.

3. Major pieces of legislation which currently provide for marine protected areas include: *Marine Parks Act; National Parks and Wildlife Act* 1975; *Fauna Conservation Act* 1992; and the *Fisheries Act* and *Fishing Industry Organisation and Marketing Act*. Relevant Commonwealth Acts includes the *Great Barrier Reef Marine Park Act* 1975.

4. Queensland has seven MPAs declared under the *Marine Parks Act* 1982 with a total area of 39,024 square kilometres: Cairns, Townsville/ Whitsunday, Mackay/Capricorn, Hervey Bay, Woongarra, Pumicestone Passage and Moreton Bay Marine Parks. Under the *Fisheries Act* 1976-1989, there are 83 MPAs comprising 48 Fish Habitat Reserves, 29 Wetland Reserves and six Fish Sanctuaries. There are also 30 national parks and six environmental parks along the coast with a total area of 823 square kilometres. Seven protected zones of two square kilometres or less have been declared for shipwrecks in waters off Queensland. The Great Barrier Reef Marine Park declared under Commonwealth legislation covers 345,000 square kilometres and extends along about 2000 kilometres of the Queensland coast.

5. The Gulf of Carpentaria and Torres Strait are the only major bioregions not represented in Queensland's system of MPAs.

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Acknowledgments:
The paper by E. Eager and J. Campbell was internally reviewed within the Queensland Department of the Environment and Heritage, Brisbane, Queensland.

Chapter 77: Marine conservation and marine protected areas in New South Wales[1]

The New South Wales coastline, which stretches in a north-south direction for over 1,000 kilometres, is washed by subtropical, warm temperate and cool temperate waters. It has a relatively narrow continental shelf which extends only 20 nautical miles or so offshore. The cool temperate waters dominate only the far southern coast of the State, while the warm temperate waters extend northwards along most of the coastline as far as southern Queensland. The overlap of inshore warm temperate and offshore subtropical waters is produced by the East Australian Current and results in a biogeographical mixing zone off the coastline of northern New South Wales.

The New South Wales coastline is, by comparison with that of much of the rest of Australia, very highly developed, and thus has the potential for a wide variety of usage conflicts and pressures. Large parts of the coastline and most estuaries have suffered through indiscriminate or ill-planned development (Chapter 52).

There are currently 22 Marine and Estuarine Protected Areas (MPAs) in New South Wales waters, including seven Aquatic Reserves, one Marine Reserve, and 14 terrestrial National Parks and Nature Reserves with marine components. The single Marine Reserve, the Solitary Islands Marine Reserve, comprises 92% of the total area of MPAs in New South Wales waters.

Legislation and responsibilities in the marine environment

Various aspects of coastal management in New South Wales are the responsibility of a wide variety of different government authorities administering a number of different Acts (e.g. the *Environmental Planning and Assessment Act*, the *Environment Protection Act*, the *Catchment Management Act* and the *National Parks and Wildlife Act* 1974), amongst which the *Fisheries Management Act* 1994, administered by New South Wales Fisheries, has the prime responsibility for the conservation of most marine and estuarine fauna and flora.

'Fish': jurisdictional complications

'Fish', as defined in the *Fisheries and Oyster Farms Act* 1935, comprise *'all or any of the varieties of marine, estuarine or freshwater fishes, and, unless the contrary intention be expressly stated or the context otherwise requires, includes crustacea and oysters and all marine, estuarine and freshwater animal life, and any part of a fish as hereinbefore defined, but does not include any species of whales'*.

Under the *National Parks and Wildlife Act* 1974, however, 'animals' were defined as all animals other than 'fish' within the meaning of the *Fisheries and Oyster Farms Act*. 'Fauna' were more specifically defined as mammals, birds and reptiles. Within National Parks and Nature Reserves all animals are protected, as are flora. Consequently, marine and freshwater fishes and invertebrates are not protected in any area of the State under the National Parks and Wildlife Act. Outside National Parks and Nature Reserves, all fauna are protected unless otherwise specified, but not all animals. Within National Parks and Nature Reserves all plants, including marine flora, are protected. Also, where lands submerged by water are included in any National Parks and Wildlife Service management plan this plan must be referred to the Minister for Fisheries, and before such a plan of management can be adopted for any subtidal area, that Minister's concurrence is required.

Although there have since been slight changes to the wording of the definition of 'fish' in the new *Fisheries Management Act* 1994, the jurisdictional situation regarding aquatic biota still exists.

Historical background to MPAs

The first recorded proposal for a marine protected area in New South Wales waters, in 1969, was for a marine reserve encompassing parts of the Solitary Islands group, off Coffs Harbour on the State's north coast. Although the feasibility of this proposal was

[1] Based on a paper by J. Burchmore and D. Pollard, New South Wales Fisheries, Pyrmont, New South Wales.

considered by both New South Wales Fisheries and the New South Wales National Parks and Wildlife Service around that time, neither organisation then had the appropriate legislation to both declare such a marine conservation area and to manage its aquatic fauna and flora. In fact, it was over 20 years before a marine reserve was finally declared in this area (see below).

This question of departmental jurisdictions was brought to a head not long afterwards, when the then State Government decided to declare such a reservation over an area of inshore marine waters in order to strengthen its claim to the adjacent Territorial Sea (three nautical mile zone), which was then being disputed by the Federal Government. This resulted in the declaration in 1971 of a 'marine extension' to the then Bouddi State (now National) Park, around 40 kilometres north of Sydney.

While the submerged land comprising this marine extension was declared under the jurisdiction of the New South Wales National Parks and Wildlife Service (NPWS), the marine extension together with its biota is managed jointly with New South Wales Fisheries, the latter having responsibility for the management and protection of all 'fish' in this area.

Aquatic Reserves legislation

In May 1979, legislation was passed in the New South Wales Parliament, under amendments to the Fisheries and Oyster Farms Act, to provide for both the declaration of Aquatic Reserves over submerged Crown Lands and the promulgation of regulations governing the taking of fish from, and the management, protection and development of, such reserves. Although no such provision previously existed in the Fisheries and Oyster Farms Act, the latter had always been conservation-oriented in providing for the protection as well as the management of fish and fisheries in New South Wales waters. It also allowed for the protection of specific areas of habitat by means of fishing closures and other means.

Although rather concise, this legislation (Section 16A of the *Fisheries and Oyster Farms (Amendment) Act* 1979) was very flexible in its provisions for the management, protection and development of a system of reserves throughout the State's inshore marine and estuarine waters.

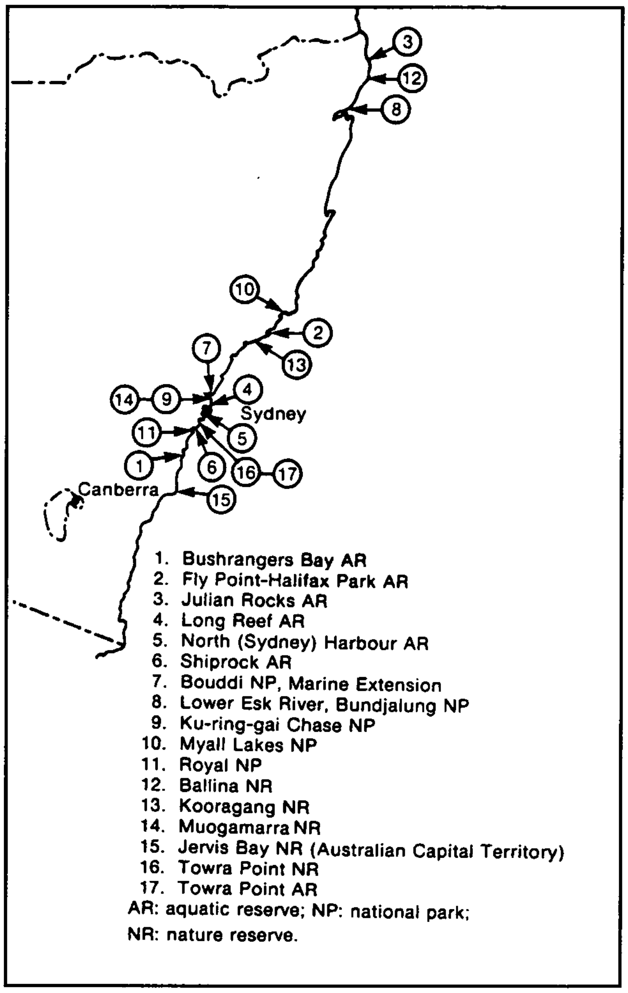
Fisheries Management Act 1994

Although the Fisheries and Oyster Farms (Amendment) Act of 1979 and its regulations included adequate and flexible legislation for the declaration, management, protection and development of Aquatic Reserves in New South Wales waters, this legislation has been considerably strengthened in the recently promulgated Fisheries Management Act of 1994. While the Aquatic Reserve regulations pertaining to this new Act have been rolled over in substantially their original form from the previous Act, the Aquatic Reserves provisions (Part 7, Division 2, Sections 194 to 197) in the body of the new Act now allow Aquatic Reserves to be declared over privately owned (in addition to Crown) submerged lands, with their owners' permission; and the revocation of any Aquatic Reserve must now be consented to by both Houses of Parliament (this was previously the prerogative of the Minister for Fisheries). In addition to 'fish', the taking of marine vegetation may now also be prohibited or regulated in Aquatic Reserves under this new Act, in which the definition of 'fish' (which still includes all aquatic invertebrates) remains substantially the same. (In addition to whales, all other aquatic mammals, birds, reptiles and amphibians are now also specifically excluded from the definition of 'fish' in the new Act).

Other provisions of the new Act may facilitate marine and estuarine conservation initiatives including provisions for the preparation and implementation of fish habitat protection plans, for the control of dredging and reclamation of fish habitats, for the protection of marine vegetation (including mangroves and seagrasses), for the protection of fish spawning habitats, for the control of noxious and introduced fish species, and for the provision of fish passage past barriers (all under Part 7). Under Part 2 of this Act there is also the provision for declaring certain fish species to be protected, as specified in the regulations (Anon. 1994). Marine or estuarine fish species currently included in these regulations are listed in Table 77.1. Amongst the protected fish species listed, the grey nurse shark and the black rock cod are listed by the Australian Society for Fish Biology as being vulnerable or potentially threatened in Australian waters.

Table 77.1: Protected marine and estuarine fish species

Common name	Scientific name
Ballina angelfish	*Chaetodontoplus ballinae*
Black rock cod (or saddle-tail rock cod)	*Epinephelus daemelii*
Eastern blue devilfish (or Bleekers devilfish)	*Paraplesiops bleekeri*
Elegant wrasse	*Anampses elegans*
Estuary rock cod	*Epinephelus coioides*
Giant Queensland groper	*Epinephelus lanceolatus*
Grey nurse shark	*Carcharias taurus*
Herbsts nurse shark	*Odontaspis ferox*
Weedy seadragon (or common seadragon)	*Phyllopteryx taeniolatus*



(Source: Ivanovici 1984)

Figure 77.1: Aquatic reserves in New South Wales.

Description of MPAs

Management objectives of MPAs

A paper on the concept of MPAs in New South Wales presented at the First International Conference on Marine Parks and Reserves defined an MPA as 'an area of marine or estuarine underwater terrain and the water above it, together with its associated fauna and flora, which has been set aside from commercial exploitation, and in which any other form of human interference is strictly controlled, for conservational, scientific, educational and/or recreational purposes' (Pollard 1977).

The conservational use of marine reserves signifies the preservation in them of representative aquatic ecosystems in their natural states, as both reservoirs of genetic diversity and sources of fauna and flora for the repopulation of surrounding exploited areas (e.g. nursery areas for species important to commercial or recreational fisheries).

The scientific use of marine reserves centres mainly around the need for preservation in them of reference areas of representative aquatic ecosystems, as undisturbed as possible by the activities of humans, both for applied ecological studies on what the effects of any one or more of human activities on such a system might be, and/or for ecological or other biological studies of more 'pure' scientific interest.

The educational use of marine reserves includes not only the education of school, college and university students in the basic principles of aquatic ecology, but of members of the general public in the broader sense of instilling in them so-called 'conservation values'.

The recreational use of marine reserves would comprise primarily what are usually referred to as passive recreational activities (e.g. underwater photography, fish watching, or just enjoying the underwater scenery), and generally exclude most active recreational pursuits, such as speedboating and water skiing, and especially such destructive activities as spearfishing, aquarium fish and shell collecting, and also, in many cases, angling.

Each of these four major uses, of course, overlaps with at least one or two of the others, and if the reserve is large enough a 'multiple-use' concept can sometimes be applied to include them all.

These main use categories were adopted by the Australian Marine Sciences Association in its Guidelines for the Establishment of Underwater Parks and Reserves in Australian Waters (Collett and Pollard 1975), and also by the Council of Nature Conservation Ministers in its Marine and Estuarine Protected Areas policy document of 1985 (CONCOM 1985).

Surveys and site selection

In anticipation of the passage of marine protected areas legislation in amendments to the Fisheries and Oyster Farms Act, throughout the mid to late 1970s New South Wales Fisheries carried out a program of investigation into the suitability of areas along the New South Wales coastline as potential sites for marine and estuarine reserves to serve the four main purposes outlined above. General field reconnaissance surveys of the entire coastline resulted in the initial identification of some 40 or so potential sites. Preliminary surveys of some 30 or so of these sites were subsequently carried out, and around 15, which were regarded as being of high or very high priority, were surveyed in more detail (Pollard 1980).

Aquatic Reserves program

The first Aquatic Reserve in New South Wales waters was declared in May 1980 around Long Reef, an extensive intertidal rock platform habitat of high educational value in Sydney's Northern Beaches area. Julian Rocks, North (Sydney) Harbour and Shiprock Aquatic Reserves were subsequently declared in March 1982, Bushrangers Bay Aquatic Reserve in May 1982, and Fly Point - Halifax Park Aquatic Reserve in

January 1983. Between the late 1960s and the early 1980s the NPWS also declared a number of national parks and nature reserves which comprised some areas of estuarine or tidal waters, though no specific management measures were applied to these waters or their aquatic biota.

While most of the above Aquatic Reserves are relatively small (between around two and 250 hectares), and remain unzoned, most of them serve more than one of the major conservational, scientific, educational and recreational purposes outlined above.

Concurrently with and following the declaration of the above reserves, plans were made for the declaration of larger multiple-use marine and estuarine reserves involving the preparation of management plans incorporating zonation and public participation in the planning process.

Management Plans

Although there had been a limited amount of public participation in the planning of some of the earlier Aquatic Reserves (primarily through both the recreational and commercial fisheries advisory bodies of that time), prior to the mid 1980s no draft plans of management were prepared for wider public comment prior to reserve declaration. From the mid 1980s onwards, however, funds were made available by the Commonwealth Government for the preparation of such plans of management, first for proposed reserves at Towra Point and Jervis Bay, and later for Lord Howe Island and the Solitary Islands. Project Officers were appointed under this States Cooperative Assistance Program funding (from the Australian National Parks and Wildlife Service, now known as the Australian Nature Conservation Agency) to help prepare these draft management plans and to supervise broad public participation programs designed to consider their effectiveness.

Towra Point Aquatic Reserve

Towra Point Aquatic Reserve, which comprises 333 hectares of primarily estuarine seagrass meadows and mangrove forests (important fish nursery habitats) on the southern shores of Botany Bay, and includes both sanctuary and refuge zones (see later), was the first of these reserves to be declared, in 1987 (later modified and regazetted in April 1990).

Solitary Islands Marine Reserve

This was followed by the declaration of the much larger (85,000 hectares) Solitary Islands Marine Reserve (Chapter 71) in April 1990, which comprised a wide variety of different marine habitats such as rocky and coral reefs, offshore islets, rocky headlands and sandy beaches; and estuarine habitats such as tidal rivers, mangroves and seagrasses. It is zoned for multiple use purposes with sanctuary, refuge, recreation and general use zones.

Lord Howe Island Marine Reserve

Lord Howe Island Marine Reserve, which is included in a World Heritage Area, has been through the full draft management planning and public participation processes and is currently awaiting declaration. The Lord Howe Island Draft Management Plan won both an Award of Excellence in Planning from the New South Wales Division of the Royal Australian Planning Institute in 1992, and a Certificate of Merit for Rural Planning Achievement in the National Awards of the Royal Australian Planning Institute in 1993.

Jervis Bay Marine Reserve

Jervis Bay Marine Reserve has now also been through the same draft planning and public participation process, and the results of the public participation phase are currently being analysed. It is hoped that these latter two marine reserves will be declared during 1995. (Chapter 72).

Table 77.2: NSW Aquatic and Marine Reserves

Name	Type	Area (ha)	Date	Comments
Long Reef	Refuge	60	1980	Rock platform of high educational value
Julian Rocks	Refuge	80	1982	Angling allowed
North (Sydney) Harbour	Refuge	250	1982	Some forms of fishing allowed
Shiprock	Sanctuary	2	1982	Dive site
Bushrangers Bay	Sanctuary	3	1982	Area for novice divers
Fly Point - Halifax Park	Refuge	75	1983	Angling allowed in part of area
Towra Point	Multiple zoning	333	1987	Estuarine wetlands of high ecological value
Solitary Islands	Multiple zoning	85,000	1991	Large multi-use management area - 4 zones

(Source: NSW Fisheries)

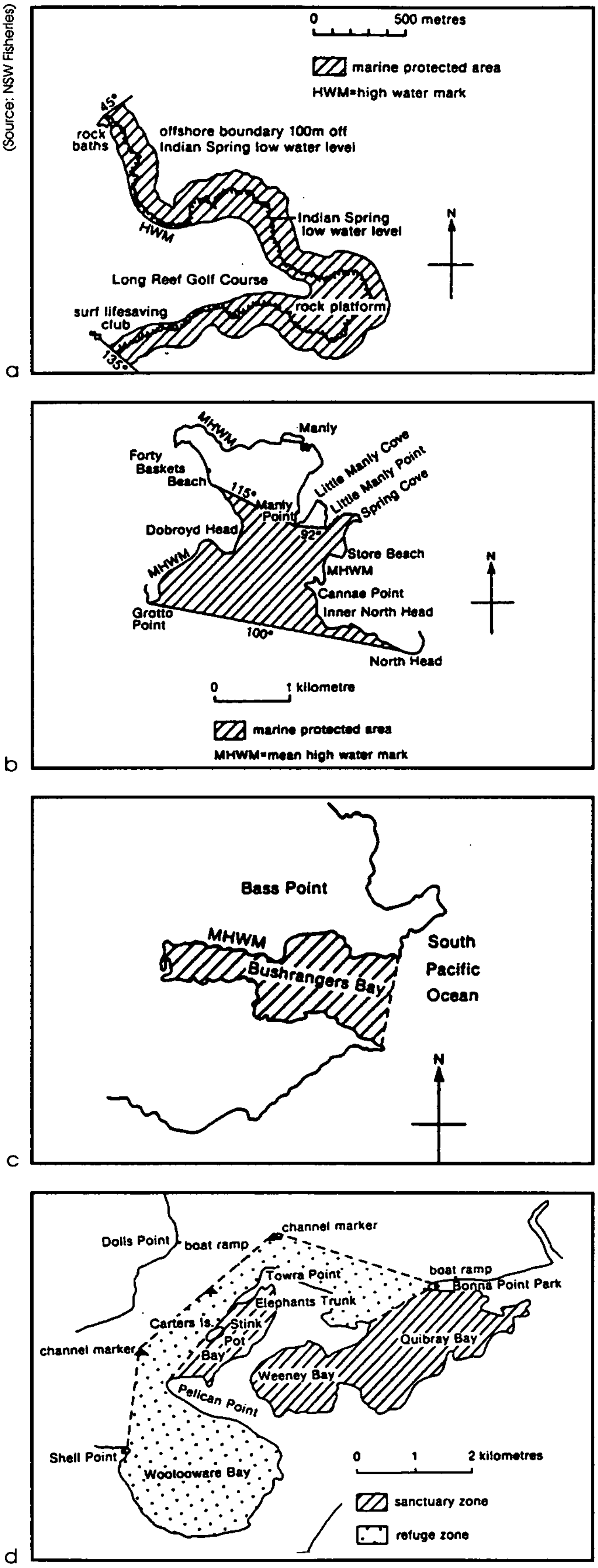


Figure 77.2: Selected Aquatic Reserves in New South Wales. (a) Long Reef, adjacent to Dee Why, Sydney. (b) North (Sydney) Harbour. (c) Towra Point, southern Botany Bay. (d) Bushrangers Bay, south of Shellharbour.

Future directions

New South Wales Coastal Policy

The first goal of the Draft Revised Coastal Policy for New South Wales (Coastal Committee of New South Wales 1994) is to 'protect, restore and enhance the natural environments' of the State. The first three objectives under this goal are 'to identify coastal lands and aquatic environments with conservation values needing protection', 'to conserve the diversity of all plant and animal species and to protect and assist the recovery of threatened and endangered species', and 'to ensure coastal land and aquatic environments have appropriate tenures, reservations, zonings and/or regulation'.

Strategic actions under these objectives for which New South Wales Fisheries has primary responsibility include the 'identification of biogeographic regions and centres of diversity along the coast to select suitable sites for representative marine and estuarine reserves', and the 'preparation of management strategies in cooperation with other agencies for the establishment of an adequate, comprehensive and representative system of marine and estuarine protected areas' in State waters. All of these main objectives and strategic actions are currently being addressed in New South Wales Fisheries' marine and estuarine protected areas program, and the Department's Corporate Plan also charges its Habitat Management Unit with the declaration of Aquatic Reserves where appropriate, and the development of management strategies for these reserves.

Ocean Rescue 2000 program

The Ocean Rescue 2000 program has provided additional funding for the development and implementation of a suitable database and geographical information system designed to access all of the necessary information for the creation of a biogeographically representative system of marine reserves in New South Wales, and the development and implementation of an appropriate educational and advisory strategy for these marine reserves and other projects.

Review of objectives

To date the main objectives of New South Wales Fisheries' Marine and Estuarine Protected Areas Program (New South Wales Fisheries 1992) have been:

- the conservation of self-perpetuating populations of particular species and their habitats;
- the conservation of representative samples of natural ecosystems, both common and rare;
- the conservation of areas of particular scientific interest; and

- the conservation of areas of the natural environment for the purposes of education and recreation.

There is now a need to determine whether all of these objectives are being met, and perhaps to give the ongoing program a more scientific, rather than *ad hoc*, approach to site selection. There is also now a recognition of the need to identify and select a set of ecologically representative areas for dedication covering the full range of aquatic habitats and species which may not be covered in the current reserve system. This need to assess the biogeographic representativeness of the existing system of aquatic reserves in New South Wales, and to assess which critical habitats of threatened or rare species are adequately protected, is presently being addressed. In addition to the more general objectives outlined above, it is also intended that increased emphasis will be given in the future to investigating and implementing the concept of marine harvest refugia for fisheries management and enhancement purposes.

Summary and conclusions

1. MPAs in New South Wales have been declared under Section 16A (1979 Amendments) of the New South Wales *Fisheries and Oyster Farms Act* 1935. New legislation for this purpose is included in the recently revised New South Wales *Fisheries Management Act* 1994. These Aquatic Reserves are administered by New South Wales Fisheries.

2. Eight Aquatic Reserves have been declared (from north to south): the Julian Rocks (off Byron Bay), the Solitary Islands (off Coffs Harbour - Wooli), Fly Point-Halifax Park (in Port Stephens), Long Reef (on Sydney's Northern Beaches), North Sydney Harbour (near Manly on Sydney's North Shore), Towra Point (in Botany Bay), Shiprock (in Port Hacking), and Bushrangers Bay (off Shellharbour, south of Wollongong).

3. Most comprise relatively small areas, except for the Solitary Islands Marine Reserve, which covers a relatively large stretch of coastline and is zoned for multiple use (comprising sanctuary, refuge, recreation and general use areas). Although much smaller, the Towra Point Aquatic Reserve is also zoned.

4. Current initiatives include relatively large marine reserves encompassing the waters around Lord Howe Island, located in the Tasman Sea offshore from Port Macquarie; and the waters in and adjacent to Jervis Bay on the mid south coast. A smaller reserve is also currently being considered around Cook Island, offshore from Tweed Heads on the far north coast.

5. A biogeographic analysis of the entire coastline is currently being undertaken to create a biogeographically representative system of such reserves for the State as a whole.

6. Although the New South Wales National Parks and Wildlife Service has no specific legislation under its Act for the creation of marine protected areas, it does administer a Marine Extension to the Bouddi National Park (at Maitland Bay to the north of the mouth of Broken Bay) and several other small aquatic areas adjacent to various of its National Parks and Nature Reserves.

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Acknowledgments:
The paper by J. Burchmore and D. Pollard was internally reviewed in New South Wales Fisheries.

Chapter 78: Marine conservation and marine protected areas in Victoria[1]

Victoria has a wide variety of marine habitats, ranging from rocky shores and sandy beaches, to large sheltered bays, inlets, estuaries and coastal lakes. The major features of the coast line are two large embayments, Port Phillip Bay and Western Port, and the largest lakes system in the southern hemisphere, the Gippsland Lakes.

Interest in Victoria's marine biota commenced with the early English and French explorers, and eighteenth and nineteenth century naturalists. The first fisheries legislation was enacted in 1859 to preserve oyster beds and restrict the use of nets in bays, estuaries and rivers, and the first comprehensive Fisheries Act was introduced in 1873. An office was established in the same year to regulate fisheries, but fisheries research did not commence until the 1940s.

Marine conservation: a background

The first marine pollution studies began in Victoria in the late 1960s following concerns about the level of impact which the urbanisation and industrialisation of the Melbourne and Geelong metropolitan areas were having upon Port Phillip Bay and Western Port. Major, multi-disciplinary regional surveys were undertaken in these bays and in the Gippsland Lakes in the 1970s, placing Victoria in the forefront of marine environmental research in this country. Within government, a Marine Studies Group was formed in the late 1970s, later joining the existing Fisheries Research Group to become the Victorian Fisheries Research Institute. Research programs had a particular emphasis on marine fisheries research and management, and the effects of environmental contaminants. A major, long-term study of the Port Phillip Bay environment is currently underway. The first marine reserve was established in 1979 under the *Fisheries Act* 1968.

Legislation and responsibilities in the marine environment

Legislation

Marine protected areas (MPAs) in Victoria can be established under the Fisheries Act, the *Crown Lands (Reserves) Act* 1978, the *National Parks Act* 1975, or through special Acts of Parliament. Other legislation can provide for special purposes. For example, the *Historic Shipwrecks Act* 1981 controls access to designated wrecks, and the *Wildlife Act* 1975 and its regulations control activities on wildlife reserves such as seabird and seal colonies. Activities in MPAs are controlled through subordinate legislation and regulations.

The legislation by which MPAs are established is a matter of issue, for although a patchwork of existing legislation can be used, the resulting complexity can be a source of confusion for both the public and management. For example, the Fisheries Act cannot control tourist operations; the National Parks Act cannot fully regulate fishing or bait collection; and the *Marine Act* 1988 cannot regulate boating for conservation purposes. In the past, challenges to particular aspects of legislative arrangements have been successful in the Victorian Supreme Court.

Management policy and framework

The absence to date of the State-wide strategic planning framework for marine areas has been a major impediment to the establishment, planning and management of MPAs in Victoria. This may be resolved when the current Land Conservation Council Marine and Coastal Special Investigation report is completed.

Responsibility for marine conservation policy and management in Victoria rests largely with the Department of Conservation and Natural Resources which comprises the lead agencies responsible for marine conservation: Fisheries, Flora and Fauna, National Parks and Crown Lands. The combination under one administrative unit and the organisation of the Department into field areas means there is integrated framework for management of MPAs in Victoria, a situation which is unique in Australia. Within the Department, responsibility for policy, State-wide programs, monitoring and specialist advice lies with the National Parks Service, supported by expert advice from the Flora, Fauna and Fisheries Division as required. At the field level, Chief Rangers of the National Parks Service are responsible for management, education, interpretation, extension and enforcement functions.

[1] Based on a paper by J. Phillips, Department of Conservation and Natural Resources, East Melbourne, Victoria.

(Source: A. Ivanovici)

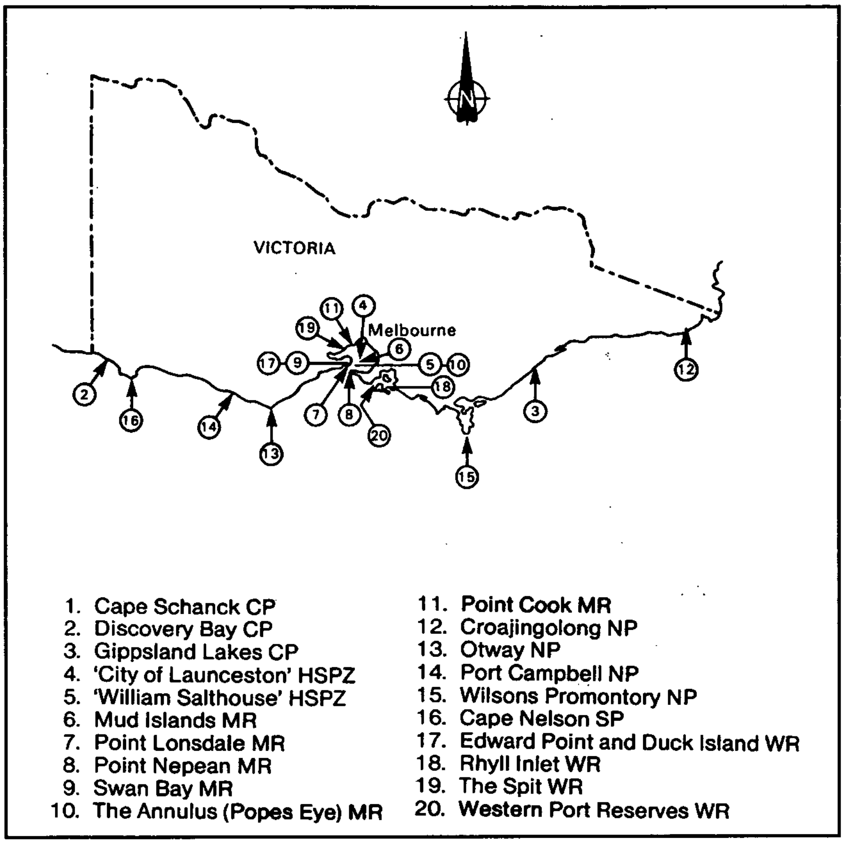

Figure 78.1: Marine protected areas in Victoria. (CP: Coastal Park; HSPZ: Historic Shipwreck Protected Zone; MR: Marine Reserve; NP: National Park; SP: State Park; WR: Wildlife Reserve.)

Description of marine protected areas

Around 70% of Victoria's coastline to the low water mark is reserved as National, State or Coastal Park, and Coastal Reserve. There are currently 12 marine protected areas: Harold Holt Marine Reserves (Point Lonsdale, Point Nepean, Swan Bay, Mud Islands, and Annulus (Pope's Eye)); Wilsons Promontory Marine Reserve and Marine Park; Nooramunga Marine and Coastal Park; Point Cook Marine Reserve; Corner Inlet Marine and Coastal Park; Shallow Inlet Marine and Coastal Park; and Bunurong Marine Park.

Harold Holt Marine Reserves

Victoria's first marine protected areas were established as a result of a proposal by the SCUBA Divers Federation of Victoria in 1972 for a marine reserve at the southern end of Port Phillip Bay. Amending legislation to allow for their establishment was introduced into the Fisheries Act in 1975, and in 1979 the first of the five Harold Holt Marine Reserves was gazetted.

The five reserves in the vicinity of Port Phillip Heads comprise the relatively pristine rocky shores of Point Nepean Marine Reserve, the more accessible rock platforms of Point Lonsdale Marine Reserve at the entrance to Port Phillip Bay, the sheltered coastal wetlands and seagrass meadows of Swan Bay, the shallow waters around the low-lying Mud Island, and the small, well-visited artificial reef of Pope's Eye.

Swan Bay

Swan Bay is the most intact natural bird habitat in Port Phillip Bay. It is a shallow, sheltered area on the south-western shore of the Bay, and is partly enclosed and protected by sand spits and barrier islands. Swan Bay is 3,000 hectares in area, of which one-third is intertidal sand and

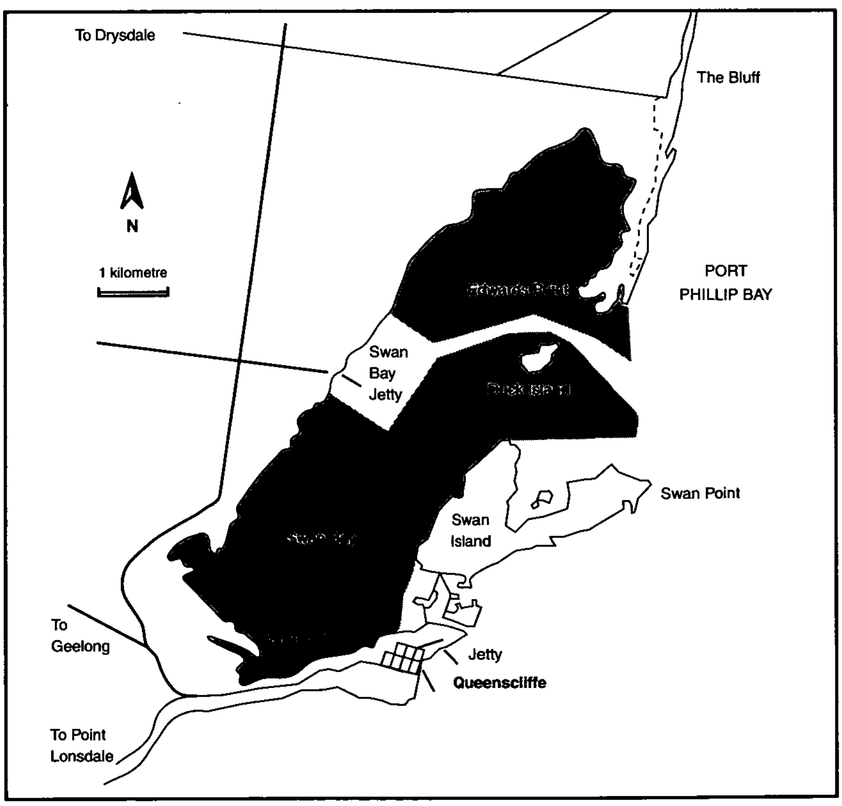

Figure 78.2: Harold Holt Marine Reserves, Swan Bay.

mudbanks. The saltmarsh along most of the perimeter and intertidal flats are important feeding grounds for up to 10,000 resident and migratory shorebirds. The Bay's saltmarsh provides one of the three over-wintering sites on the Australian mainland for the endangered orange bellied parrot.

Extensive meadows of seagrasses provide feeding and nursery habitats for whiting, mullet, garfish and flounder. One seagrass, *Zostera muelleri*, is a major food source for the black swan after which the Bay is named. Commercial fishing is prohibited in most of the Reserve, and speed boats are restricted in speed.

Annulus (Pope's Eye)

Three hectares in area, this is one of the smallest MPAs in Australia. An artificial reef of bluestone (originally constructed as part of the Port Phillip Bay fortifications), Pope's Eye is popular with dive operators and clubs, recreational divers and marine scientists because of its prolific and colourful sponges, soft corals, seafans, bryozoa and sea squirts. No fishing or collecting is permitted, other than for scientific research. The Annulus is a popular site for recreational divers who share the resource with commercial tour operators who are self-regulated.

Wilsons Promontory Marine Park and Marine Reserve

Wilsons Promontory is a high granite peninsula which forms the most southerly point of the Australian mainland. A 10,000 hectare Marine Park and Marine Reserve established in 1986, extends 300 metres from the shore. Eighteen of the many inshore islands are reserved in Wilsons Promontory National Park.

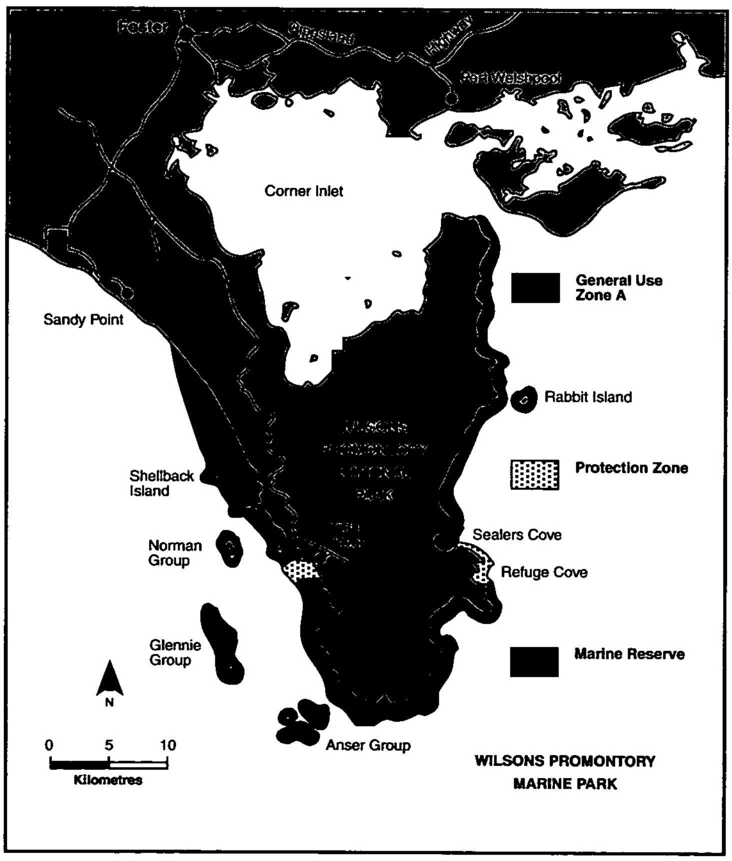

Figure 78.3: Wilsons Promontory Marine Park.

The Marine Park includes significant cultural features such as shipwrecks and remains of maritime industries, and steep granite dropoffs which are unique in Victoria. The marine communities are rich and diverse; seaweed communities (dominated by kelps and *Caulerpa*); seagrasses, encrusting invertebrates, soft bottom benthos and sandy shore assemblages. The Marine Park is effectively buffered from land disturbances by the terrestrial National Park.

Three management zones have been proposed in the draft management plan: a Sanctuary Zone which provides for non-exploitative uses ('look but don't take'); a Recreational Zone which permits recreational activities including line fishing, but prohibits spearfishing, other harvesting activities and commercial activities; and a General Use Zone which permits recreational and commercial activities consistent with conservation objectives.

Corner Inlet and Nooramunga Marine and Coastal Parks

These Marine and Coastal Parks (around 37,700 hectares in area) are bound by the South Gippsland coastline to the north, and by the northern shores of Wilsons Promontory and a series of barrier islands and sandy spits in the south. Their sheltered water and extensive tidal mud and sand flats are internationally significant for migratory wading birds and are listed on the RAMSAR Convention. The world's southernmost mangroves occur in southern Corner Inlet. Corner Inlet also contains Victoria's only extensive beds of the broad-leafed seagrass *Posidonia australis*.

The Nooramunga Marine and Coastal Park includes numerous islands with significant remnants of coastal vegetation, and large areas of mangroves and saltmarsh. The coastal areas of these parks provide habitat for many flora and fauna species, including the rare Swamp Antechinus and New Holland Mouse. Seabirds such as Caspian, Fairy and Little Terns and Hooded Plovers breed and roost on sandy beaches. Other noteworthy species found in the parks include the endangered Orange-Bellied parrot and the rare Ground Parrot.

Shallow Inlet Marine and Coastal Park

The Shallow Inlet Marine and Coastal Park (around 300 hectares in area) has extensive mudflats and sandy intertidal areas which provide significant habitat for migratory wading birds including the eastern curlew, lesser golden plover, red-necked stint and the curlew sandpiper. The inlet and beaches around the entrance also provide valuable habitat for other shorebirds such as hooded plovers and oystercatchers. The sheltered waters are very popular for boating, fishing and sailboarding.

Bunurong Marine Park

Located 140 kilometres east of Melbourne, the Bunurong Marine Park stretches along 17 kilometres of coastline and extends one kilometre out to sea. The shore is scenic, and features rugged sandstone cliffs, sandy coves, rocky headlands, caves and rock pinnacles. It is noted for its early Cretaceous fossil dinosaur remains. An intertidal rock platform extends well offshore to a sandy shelly bottom. A scenic coastal road runs along the boundary and car parks and walks make the Marine Park very accessible to tourists, local naturalists and school children.

The Bunurong Marine Park was established in 1991, using provisions of the Fisheries, Crown Lands (Reserves) and National Parks Acts. It is zoned into three areas: a central, highly protected Sanctuary Zone for non-exploitative uses, and two flanking Conservation Zones where limited commercial and recreational fishing are allowed, for example, for abalone and rock lobster without the use of scuba.

Summary and conclusions

1. Victoria has a wide variety of marine habitats, ranging from rocky shores and sandy beaches, to bays, inlets, estuaries and coastal lakes. The major features of the coastline are two large embayments, Port Phillip Bay and Western Port, and the largest lakes system in the southern hemisphere, the Gippsland Lakes.

2. Around 70% of Victoria's coastline to the low water mark is reserved as National, State or Coastal Park, and Coastal Reserve. There are 12 marine protected areas.

3. The legislation by which MPAs are established is a matter of issue. Although a patchwork of existing legislation has been used, the resulting complexity is source of confusion for the public and management. Challenges to particular aspects of legislative arrangements have been successful in the Victorian Supreme Court.

4. Victoria has 12 marine protected areas: Harold Holt Marine Reserves (Point Lonsdale, Point Nepean, Swan Bay, Mud Islands, and Annulus (Pope's Eye)); Wilsons Promontory Marine Reserve and Marine Park; Nooramunga Marine and Coastal Park; Point Cook Marine Reserve; Corner Inlet Marine and Coastal Park; Shallow Inlet Marine and Coastal Park; and Bunurong Marine and Coastal Park.

5. A strategic plan for marine areas is currently under development.

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Acknowledgments:
This chapter was internally reviewed by the Department of Conservation and Natural Resources, East Melbourne, Victoria.

Chapter 79: Marine conservation and marine protected areas in Tasmania[1]

Tasmania has approximately 5,400 kilometres of coastline, more per unit land area than any other State in Australia. Coastal environments include magnificent rocky reefs, scenic sandy beaches and towering sea cliffs. The main island is surrounded by islands, and is cut by a myriad of bays and estuaries which play a fundamental role in the maintenance of coastal ecosystems. Marine fauna include delicate basket stars and sea dragons, rarely seen endemic handfish, dolphins, seals, little penguins, great white sharks and migrating whales.

Tasmania has diverse cool temperate and subantarctic habitats and lies at the meeting place of four marine bioregions. It includes the core of one of the world's smallest bioregions, and an area with one of the world's highest diversities of marine plants. About 80-90% of species of most marine groups are endemic, compared to 10% of most groups in the north. As a result, the marine environment of Tasmania is in many ways more significant in world terms than tropical areas such as the Great Barrier Reef.

Most of Tasmania's population centres and major industries are located on or near the coast. Coastal waters have been subject to extensive recreational and commercial fishing and shipping activity, and coastal and marine areas make a significant contribution to the State's economy. Many parts of the coast are important attractions in the growing tourist industry.

A marine conservation program is in progress in the State with the initial aim of protecting representative or unique coastal marine communities. Four small but significant marine reserves have been declared to date, with further areas under consideration.

Legislation and responsibilities in the marine environment

In Tasmania, responsibility for the marine environment is shared by a number of State agencies. Key agencies are the Department of Primary Industry and Fisheries (DPIF) and the Department of Environment and Land Management (DELM). DPIF currently has responsibility for the regulation and management of fish and fishing under the *Fisheries Act* 1959.

The Parks and Wildlife Service (P&WS) of DELM is responsible for conservation, including some marine resources such as marine mammals, seabirds and shipwrecks. The Service administers the *National Parks and Wildlife Act* 1970 which provides for the establishment and management of marine reserves. Jurisdiction does not extend to aquatic or littoral animals or fish. Fishing in marine reserves is restricted under the Fisheries Act 1959.

The Environmental Management Division of DELM is the agency responsible for the prevention of pollution of Tasmanian waterways under the *Environmental Management and Pollution Control Act* 1994, elements of which will come into force in 1995.

Marine pollution from oil by shipping is managed under the *Tasmanian Pollution of Waters by Oil and Noxious Substances Act* 1987. The International Convention for the Prevention of Pollution from Ships (MARPOL) annexes I (oil), II (noxious liquid substances) and V (garbage) are in force in Tasmania as throughout Australia.

The present fisheries legislation is under review and will be replaced by a new Marine Living Resources Act which is proposed to include new powers of reservation for marine areas. The new Act will focus on marine ecosystems rather than fish stocks, and have sustainable development objectives as its basis. These objectives are common to a suite of legislation now forming the State's resource management and planning system.

Management Policy

In 1991, a joint working group comprising the then Departments of Environment and Planning, Parks Wildlife and Heritage and Primary Industry developed a Policy for the establishment of a system of marine protected areas for Tasmania, based on IUCN guidelines for marine protected areas.

[1]Based on a paper by C. Rees, Department of Environment and Land Management, Hobart, Tasmania.

Marine reserves policy

The goals of the Department of Environment and Land Management's marine reserves policy include:

- to provide for the wise use, protection, appreciation and enjoyment of the marine ecosystem in perpetuity through the development and management of a system of marine reserves;
- to establish marine reserves in each of the four main biogeographical provinces found around the coastline of Tasmania; and to establish other particular marine reserves for conservation, educational and/or recreational purposes;
- to develop management plans for each reserve;
- to consult closely with interest groups and government agencies with common interests in the marine environment. A commitment is made for consultation with these groups during the early stages of introducing and establishing marine reserves, during the preparation of management guidelines and during regular reviews and alteration of reserve management plans;
- to provide interpretive material to promote a better understanding, appreciation and enjoyment of the State's marine reserves; and
- to conduct research to provide quantitative and qualitative information for management of the marine reserves and to augment scientific studies undertaken in the early 1980s.

Permitted activities in the State's marine reserves include boating, swimming, sailing, diving, handlining, angling and other activities dependant on the particular reserve. Non-permitted activities include ocean dumping, aquaculture (except the collection of spat), spearfishing, commercial exploration, extraction and development of non-renewable resources, any activity that threatens continued existence of indigenous flora and fauna, and any activity that threatens historical or archaeological resources.

Management roles and infrastructure

Marine Reserves are managed jointly by the Parks and Wildlife Service and Department of Primary Industry and Fisheries. Day-to-day management responsibility rests with rangers located on adjacent terrestrial National Parks, whereas DPIF conducts monitoring and research. The Marine Police, together with Fisheries Inspectors, are responsible for enforcement of Fisheries Regulations prohibiting the taking of fish from Marine Reserves. The duties are undertaken as part of the general functions of the Marine Police and are not identified separately.

Although management plans for the marine reserves have not yet been developed, there are management objectives common to all marine reserves. The most important of these are:

- to protect and preserve flora and fauna, ecosystems and features of special scientific, archaeological or historic importance;
- to provide a range if interpretive facilities and educational activities;
- to encourage natural history study and scientific research; and
- to encourage recreational value and fulfil as much of the demand for area use as is consistent with the conservation and restoration of the natural environment.

All four marine reserves have been equipped with basic interpretive and educational facilities such as signboards and information leaflets. In addition, an underwater interpretive trail for snorkelling or diving has been established at the Tinderbox Marine Reserve.

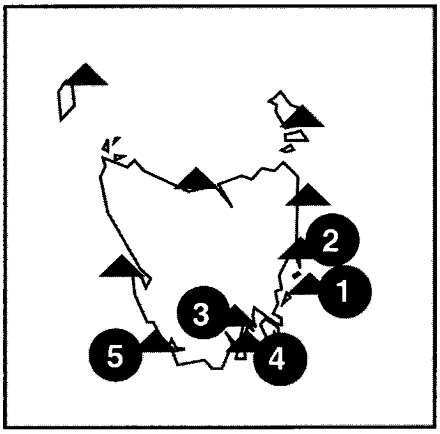

Figure 79.1: Tasmania has diverse cool temperate and subantarctic marine habitats. It includes the core of one of the world's smallest marine bioregions, and a bioregion with one of the world's highest diversities of marine plants. Tasmania has 19 MPAs (about 2% of the coast), the majority of which were set aside for reasons other than marine conservation. The main MPAs are: (1) Maria Island National Park; (2) Governor Island Marine Nature Reserve; (3) Tinderbox Marine Nature Reserve; (4) Nine Pin Point Marine Nature Reserve; and (5) Port Davy/Bathurst Harbour in the Southwest National Park.

Tasmania's marine reserves

Prior to 1991, Tasmania had 15 limited MPAs principally for the protection of habitat for wading birds, and a further 10 wetlands with the limited protection offered under the RAMSAR convention. The Fisheries Reserve at Crayfish Point, Taroona, had also been established with restrictions on capturing rock lobsters. Marine habitats and ecosystems were not protected, and gillnetting, for example, was allowed along the entire Tasmanian coastline.

In 1991, based on scientific work conducted in the late 1970s, a system of marine reserves was initiated with the aims of protecting representative marine habitats, ecosystems and communities, allowing fish propagation, and enhancing public enjoyment of the marine and coastal environment. The long-term aims of the marine reserve system are to establish large representative marine reserves in each of the four Tasmanian marine bioregions, and to establish other smaller reserves for scientific, educational and recreational purposes.

In the initial phase of the program, four reserves containing representative Maugean inshore marine communities were identified for declaration. These are located on the east and south-east coasts, and include three small areas of scientific or recreational interest (Governor Island off Bicheno; Ninepin Point and Tinderbox in the D'Entrecasteaux Channel), and one larger area on the north-western section of the coastline of Maria Island.

The Maria Island reserve was to include Chinamans Bay which provides habitat for significant areas of seagrasses. As a result of community pressure during the public consultation process, Chinamans Bay was excluded from the reserve conditional on suitable substitutes being found elsewhere, although this has not yet occurred.

Maria Island National Park (marine extension)

The marine extension of the National Park is approximately 1,500 hectares in extent and extends from the Fossil Cliffs in the north-east to Return Point on the west coast.

Features of the Maria Island marine reserve include:
- representative range of Tasmania's east coast marine habitats;
- sandstone reefs at Howells Point;
- seagrass beds and fish nursery in the sheltered Mercury Passage;
- diversity of plants and animals; and
- underwater forests of giant kelp (15-20 metres in height) in Fossil Bay.

There is, however, little reef protected in the reserve, and the kelp beds have suffered similar decline to those along much of the Tasmanian coastline.

Governor Island Marine Nature Reserve

This 690 hectare marine reserve lies off Governor Island at Bicheno, on Tasmania's central east coast.

Features of the Governor Island Marine Reserve include:
- unusual vertical rock faces;

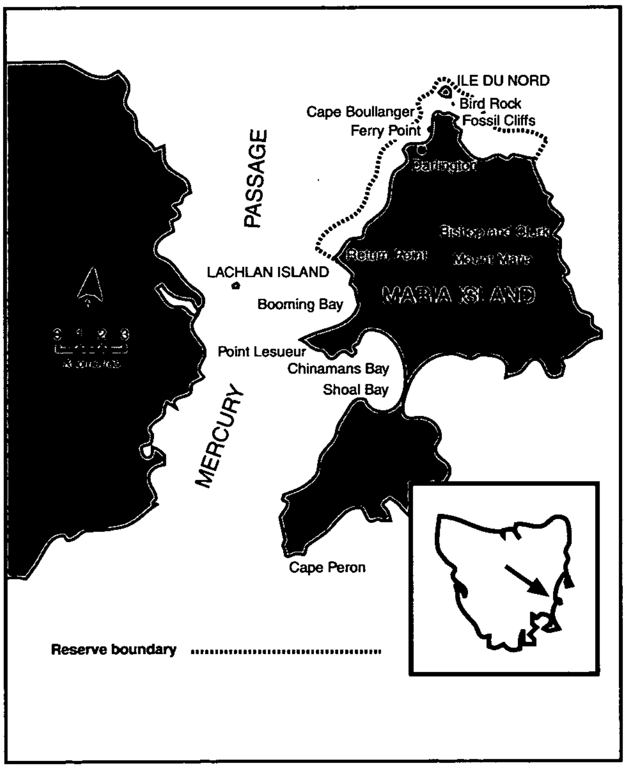

Figure 79.2: Maria Island Marine Reserve.

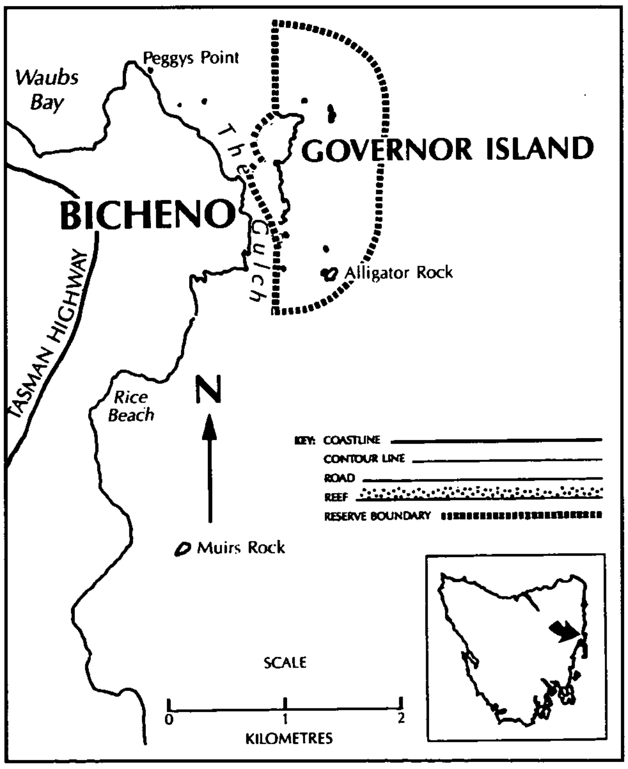

Figure 79.3: Governor Island Marine Reserve.

- interesting invertebrates such as sea whips, sea fans and yellow zooanthids;
- large spectacular caves;
- a diverse community in a small area;
- popular diving because of clear water and diversity of marine life;
- easy access to deepwater species; and
- an important crested tern colony on Governor Island.

Tinderbox Marine Nature Reserve

This small marine reserve of 45 hectares is at Tinderbox, 30 minutes south of Hobart, and extends 200 metres offshore. It includes some foreshore areas.

Features of the Tinderbox marine reserve include:

- a large variety of fish and seaweed;
- sandstone shore platforms and cobbled reefs;
- good, safe diving; and
- an underwater dive trail with interpretation (one of the few such trails in temperate waters).

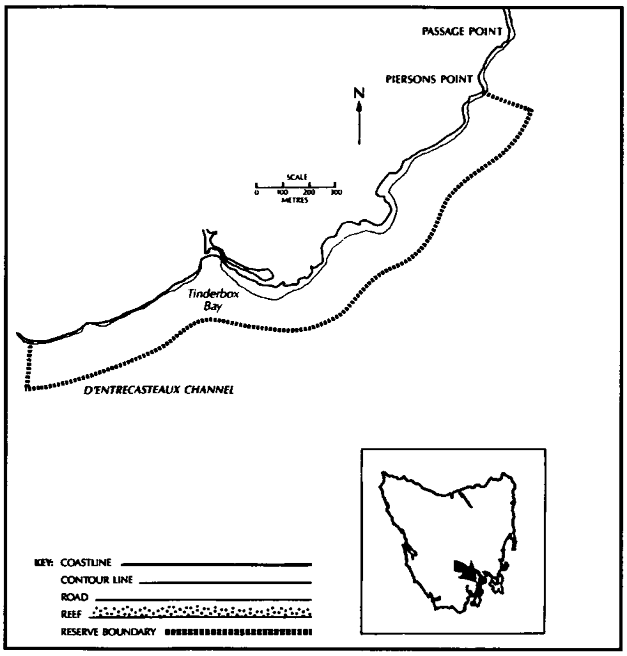

Figure 79.4: Tinderbox Marine Nature Reserve.

Ninepin Point Marine Nature Reserve

This small 60 hectare marine reserve is located at the mouth of the Huon River. The reserve extends in a 500 metre radius seaward from Ninepin Point and also includes the terrestrial part of the point.

Features of the Ninepin Point marine reserve include:

- a spectacular reef at only eight metres depth;
- dark tannin-rich waters from the Huon River which have resulted in species normally found at greater depths being found at less than eight metres;
- an array of deepwater red seaweeds; and
- estuarine fauna and flora.

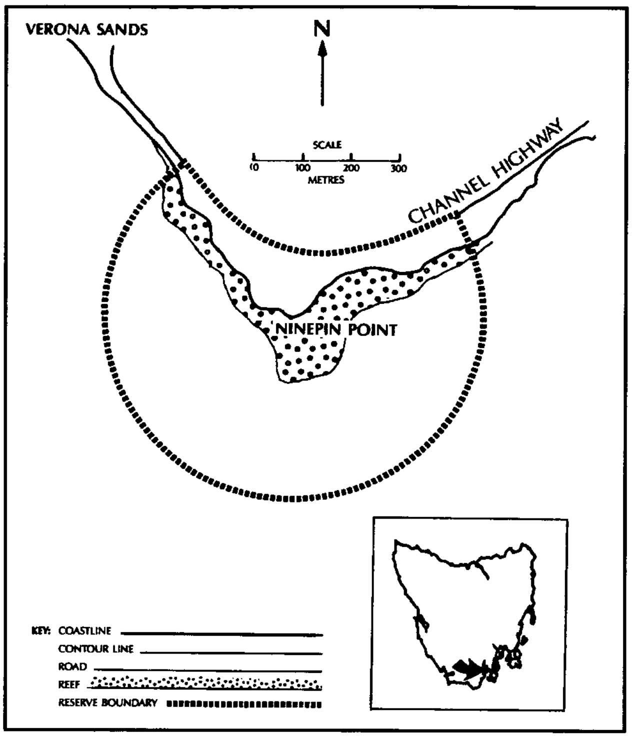

Figure 79.5: Ninepin Point Marine Nature Reserve.

Future marine protected areas

Detailed biological surveys of reef habitats and baseline studies which have been conducted in recent years with Ocean Rescue 2000 assistance are now almost completed.

Tasmania's early strategy for the development of marine reserves was based on a biogeographical regionalisation derived from survey work which had some limitations. A review of this regionalisation which is now underway will guide further marine reserve proposals.

Areas being considered for possible marine reserve status in the near future include:

Macquarie Island

The waters surrounding Macquarie Island are representative of the subantarctic region. They contribute to the maintenance of marine species and those animals which use the existing terrestrial Macquarie Island Nature Reserve.

Kent Group

The waters around the Kent Group in eastern Bass Strait are representative of a unique marine region. A reserve would represent elements of the southern New South Wales (or Peronian), the Southern Australian (or Flindersian) and the Tasmanian or Maugean marine provinces, and conserve an area of high plant and animal diversity.

Tasmania will continue to develop interpretive and educational programs to promote marine conservation.

As part of its approach to 'wise and sustainable use' of its marine resources, significant changes are being proposed for Tasmania's fisheries legislation and management plans are being drafted to guide the conservation and use of marine resources.

Summary and conclusions

1. Tasmania's long coastline and many offshore islands include components of four marine bioregions with a high diversity of flora and fauna.

2. Authorities responsible for the marine environment are the Department of Environment and Land Management (within which the Parks and Wildlife Service is primarily responsible for managing marine reserves, and the Environmental Management Division for pollution), and the Department of Primary Industry and Fisheries (within which the Marine Resources Division is responsible for managing fish stocks and their habitats).

3. Tasmania has declared four marine reserves, at present totalling 1,665 hectares in area.

4. Tasmania's marine bioregions are under review and the location of future reserves is likely to reflect the outcome of this exercise. Macquarie Island and some Bass Strait islands are presently being considered for reserve status.

Acknowledgments:
This paper by C. Rees was internally reviewed in the Department of Environment and Land Management, Hobart, Tasmania.

Chapter 80: Marine conservation and marine protected areas in South Australia[1]

South Australia has over 3,700 kilometres of coastline, and some of the most biologically diverse of Australia's temperate coast. The diversity is the result of the array of coastal landforms and habitats, and the variability in sea temperatures, particularly in the gulfs region. It has globally significant populations of a number of rare and endangered species, from southern right whales, Australian sea lions, New Zealand fur seals, to leafy sea dragons and great white sharks.

South Australia was the first State to enact comprehensive legislation specifically to establish marine protected areas. *The Fisheries Act* 1971 was the first to provide specifically for the protection of the aquatic habitat, through the creation of Aquatic Reserves. Of particular significance was the integration of resource management (under Fisheries Regulations) and habitat protection (through reserves) with the goal to 'provide for the wise use, protection, appreciation and enjoyment of the South Australian marine habitat'.

Legislation and responsibilities in the marine environment

Marine protected areas

The prime legislative responsibility for the protection of the aquatic habitat in South Australia lies with the *Fisheries Act* 1982 (21 MPAs) but MPAs may also be established under the *National Parks and Wildlife Act* 1972 (seven MPAs) and the *Historic Shipwrecks Act* 1981 (one MPA). In 1991 the Fisheries Act was amended to include provision for the constitution of Marine Parks and to align MPAs with terrestrial parks.

Under the Fisheries Act there are 14 Aquatic Reserves, four Sanctuaries and three Restricted Use Areas. They are managed by Department of Primary Industries (Fisheries).

MPAs declared under the National Parks and Wildlife Act are generally extensions of terrestrial parks to the low-tide mark. They are managed by the National Parks and Wildlife Service of the Department of Environment and Natural Resources.

The Historic Shipwrecks Act affords total protection to vessels and their artefacts within an area of one square kilometre. MPAs under this Act are managed by the State Heritage Branch, Department of Environment and Natural Resources.

Wildlife management

Under the Fisheries Act all aquatic organisms and their habitat are protected through the proclamation of Aquatic Reserves and may be afforded a high level of protection. Marine fauna and flora are also protected under the National Parks and Wildlife Act. Because of this overlap, complementary legislational and jurisdictional arrangements exist between the two management agencies. Marine flora is also protected under the *Native Vegetation Act* 1991 and mangroves are protected under the *Harbours Act* 1936. Whales, dolphins and seals are completely protected under the Commonwealth's *Whale Protection Act* 1980.

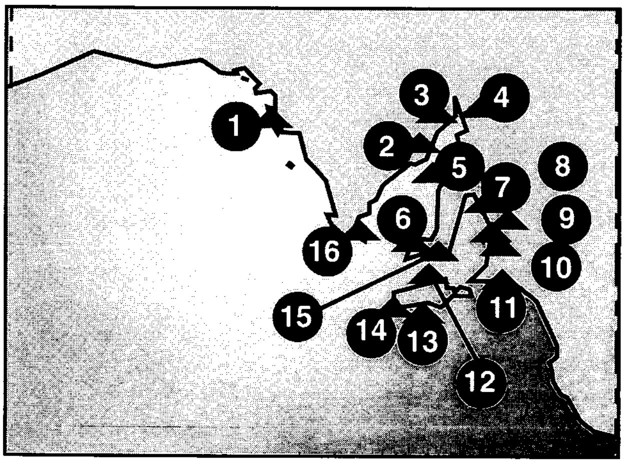

Figure 80.1: South Australia's biologically diverse coastal and marine ecosystems are of great ecological, cultural and economic importance. South Australia currently has 30 MPAs, with a total area of around 300 square kilometres (1.5% of State waters). The main MPAs are: (1) Point Labatt; (2) Cowleds Landing; (3) Blanche Harbour; (4) Yatala Harbour; (5) Goose Island; (6) Troubridge Hill; (7) Chapman Creek; (8) Barker Inlet; (9) Port Noarlunga and Onkaparinga Estuary; (10) Aldinga Reef; (11) West Island; (12) American River; (13) Bales Beach, Seal Bay; (14) Clinton Conservation Park; (15) Troubridge Island Conservation Park; and (16) Dangerous Reef Conservation Park.

[1]Based on a paper by Dr K. Edyvane, South Australian Research and Development Institute (Aquatic Sciences), Adelaide, South Australia.

Fish and fisheries management
Under its regulations, the Fisheries Act has considerable flexibility to control and manage all activities relating to the taking of any aquatic organism. Regulations enable the control of fishing effort through licences, quotas, bag limits, minimum size limits and closed seasons. Special protection applies to blue groper (closed areas), western king prawns (protected from recreational use) and leafy sea dragons (total protection) (see Chapter 55).

Types of marine protected areas

MPAs established under the Fisheries Act
MPAs established under this Act include Aquatic Reserves, Sanctuaries and Restricted Use Areas, and Marine Parks.

Aquatic Reserves
Aquatic Reserves are small in size but afford a high level of protection through restrictions on access and/or fishing activities. Public access is generally prohibited in areas of important conservation and scientific value such as breeding colonies of Australian sea lions.

There are three levels of protection in Aquatic Reserves: (1) areas where public access is totally prohibited (e.g. Point Labatt Aquatic Reserve, Seal Bay Aquatic Reserve); (2) areas where removal of organisms or disturbance of the habitat is prohibited (the majority of reserves); and (3) areas where some fishing is permitted (e.g. Barker Inlet-St Kilda Aquatic Reserve, Troubridge Hill Aquatic Reserve). The Director of Fisheries may issue a permit for specified activities such as collection of specimens, scientific research, filming.

While most Aquatic Reserves are not zoned, West Island and Whyalla-Cowleds Landing Aquatic Reserves have three zones: research (where access and removal of organisms are prohibited); diving and recreational; and 'no fishing'. Line fishing and crabbing is permitted in some estuary and mangrove reserves despite recent research showing high recreational fishing effort and a large proportion of undersized fish in the catch. No management plans are required for Aquatic Reserves.

Sanctuaries and Restricted Use Areas
Four Sanctuaries were established in the 1970s for the protection of the southern rock lobster *(Jasus edwardsii)*. The Restricted Use Areas were established to prohibit netting. South Australia also restricts activities on piers, jetties and wharves and, as such, these are recognised as MPAs.

Marine Parks
Under the 1991 amendment of the Fisheries Act, the control and administration of all Marine Parks rests with the Minister of Primary Industries. A management plan must be proposed within two years of the constitution of a Marine Park. This should involve public consultation, and consider the interests of any adjacent reserve established under the State National Parks and Wildlife Act and the Commonwealth, where relevant. It is anticipated that existing Aquatic Reserves will be reviewed and designated as Marine Parks, each with a management plan.

MPAs established under the National Parks and Wildlife Act
These include five Conservation Parks (Clinton, Port Gowler, Troubridge Island, Hallett Cove and Seal Bay); one National Park (Coorong); and one Game Reserve (Coorong). Management plans are produced by the Department through the National Parks and Wildlife Advisory Committee, and public consultation.

MPAs established under the Historic Shipwrecks Act
Nineteen historic wrecks have been declared in South Australia; only the *Zanoni* is in a protected zone which also protects the habitat and restricts activities.

Current status of MPAs
Despite its early establishment of MPAs, South Australia has conserved the least proportion of its

Table 80.1: MPAs in South Australia: legislation, type, name and area (ha)

(1) ***South Australian Fisheries Act*** **1982:**
Aquatic Reserves: Aldinga Reef (505); American River (1,525); Barker Inlet-St Kilda (2,055); Blanche Harbour-Douglas Bank (3,160); Goose Island (54); Point Labatt (230); Port Noarlunga Reef and Onkaparinga Estuary (300); Seal Bay, Bales Beach (1,140); St Kilda-Chapman Creek (870); Troubridge Hill (460); West Island (65); Whyalla-Cowleds Landing (3,230); Yatala Harbour (1,426).
(Subtotal: 15,020 ha)

Restricted Use Areas: Jetties, piers, wharves and netting closures (number and area not available); Outer Harbour - Marino (2,166); Rivers Hindmarsh and Inman (25).
(Subtotal: >2,191 ha)

Sanctuaries: Cape Jaffa (950); Gleasons Landing (350); Margaret Brock Reef (314); Penguin Island-Rivoli Bay (40).
(Subtotal: 1,654)

(2) ***South Australian National Parks and Wildlife Act*** **1972:**
Conservation Park: Clinton (165); Port Gawler (380); Seal Bay (2); Troubridge Island (30); Hallett Cove (30).
(Subtotal: 607 ha)

National Park: Coorong (3,178)

Game Reserve: Coorong (6,840)

(3) ***Historic Shipwrecks Act*** **1981**
Historic Shipwreck Protected Zone (95)

State total MPAs: 29,585 ha

waters of any State. Of the 14 MPAs declared since 1971, only two were created in the past decade. South Australia has only 295 square kilometres of MPAs (1.4% of its waters), which constitutes only 0.07% of the nation's MPAs.

Description of MPAs, by purpose

South Australia's MPAs have been established for a number of purposes: ecologically representative areas; protection of endangered species and habitats; protection of breeding sites of economically important species; tourism, recreation and education; cultural and historical purposes; research purposes; and environmental monitoring.

Ecologically representative areas

South Australia is included in the southern, temperate Flindersian Province of Australia. Within South Australia there are two major coastal sub-provinces: the cold temperate south-east (Maugean Sub-province) and transitional cool to warm temperate west.

Aquatic Reserves have been established to represent the three major habitat types: estuaries, mangrove-seagrass communities, and reefs and rocky shores. Several different habitats are represented within some of the larger MPAs.

Estuaries are of special importance in South Australia because of the State's generally arid nature. South Australia has the fewest estuaries in Australia (15), of which only three have been given habitat protection as Aquatic Reserves. These have been on the basis of fish habitats rather than for environmental reasons. Estuaries of outstanding conservation value include the Coorong (reserved), northern Spencer Gulf and Tourville Bay, Little Para River, Tod River, Eight Mile Creek and Kangaroo Island's Harriet, Stunsail Boom and Cygnet Rivers.

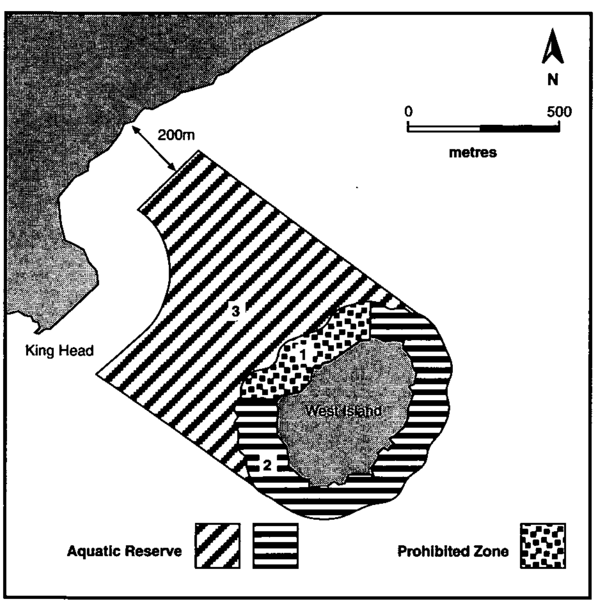

Figure 80.2: West Island Aquatic Reserve.

Aquatic Reserves established to protect ecologically important mangrove and seagrass communities include: Whyalla-Cowleds Landing and Blanche Harbour-Douglas Bank (Spencer Gulf); Yatala Harbour; American River Inlet (Kangaroo Is.); and Barker Inlet-St Kilda and St Kilda-Chapman Creek (Adelaide).

Aquatic Reserves established to protect the diverse fauna and flora of rocky reefs include: Port Noarlunga Reef-Onkaparinga Estuary, Aldinga Reef, Troubridge Hill, Goose Island (all in Gulf St Vincent and Spencer Gulf) and West Island. No reefs in the more exposed south-east or west coast of the State are reserved.

Bioregions and habitats not well represented

The Maugean Sub-province is not currently represented in the State's MPAs. Bioregions not well represented include the West Coast limestone cliffs and dune transgressions (from southern Eyre Peninsula to the Western Australian border), and northern Spencer Gulf which has a distinct tropical and possibly relic algal flora and endemic epifauna. Habitats under-represented include kelp communities, soft-bottom benthos, estuaries, beach habitats and wave-exposed cliffs.

Protection of endangered species and habitats

The Seal Bay Aquatic Reserve on Kangaroo Island and Point Labatt Aquatic Reserve on the West Coast were established to protect the habitat and main breeding areas of the rare Australian sea lion. The former provides sanctuary for several hundred sea lions, while the latter protects the only sea lion breeding colony on the Australian mainland. There has been a recent proposal to establish a Marine Park at the head of the Great Australian Bight to protect the calving sites of the endangered southern right whale.

Protection of breeding sites of economically important species

Many of the reserved mangrove and seagrass areas were established to protect important nursery and feeding areas of commercial species such as King George whiting, yellowfin whiting, jumping mullet, prawns and crabs. It has recently been demonstrated that reserves also provide an important larval source for the blacklip abalone.

Tourism, recreation and education

Many of the reserves established to conserve reef fauna and flora provide opportunities for scuba diving and fishing. Port Noarlunga Aquatic Reserve is South Australia's most intensively used aquatic

Port Noarlunga Reef-Onkaparinga Estuary, Aldinga Reef Aquatic Reserves

These reef habitats are close to Adelaide and are very popular with scuba divers. They were established in 1971 to protect fishes from spearfishing. Port Noarlunga Reef is 1.6 kilometres long and formed from a consolidated Pleistocene sand dune, while Aldinga Reef is a limestone reef with a spectacular cliff or 'drop-off'. These reefs include brown algal communities (e.g. *Ecklonia radiata*, *Cystophora* and *Sargassum* species), a range of invertebrates (e.g. sponges, hydroids, bryozoans, ascidians and mollucs), and a diverse array of reef fish. However, they are susceptible to human impacts from recreational users and land-based pollutants.

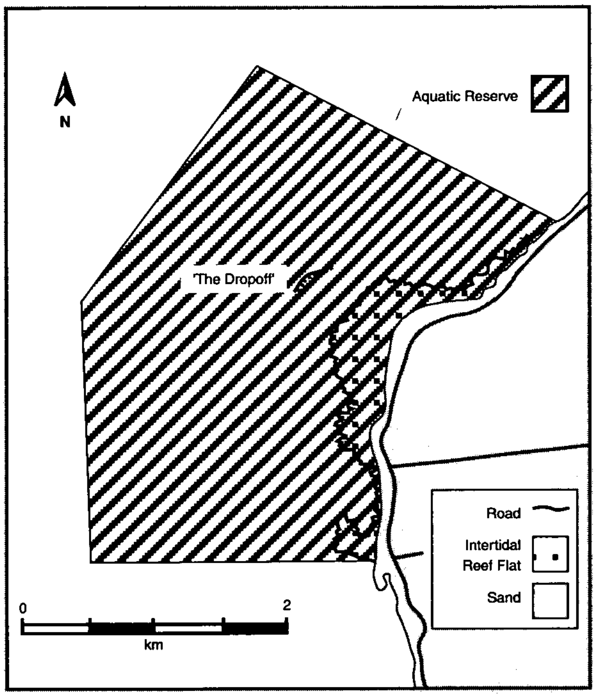

Figure 80.3: Aldinga Reef Aquatic Reserve.

Historic shipwrecks

Protected under South Australian legislation are:
Gulfs region: *Tigress* (1840-48); *Grecian* (1841-50); *Marion* (1850-51); *Nashwauk* (1853-55); *San Miguel* (1865-67); *Zanoni* (1865-67); *Iron King* (1867-73); *Star of Greece* (1868-88); *Glenpark* (1897-1901); *Norma* (1889-1907); and *Santiago* (1856-1945).
Wardang Island: *Songvaar* (1884-1912); *Moorara* (1909-1975), *Australia* (1879-1912); *MacIntyre* (1877-1927); *Monarch* (1871-1909); *Notre Dame D'Arvor* (1902-1920), *Investigator* (1882-1918) and *Aagot* (1882-1907).

Protected under Commonwealth legislation are:
South-east/Coorong region: *Margaret Brock* (1848-52); *Nene Valley* (1852-1854); *SS Admella* (1857-1859); *Geltwood* (1876); and *Glenrosa* (1857-1908).

Kangaroo Island: *Fides* (1857-1860); *Loch Vennachar* (1875-1905); *Montebello* (1900-1906); *Robert Burns* (1857-1908) and *SS Clan Ranald* (1900-1909).

habitat. However, a survey in 1987 indicated that fewer than 50% of users were aware of its protected status, necessitating the erection of signs showing its boundaries and permitted and non-permitted activities. An underwater interpretation trail was established on the reef to heighten public awareness of the marine environment and the need for protection.

Cultural and historic purposes

South Australia has a rich maritime heritage and a number of well known shipwrecks dating from 1840. Historic shipwrecks are generally well protected in South Australia, particularly within the sheltered gulfs. Nineteen wrecks are protected under the South Australian Historic Shipwrecks Act and ten in Commonwealth waters are protected by the Commonwealth *Historic Shipwrecks Act* 1976.

Research purposes

Only one MPA has been established for research purposes. West Island was reserved in 1971 to protect local abalone and provide a research station for long-term ecological studies and population studies on abalone. Areas around other research stations (e.g. Coobowie on York Peninsula) and major research sites require similar protection. These include Cape Jervis on Wright Island, Rosetta Head at Victor Harbour, Pearson Island (Investigator Group), and St Francis Island (Nuyts Archipelago).

Environmental monitoring

Three Aquatic Reserves are located close to urban centres and are subject to a number of human impacts (Aldinga Reef, Port Noarlunga Reef and Barker Inlet-St Kilda Aquatic Reserves). The last site is adjacent to metropolitan Adelaide and is influenced by sewage effluent, stormwater discharge and cooling waters from a power station. Studies have shown that heavy metals have accumulated in the mangrove-seagrass ecosystem.

Future of MPAs in South Australia

Despite its early lead in the establishment of MPAs, South Australia has only a limited area of MPAs. South Australia lacks the large, multiple-use MPAs which have now been adopted as a strategic tool in most other States to manage a number of activities and uses on a large, regional basis. The amendments to the Fisheries Act in 1991 now allows the establishment of large, multiple-use Marine Parks.

In 1989 the South Australian Government announced its intention to establish the State's first Marine Park, the Great Australian Bight Marine Park. The primary purpose of this would be to protect the critical breeding and calving areas of the endangered southern right whale. The proclamation of the park is yet to proceed.

The proposed Great Australian Bight Marine Park

Location
From the Dog Fence, just west of Cape Adieu, to Eucla in Western Australia, and a distance out to sea of 12 nautical miles.

Area
1,614 sq km State waters; 9,906 sq km Commonwealth waters.

Purposes
To protect critical breeding sites of endangered southern right whales *(Eubalaeena australis)* and other species. The world population of southern right whales is 3,000 individuals, and the Australian population is 400-800. At least 17 other species of cetaceans have also been recorded in the area, including blue, sperm, minke and humpback whales. Two species of pinnipeds also occur here: the New Zealand fur seal *(Arctocephalos forsteri)* and the rare Australian sealion *(Neophoca cinerea)*.

The area has a high species diversity of other fauna and flora (e.g. South Australia has >200 species of sea squirts, the highest in the world).

Geology and geomorphology
Spectacular steep Tertiary limestone cliffs extending 209 km from Head of Bight to Wilsons Bluff in west. These average 90 metres in height in western Nullarbor. The last 30 kilometres is partly transgressed by the Holocene dunes which build the extensive Merdayerrah Sandpatch.

Oceanography
The warm Leeuwin Current brings tropical species from the north-west, such as the tropical pelagic oriental bonito and southern bluefin tuna which travel with the Leeuwin from their spawning grounds in the Java Sea. It is probably also responsible for relic tropical marine flora. The continental shelf is broad and shallow.

Fisheries
Commercial fisheries include shark gillnetting; deepwater flathead trawling; southern bluefin tuna; abalone; southern rock lobsters. Recreational fisheries include mullaway and other species.

Scenic and wilderness values
The scenic and wilderness values are very high. Coastal regions are typically undisturbed with low levels of human habitation.

Cultural values
Important Aboriginal and non-Aboriginal sites are present. No historic sites currently protected.

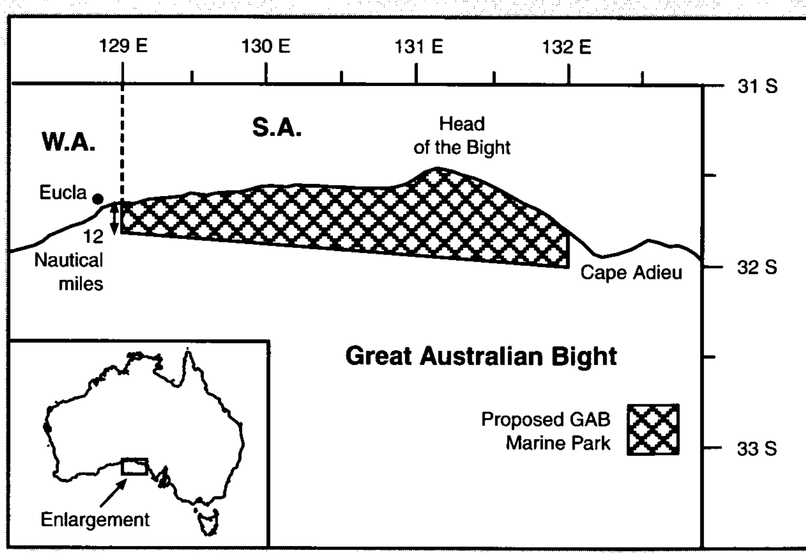

Figure 80.4: Proposed Great Australian Bight Marine Park.

The Department of Primary Industries (Fisheries) is currently undertaking a strategic review on the status and management of MPAs, including the integration of the State's MPAs within a national, representative system of MPAs, as proposed in the Ocean Rescue 2000 program. As part of this, SARDI (Aquatic Sciences) is undertaking a long-term research program to: identify the range of habitats and communities; identify bioregions and potential MPAs; develop marine monitoring methodologies; and develop an appropriate education program to promote MPAs.

Summary and conclusions

1. South Australia's diverse marine and coastal ecosystems are of great ecological, cultural and economic importance.

2. South Australia was the first State to introduce comprehensive legislation to protect aquatic habitats in 1971. It currently has 28 MPAs, declared under three sets of legislation, with a total area of 295 square kilometres.

3. The proportion of MPAs in South Australia is currently the least of any Australian State. The existing MPAs are small (although highly protected). They are designed to protect specific sites or habitats largely for fisheries management purposes. Important bioregions and habitats and management objectives are under-represented.

4. A strategic review of MPAs is underway in the State, and research is being conducted on habitats, communities and bioregions, and the number, size and location of MPAs which may be integrated into the Ocean Rescue 2000 program.

5. The first, large multiple-use Marine Park is planned for the head of the Great Australian Bight.

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Acknowledgments:
The paper by Dr Edyvane was reviewed within the South Australian Research and Development Institute (Aquatic Sciences), and by the Department of Environment and Planning, Adelaide, South Australia.

Chapter 81: Marine conservation and marine protected areas in Western Australia[1]

Western Australia has a long and varied coastline with a high diversity of marine life. Its northern shores lie in the tropical zone and feature extensive coral reef and mangrove ecosystems, equivalent but significantly different to those of north-eastern Australia. The southern shores lie in the temperate zone and have a distinctive flora and fauna because of the climate and a very different geological history to that of the north. Western Australia has an active marine conservation program. It currently has six marine parks (including the major Ningaloo and Shark Bay Marine Parks) and one marine nature reserve, totalling 1.144 million hectares in area. An extensive network of marine reserves has been recently proposed.

Most of Western Australia's major towns and cities are situated on the coast, and economically important commercial fishing, shipping and petroleum industries occur in coastal and offshore waters. Marine recreation and tourism are rapidly developing; recreational fishing and diving both play important roles in both regional and local economies. The Ningaloo Reef, Shark Bay and the metropolitan reefs are already extensively used by local people, and national and international visitors. Despite the vastness of the coastline, there are already many situations where management and protection measures are necessary to ensure that natural resources are shared equitably and utilised in a permanently sustainable manner.

Legislation and responsibilities in the marine environment

Conservation of marine species is undertaken through fisheries and wildlife legislation. The Western Australian *Wildlife Conservation Act* 1950 protects flora and flora throughout the State, including that living in or migrating to or through State waters. Several threatened species are given special protection under the Wildlife Conservation Act. Fisheries are managed under the *Fisheries Act* 1905.

Impacts of human activities such as mining, fishing, shipping, industrial pollution or tourism on marine habitats may be controlled by permit or licence under the respective controlling legislation, or the *Environmental Protection Act* 1986. Coastal lagoons, estuaries and rivers in the more populous south-west which are subject to heavy use are controlled by a number of different authorities. The Waterways Commission was established under its own legislation to ensure that waterways are conserved and effectively managed to maintain or enhance environmental quality and public amenity. The Swan River Trust was established to control pollution in the estuary of that river.

Marine reserves

Attention was first officially drawn to the need for marine conservation reserves in the State in 1974 by the Conservation Through Reserves Committee which was appointed by the Environmental Protection Authority (EPA) to evaluate and review national parks and nature reserves. The EPA's subsequent recommendations, some of which have since been implemented, included reservation of several marine areas.

Marine reserves legislation

The *Conservation and Land Management Act* 1984 (CALM Act) established the National Parks and Nature Conservation Authority as a new vesting body for conservation reserves, with the Department of Conservation and Land Management (CALM) as the government managing agency.

Marine reserves may also be established under special legislation and under the Fisheries Act. The *Rottnest Island Authority Act* 1987 established the Rottnest Island Reserve including waters for a distance of 800 metres surrounding the island. Two small areas within this area have been declared 'conservation zones'.

Under the CALM Act, Marine Nature Reserves are reserved for: '(a) the conservation and restoration of the natural environment; (b) the protection, care and study of indigenous flora and flora; and (c) the preservation of any feature of archaeological, historic or scientific

[1]Based on a paper by Dr B.R. Wilson, Murex Consultants, for Department of Conservation and Land Management, Como, Western Australia.

interest.' Marine flora and fauna may not be 'taken' except for scientific purposes under licence. Recreational and commercial fishing are not permitted.

Under the CALM Act, Marine Parks are reserved for *'... the purpose of fulfilling so much of the demand for recreation by members of the public as is consistent with the proper conservation and restoration of the natural environment, the protection of indigenous flora and fauna and the preservation of any feature of archaeological, historic or scientific interest ...'*

Commercial and recreational fishing are permissible in marine parks in accordance with the Fisheries Act and administered by the Fisheries Department. Marine parks can be considered a multiple-use category of marine reserve and management for restricted conservation or recreation purposes is achieved through zoning schemes formalised in management plans.

Marine reserves management policy

The Department of CALM adopted a policy statement in 1991 for marine reserves with the general operational objective being: *To establish and manage a system of marine and estuarine reserves for the conservation of the flora and fauna, ecosystems and habitats, environmental research and reference, and such public recreation and commercial use as may be consistent with the maintenance of the natural environment.*

A Marine Parks and Reserves Selection Working Group, an expert group established by the Minister for the Environment, has divided the Western Australian coast into five Coastal Geographic Zones, roughly based on the major geomorphological, climatic and biogeographic features, and each of these was considered in terms of significant habitat types present. The objectives were to identify areas which contain representative samples of the habitats, flora and fauna characteristic of each Zone; and to identify areas which have special conservational and recreational value making them worthy of special protection. The Working Group reported on these in 1994.

Management roles and infrastructure

Within the Department of CALM, responsibility for marine park policy and administration lies with the Directors of Nature Conservation and National Parks, and their support staff. Field activities and specific park management are undertaken through the Department's Regional Operations structure. Ningaloo and Marmion have Managers with specialist marine training. In Ningaloo, Shark Bay and Shoalwater Islands Marine Parks, management is integrated with that of the adjacent terrestrial reserves. Management of recreational and commercial fisheries is carried out by the Department of Fisheries. Enforcement is undertaken as necessary, for example, during the abalone seasons in the Marmion and Shoalwater Islands Marine Parks.

Because the marine reserve program is a relatively new venture and has come at a time of restrictions for government resources, it has not been possible to create a whole new marine reserve infrastructure. Rather, the positions allocated to marine management have come from the re-allocation of existing resources from other areas.

In July 1994 the State government announced that a new vesting authority for marine reserves would be established. A new reserve category, Marine Management Area, which is explicitly multiple-use, is to be created under the CALM Act. A detailed policy on access for petroleum development was also released.

CALM zoning policy

CALM has developed a zoning policy, applied through the management planning process, for multiple-use areas. The four categories are:

Sanctuary Zone: with complete protection of the ecosystems. Extractive uses such as fishing are not permitted, but compatible recreational and tourism activities may occur subject to supervision. (A sanctuary zone has the same level of protection as a marine nature reserve without the statutory protection, as its boundaries may be changed during management planning).

Recreation Zone: designated for public recreational activities such as boating and fishing, while maintaining habitats and communities in as undisturbed a state as possible. Commercial fishing is not permitted, but commercial tourism which is compatible with public use and environmental protection is permitted.

General Use Zone: designated for recreational and commercial use, including extractive uses such as fishing, subject to management to ensure sustained production while maintaining habitats and living communities in as undisturbed state as possible.

Other: for any specified conservation, recreational or commercial activity or combination, consistent with the purpose of the park.

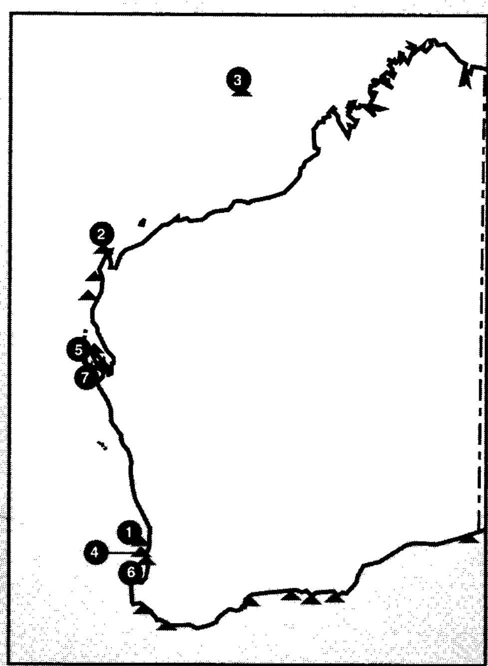


Figure 81.1: Western Australia has biogeographically distinctive tropical and temperate fauna and flora, and an overlap zone. Western Australia has an active marine protected areas program, with seven areas totalling 11,459 sq kilometres. These are (1) Marmion; (2) Ningaloo; (3) Rowley Shoals; (4) Swan Estuary; (5) Shark Bay; (6) Shoalwater Islands Marine Parks; and (7) Hamelin Pool Marine Nature Reserve. A comprehensive scientific report was released in 1994 identifying around 70 candidate areas for a network of MPAs, from the Kimberley Coast in the north, to the southern coast.

Descriptions of selected marine protected areas

Rowley Shoals

Rowley Shoals comprise three remote, oval shaped, coral atolls (Clerke, Imperieuse and Mermaid Reefs) along the edge of the North West Shelf, west of Broome. They are among the world's most pristine atolls and have a rich coral and fish fauna. Although occasionally visited by Indonesian fishers and boat charters from northern ports, they have not been subject to intensive fishing pressure. Shell collecting and the taking of giant cods are prohibited under fisheries legislation. As Clerke and Imperieuse have emergent sand cays, the waters within three nautical miles are Western Australian territory. Mermaid Reefs is Commonwealth territory and has been declared a national nature reserve under Commonwealth legislation. Management as a single unit is planned.

Shark Bay Marine Park

Shark Bay, and its eastern inlet known as Hamelin Pool, was initially recommended as an aquatic reserve by the EPA in 1975. The Bay was nominated for listing as a World Heritage Area, and was accepted in 1991. After an extensive public participation phase, the Hamelin Pool Marine Nature Reserve and Shark Bay Marine Park were gazetted in 1990, and the northern half of the Peron Peninsula was reserved as a national park in 1993. Shark Bay Marine Park covers an area of about 748,700 hectares.

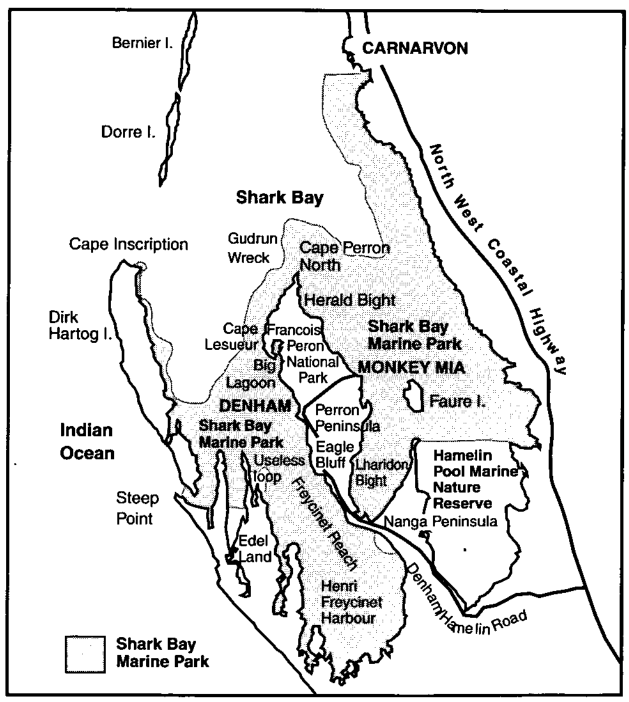


Figure 81.2: Shark Bay Marine Park.

The outstanding marine features described in the nomination included the unique stromatolites and hypersaline environment of Hamelin Pool, and the Wooramel Seagrass Bank which supports one of the world's largest dugong populations, estimated to be around 10,000. The area also has a unique benthic fauna of the extensive carbonate sand flats, the southernmost nesting sites of two species of sea turtles and the famous dolphins of Monkey Mia. CALM is currently preparing a management plan to protect the important natural features whilst facilitating recreation and tourism, and sustaining existing fisheries.

Marmion and Shoalwater Islands Marine Parks

These metropolitan marine areas were recommended for reservation by the EPA in 1983. Marmion, which encompasses a section of the mainland coast characterised by limestone reefs, seagrass beds and spectacular underwater caves, was the first declared marine reserve in Western Australia and a management plan was finalised in 1991. Its biota is characteristically temperate, with some tropical stragglers. Humpback whales migrate through the park in their journeys between Antarctica and the North West Shelf, and sea lions use Little Island as a resting place.

Marmion is used extensively for recreation. It is easily accessible and provides safe refuges for small craft. It contains popular diving, fishing, surfing and swimming areas. Problems include crowding, equitable access, and maintenance of fish stocks.

Shoalwater Islands Marine Park has similar features to Marmion. It is a deep basin in Warnbro Sound and is unique as the only similar habitat, in Cockburn Sound, is now highly industrialised and polluted. The seagrass meadows off Becher Point are among the most extensive on the west coast. The islands provide nesting sites for a wide variety of seabirds, including important populations of the little penguin (on Penguin Island), and haul-out sites for the Australian sea lion (on Seal Island). Like Marmion Marine Park, it is subject to rapidly increasing recreational use as the adjacent coast is among Perth's

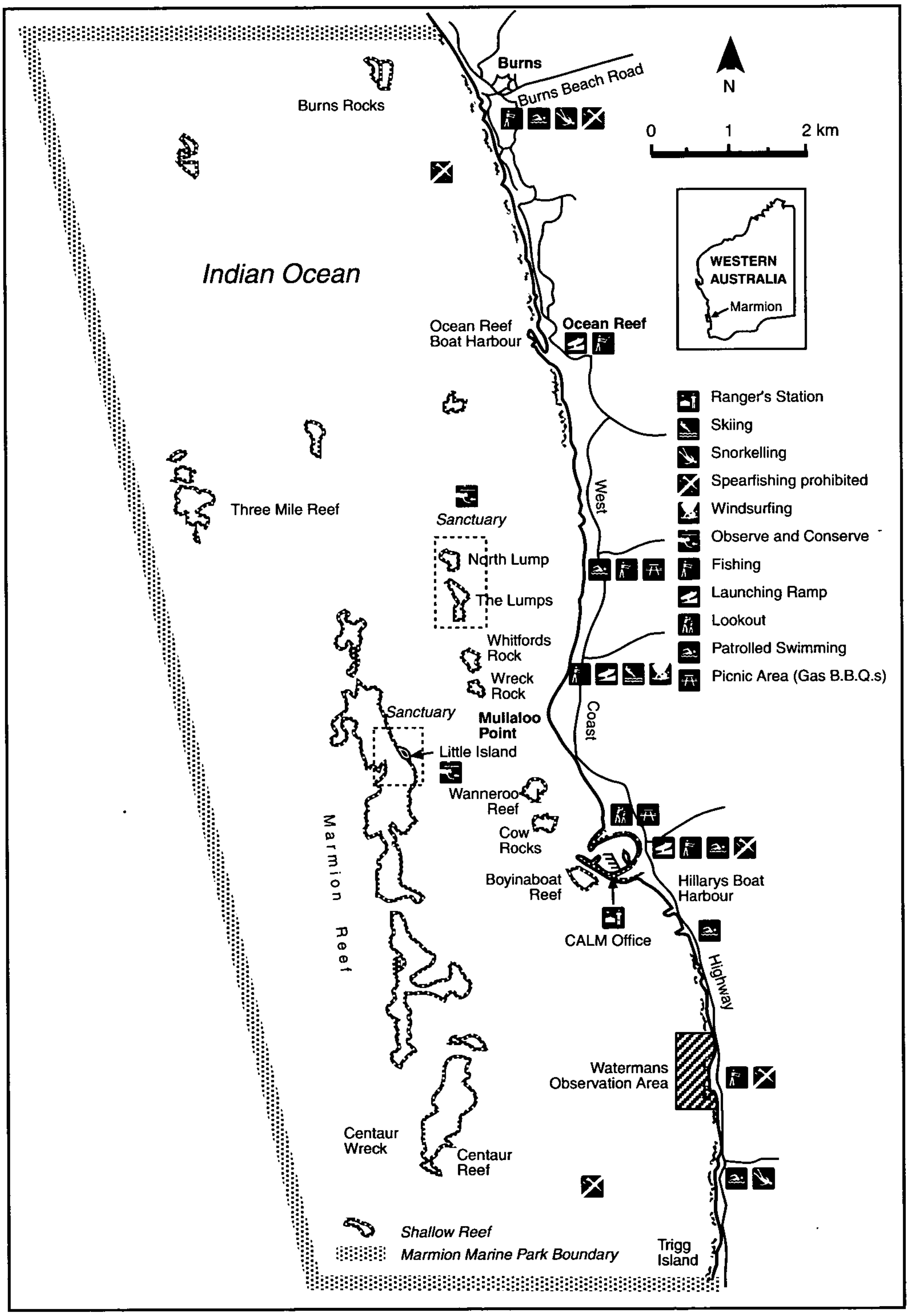


Figure 81.3: Marmion and Shoalwater Island Marine Parks.

fastest growing housing areas. A management plan is currently being produced.

Swan Estuary Marine Park

In 1990, three sections of the shore of the Swan Estuary - Milyu in South Perth, Alfred Cove in Attadale, and Pelican Point in Crawley - were reserved primarily as habitat for migratory wading birds. Because of considerable recreational use in two sites, they were given Marine Park status. CALM is currently producing a management plan to address potential conflicts between recreational use and protection of wader habitat.

Ningaloo Marine Park

This unique mainland fringing reef is described in detail in Chapter 70.

Table 81.1: Marine Reserves established under the CALM Act

Marine Park (& no.)	Area (ha)	Gazettal date	Management plan approved
Marmion (1)	9,350	1-5-87	30-1-91
Ningaloo (2)	224,,000	3-4-87	12-10-89
Rowley Shoals (3)	23,250	15-5-90	
Swan Estuary (4)	340	25-5-90	
Shark Bay (5)	748,735	30-11-90	
Hamelin Pool (6)*	132,000	25-5-90	
Shoalwater Islands	6,545	25-5-90	
Total area	1,144,220		

* Marine Nature Reserve

Future marine protected areas

The Marine Parks and Reserves Selection Working Group completed a draft report in 1994 recommending candidate areas for additional reserves along the Western Australian coastline. Some of these endorsed previous EPA, CALM and other recommendations. They include recommendations for major marine reserves on the Kimberley and Pilbara coasts representing tropical mangrove and coral reef environments; on the West Coast representing the limestone reef and lagoonal habitats typical of the tropical-temperate transition zone; and on the South Coast representing the complex granite shore and estuarine habitats characteristic of the temperate south. Each recommen- dation, if accepted in principle by the Government, will require detailed notices of intent providing opportunities for public comment.

While this will eventually establish a network of marine protected areas, it is recognised that considerable resources will be required for their effective management.

Summary and conclusions

1. Western Australia has a vast coastline with biogeographically distinctive tropical, temperate and overlap fauna and flora.

2. Marine environmental authorities include the Department of Conservation and Land Management (primarily responsible for marine reserves), Department of Environment Protection (responsible for marine environmental protection), the Fisheries Department (responsible for protecting fish stocks and managing fisheries), and various commissions (responsible for specific waterways).

3. Western Australia has an active marine reserves program, with seven major areas totalling 1,144,220 hectares.

4. A system of reserves is planned to extend from the Kimberley coast in the north, to the southern coast.

Acknowledgments:
The paper by Dr Wilson was internally reviewed within WA CALM, Como, Western Australia.

Chapter 82: Marine conservation and marine protected areas in the Northern Territory[1]

From the rich waters of the Gulf of Carpentaria, to the wilderness of Arnhemland and wetlands of Kakadu, the Northern Territory's coastal and marine environments contain some of the most culturally, scenically and ecologically significant areas around Australia. The Northern Territory has a sparse population and few of the problems of the southern States. Around 84% of the coast is owned by Aboriginal people who have strong cultural ties to the sea, a well developed system of traditional custodianship, and spiritual connections with numerous sites and species of marine fauna and flora. The challenge in the Northern Territory will be to maintain the unique nature of the marine environment under the increasing pressures of economic development.

The management of the diversity of marine and coastal environments and interests in the Northern Territory takes a number of forms, including fisheries management regimes, the Coastal Management Policy, land use planning provisions, and a system of marine protected areas. This chapter reviews the Territory's approach to marine conservation and MPAs and indicates future directions for MPAs.

Legislation and responsibilities for marine protected areas

MPAs under Northern Territory jurisdiction are managed by the Conservation Commission of the Northern Territory and the Department of Primary Industry and Fisheries, either jointly or separately.

Conservation Commission Parks and Reserves
MPAs managed by the Conservation Commission are established under the *Territory Parks and Wildlife Act*, the *Crown Lands Act*, or park-specific legislation. Section 12 of the Parks and Wildlife Act provides for the reservation of marine or terrestrial areas as parks or reserves, each requiring preparation of a Plan of Management. The by-laws of this Act enable the Conservation Commission to manage a range of park uses such as tourist programs and facilities, fishing, vehicular access, boating and camping. Cobourg Marine Park, the Territory's largest, was declared under this Act.

Lands may also be reserved under Section 76 of the Crown Lands Act for the 'recreation or amusement of the public', 'the preservation or protection of places of historic interest', and 'the protection and conservation of native wildlife and fauna.' Casuarina Coastal Reserve, a popular recreation area in Darwin, was reserved under this Act but the Management Plan is enforced under the by-laws of the Territory Parks and Wildlife Conservation Act.

Department of Primary Industry and Fisheries Reserves

The *Fisheries Act* 1988 and Fisheries Regulations provide the framework for the development, management and conservation of fish and aquatic life of the Territory. It provides for the management of fishery resources through management plans controlling all user groups; licensing of commercial fishers, traders and processors, aquaculture operators and others. It also acknowledges the rights of traditional subsistence fishing by Aboriginal peoples. Under Part III of the Act, the Minister for Primary Industry and Fisheries may declare an area or fishery to be a managed area or managed fishery. This requires a management plan, and a management advisory committee may be formed to advise the Minister. In addition to the managed fisheries, there are two declared managed areas for the protection of aquatic life, the Doctors Gully Aquatic Life Reserve, and the East Point Aquatic Life Reserve, both in Darwin.

Fisheries management in Marine Parks

While the Conservation Commission is responsible for the management of all flora and fauna within parks declared under the Territory Parks and Wildlife Conservation Act, it has been agreed that management of fisheries is more suitably undertaken using the specialised provisions of the Fisheries Act.

[1]Based on a paper by R. Billyard, Senior Planner, Conservation Commission of the Northern Territory, Darwin, Northern Territory; and Dr R. Pyne, Assistant Director, Policy and Administration, Department of Primary Industry and Fisheries, Darwin, Northern Territory.

This allows the application of existing Territory-wide fisheries regulations, use of more responsive Fisheries Management Plans, and avoids duplication of legislation and resources. The agreement provides for Marine Parks to be declared Fishery Management Areas under the Fisheries Act. Existing legislation over commercial and recreational fishing, including the Fisheries Regulations and the Barramundi, Spanish Mackerel, Pearl Oyster and Mud Crab Management Plans remain in effect within Parks, but may be supplemented with additional controls if necessary.

Types of marine protected areas

Because the Northern Territory coast is isolated and sparsely populated for most of its length, there has not yet been the need for intensive management. With the exception of the Cobourg Marine Park, all MPAs lie in the Darwin area, reflecting the intensity of resource use and the consequent need for special protection of significant sites.

Selection of MPAs

Existing MPAs have been set aside for a variety of purposes, including protection and conservation of marine life (e.g. Cobourg Marine Park, and Doctors Gully Aquatic Life Reserve); responses to particular threats (e.g. collection of aquarium specimens at East Point Aquatic Life Reserve); and public recreation and conservation (e.g. Casuarina Coastal Reserve).

With the assistance of the Ocean Rescue 2000 program, the Conservation Commission is now systematically identifying candidate areas for future MPAs. These will be based on physical factors such as climate, geology and currents; biological factors such as distribution of fauna and flora, habitats and endangered species; resource use such as tourism, fishing, mining and ports; and land tenure and cultural information such as Aboriginal cultural associations, and traditional hunting and fishing.

Management planning

Management planning for MPAs is undertaken by the Conservation Commission and the Department of Primary Industry and Fisheries. While there are some similarities in the processes (e.g. requirements for public consultation), they are sufficiently different to require explanation.

In the Conservation Commission Marine Parks management planning is undertaken by the Commission's Park Development Unit, with wide public involvement. A range of consultative mechanisms are required under the Territory Parks and Wildlife Conservation Act. Prior to declaration of a Marine Park, a report to the Administrator must be advertised and circulated for public comment. The production of a Plan of Management of a Marine Park requires a similar process of public scrutiny.

Management Committees may be formed for parks. These may include voluntary bodies advising on cooperative management between local people and the Commission.

Aboriginal involvement in MPAs

Aboriginal involvement in the planning and management of MPAs is increasingly important in the Northern Territory as around 84% of the coastline is under Aboriginal ownership. Much of this extends to the low-water mark, making Aboriginal people custodians of most intertidal lands in the Territory. This makes their involvement fundamental to the planning of MPAs.

Section 73 of the Territory Parks and Wildlife Act provides for agreements with Aboriginal Land Councils relating to schemes for the protection and conservation of wildlife and natural features on Aboriginal land. These agreements can also involve lease-back arrangements in which Aboriginal Land Trusts lease land to the Conservation Land Corporation for management of a park or reserve. The Conservation Commission then manages the area for, and on behalf of Aboriginal owners. Management Committees established under these agreements provide for a majority Aboriginal membership.

Resources for MPAs have been progressively increasing as the scale of the marine conservation estate has expanded. As most MPAs contain terrestrial components, it is not possible to separate direct expenditure. The total expenditure on Cobourg Marine Park and Casuarina Coastal Reserve has been around $1 million to date. Together with Gurig National park they employ ten staff, three of whom are Aboriginal Rangers at Gurig.

Department of Primary Industry and Fisheries Management Plans and MPAs

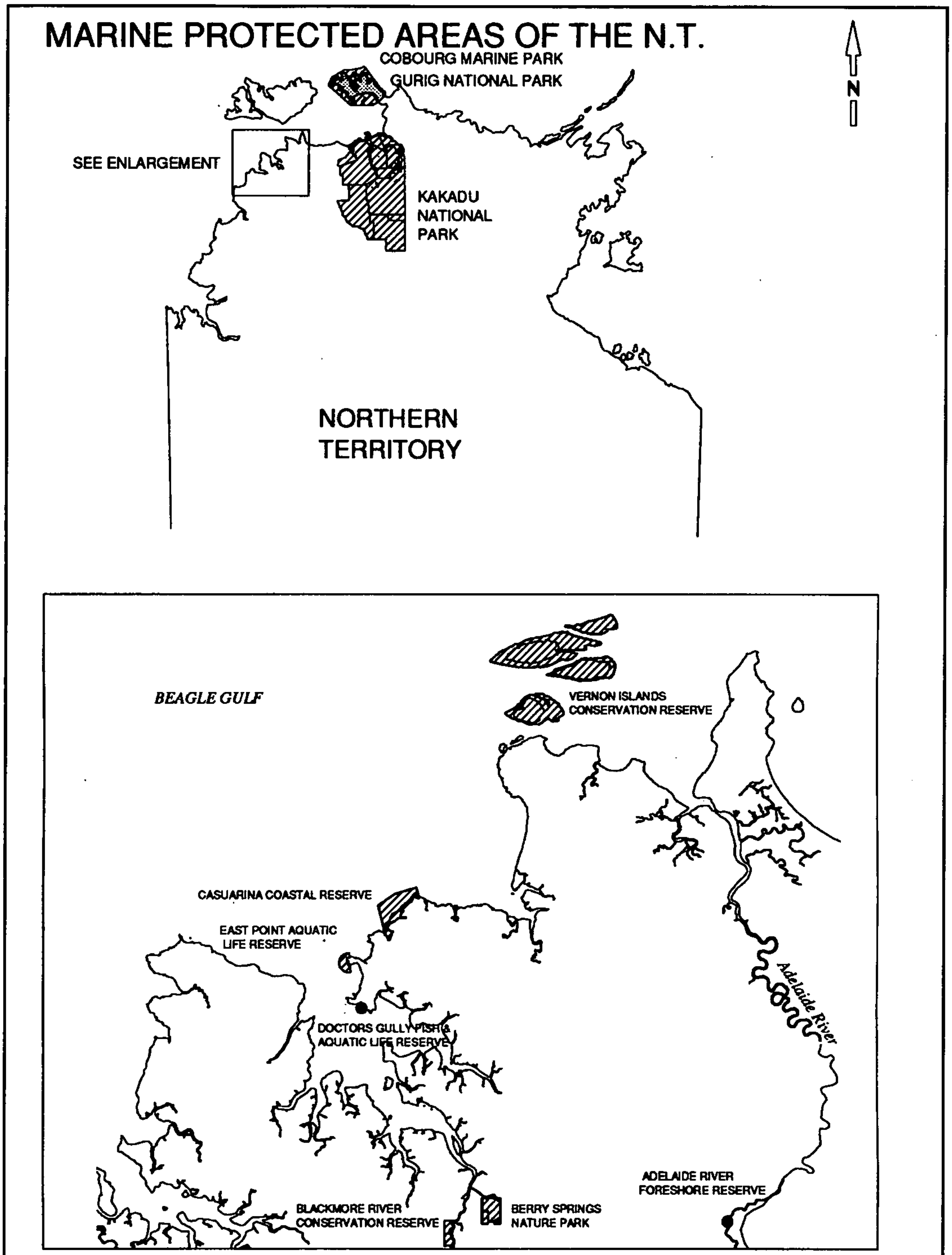
Development and management of Fisheries Management Plans, including those for MPAs, are the responsibility of the Fisheries Division within the Department of Primary Industry and Fisheries, and involves detailed public comment. A Fisheries Management Advisory Committee is appointed by the Minister and may be drawn from the commercial or recreational fishing sectors and other relevant bodies. After preparation, the Management Plan is submitted to the Minister who may then advertise the Plan and release it for further public comment.

The two Fisheries Reserves, both in Darwin Harbour, require few facilities and the regular monitoring of fish and aquatic life is undertaken by the Fisheries

Division. Fisheries surveillance and enforcement of the Fisheries Act and Regulations is undertaken by the Northern Territory Police; ten officers of the Fisheries Enforcement Squad carry out patrols along the coast. A number of Conservation Commission Rangers are empowered to enforce provisions of the Fisheries Act.

Commonwealth Fisheries Management

Under the Offshore Constitutional Settlement, the Commonwealth manages fisheries beyond three nautical miles, and the Northern Prawn Fishery to the high-water mark. It also manages the waters of Kakadu National Park.



Note:East Point Aquatic Life Reserve and Doctors Gully Fish and Aquatic Life Reserve are managed by the Department of Primary Industry and Fisheries. Other marine protected areas are managed by the Conservation Commission with the exception of Kakadu National Park which is managed by the Australian Nature Conservation Agency (Commonwealth). Gurig National Park is managed by the Conservation Commission for and on behalf of the Cobourg Peninsula Sanctuary Board.

Figure 82.1: Marine protected areas of the Northern Territory.

Descriptions of selected marine protected areas

Cobourg Marine Park

Cobourg Marine Park (229,000 hectares) is the most extensive MPA in the Territory. It was declared under Section 12 of the Territory Parks and Wildlife Conservation Act in 1983 to provide for the protection and conservation of the marine environment surrounding the Cobourg Peninsula and the Gurig National Park on the basis of its natural, Aboriginal, historic, recreational, educational and scientific values.

The area has extensive seagrass beds which are habitats for dugongs and turtles (flatback, green, leatherback, olive ridley, and hawksbill). It contains six known shipwrecks, and offers excellent opportunities for scuba diving, boating and fishing. A tourist facility, Seven Spirit Bay Wilderness Retreat, has been established in Coral Bay and specialises in eco-tourism.

The Aboriginal traditional owners of the Coburg Peninsula direct the management of Gurig National Park, via the Cobourg Peninsula Sanctuary Board. The traditional owners have an important input into planning and management of Gurig National Park and adjacent Cobourg Marine Park. Three Aboriginal Rangers are engaged in day-to-day management in Gurig.

Since declaration, management planning of Cobourg Marine Park has proceeded slowly because of complex issues including fisheries and wildlife management, Aboriginal involvement in management, and the traditional owners' desire for recognition of traditional ownership. Agreement on fisheries management has been recently achieved between the Conservation Commission and Department of Primary Industry and Fisheries, with the result that the Park has been declared a Fisheries Managed Area. A Fisheries Management Plan is being produced in conjunction with the Draft Plan of Management for the Marine Park.

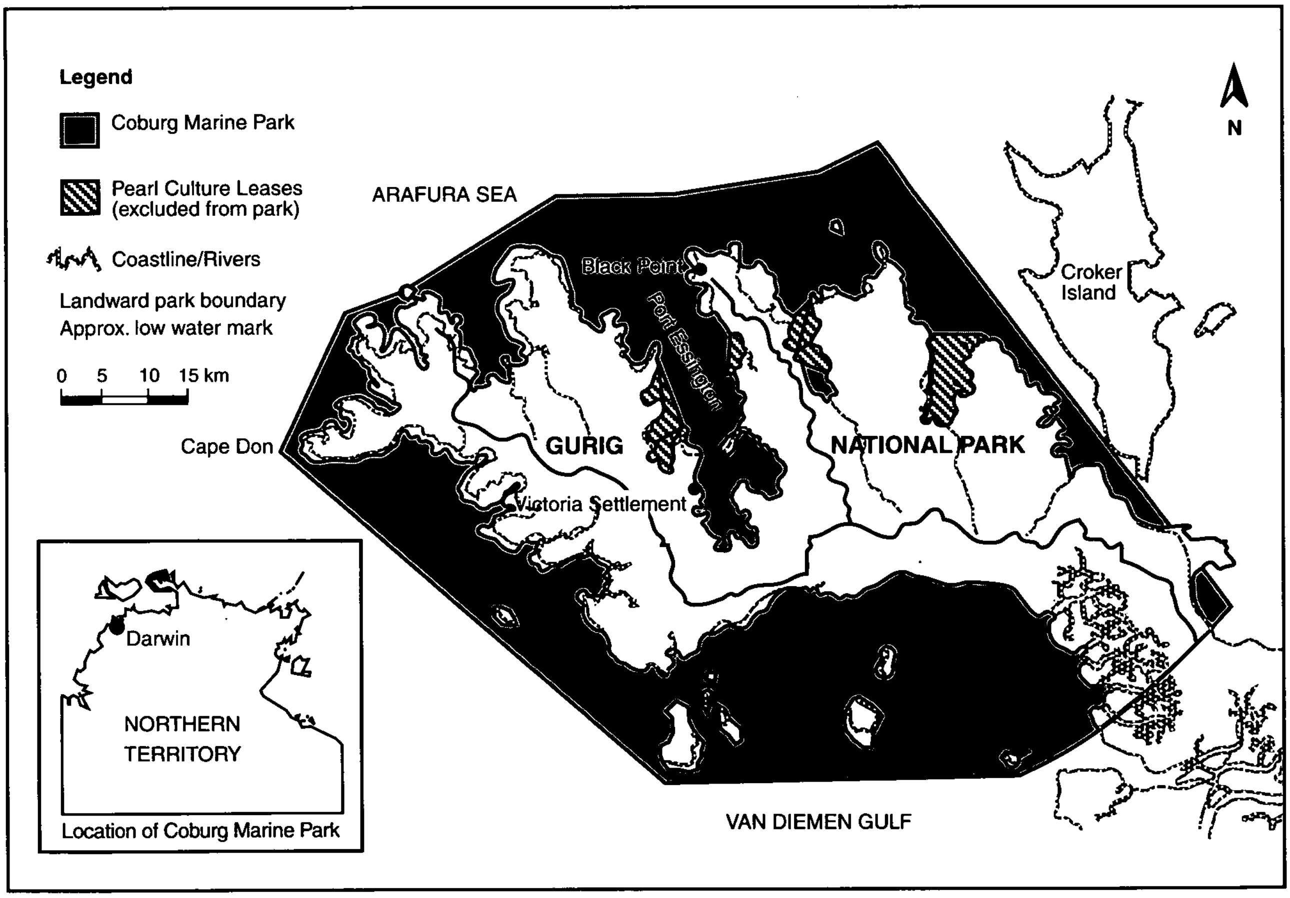


Figure 82.2: Cobourg Marine Park

Casuarina Coastal Reserve

Casuarina Coastal Reserve was reserved in 1982 under the Crown Lands Act, with management vested in the Conservation Commission. Its location along the shore of Darwin's northern suburbs makes it popular for recreation. It has the highest visitation rate of any park or reserve in the Territory, around 700,000 visits per year, mainly by local people. It is also one of Darwin's prime recreational fishing locations.

The Reserve contains extensive intertidal and subtidal seagrass beds. Dugongs are regularly sighted, and the beaches are occasionally used by nesting flatback turtles. The Larrakia Aboriginal people have associations with sites in the Reserve, particularly the sacred site of Dariba Nunggalinya (Old Man Rock), a prominent outcrop associated with the passage or dreaming track of ancestral beings. This is registered under the Northern Territory Aboriginal Sacred Sites Act.

The Casuarina Coastal Reserve Management Plan, prepared in 1991, and by-laws of the Territory Parks and Wildlife Conservation Act provide the basis for management. Proposals before government entail its incorporation into the proposed Beagle Gulf Marine Park, enabling more effective conservation while maintaining its recreational value.

East Point Aquatic Life Reserve

The East Point Aquatic Life Reserve was originally declared under the Fish and Fisheries Act in 1984 to control excessive harvesting of corals, anemones and aquarium fish by professional and amateur collectors, and tramping damage to the reef. Surveys by the then Darwin Community College (now the Northern Territory University) and the Northern Territory Museum found over 100 species of corals and anemones, 50 species of tunicates (sea squirts), 130 species of molluscs, 200 species of sponges and over 100 species of fish.

In 1991 the Northern Territory Museum of Arts and Sciences proposed that the sponge and tunicate beds to the west and south of the Reserve were also worthy of protection. A further 175 hectares was added and the area was renamed the East Point Aquatic Life Reserve. A Management Plan which came into effect in 1993 prohibits commercial fishing, the use of fishing gear other than a rod or line, the taking of fish less than 30 centimetres in length, and the removal of sedentary organisms such as corals and sponges.

The Reserve provides excellent opportunities for recreational, scientific and educational activities. It is popular with scuba divers and anglers, and is used for field studies by Darwin schools, and research by the Northern Territory Museum.

Future MPAs

Although the coastal population and pressures on the Territory's marine environment have been low to date, uses of the marine environment will undoubtedly increase in the future. The key to marine conservation in the next century will be the ecologically sustainable development of marine resources while preserving marine biodiversity.

MPAs will continue to be an important component of marine environmental management in the Northern Territory. Other components include fisheries management (e.g. controlling effort, netting closures in estuaries, closed seasons and areas for trawling, bag and size limits, and protected species), and environmental management arrangements such as oil-spill contingency planning, erosion control, environmental impact assessment, coastal monitoring, and protection of significant Aboriginal and heritage sites.

Through Ocean Rescue 2000 funding, the Conservation Commission has commenced developing a representative system of MPAs, the first of which is the Beagle Gulf Marine Park which will provide for sustainable resource use and protection of sensitive and significant sites in the Darwin region. The Commission is also developing the Coastal Resources Atlas, a computer database and mapping package. The Coastal Resources Atlas will provide a database of conservation values and resource use across the Territory coast and assist in the process of identifying potential MPAs.

The considerable experience gained in the joint-management of terrestrial areas with traditional Aboriginal owners will be applied to MPAs, and the consultative process developed with all interest groups will be maintained to ensure a high degree of public acceptance and voluntary compliance with the MPAs.

Summary and conclusions

1. The coastal and marine environments of the Northern Territory are amongst the most culturally, scenically and ecologically significant in Australia.

2. Human populations are low, the majority of the coast is uninhabited, and environmental pressures are currently minimal.

3. Four MPAs have been established under the Territory Parks and Wildlife Conservation Act, the Crown Lands Act, and under the Fisheries Act and Regulations.

4. A representative system of MPAs is currently being developed in conjunction with the Ocean Rescue 2000 program. The first of these is to be the large, multi-use Beagle Gulf Marine Park.

5. The management challenge in the following century is ecologically sustainable development whilst preserving the Territory's unique marine biodiversity.

Acknowledgments:
The technical paper by R. Billyard and Dr Pyne was reviewed internally in their departments.

Chapter 83: Summary and conclusions: major findings of the State of the Marine Environment Report for Australia[1]

On the basis of the existing limited information, and in comparison with both neighbouring countries and equivalent developed countries in the northern hemisphere, the condition or 'health' of Australia's marine environment might be rated as 'generally good', but with many important caveats or qualifiers.

The major concerns relating to Australia's marine environment are considered to be:

1. Declining marine and coastal water quality, and increased sedimentation, particularly as a result of inappropriate catchment land use practices.

2. Loss of marine and coastal habitat.

3. Unsustainable use of marine and coastal resources.

4. Lack of strategic, integrated planning in the marine and coastal environments.

5. Lack of marine science policy and lack of long-term research and monitoring of the marine environment.

(Based on the information obtained in the SOMER process and the conclusions of the SOMER Advisory Committee members; considered by members of the ANZECC Standing Committee; and endorsed by the Marine Environment Conference, 1995.)

This concluding chapter summarises the major issues and concerns regarding Australia's marine environment. It also makes a general assessment on the state of Australia's marine environment, and discusses recent findings on the state of the world's marine environment. It concludes with a summary of important Australian and United Nations reviews and agreements on marine environmental management.

The major issues

A great number and variety of issues and problems were identified by the technical experts who contributed to SOMER. While it was difficult to compare diverse environmental, social, management and scientific issues, the SOMER Advisory Committee identified from these what they considered to be the most serious issues affecting our marine environment.

1. Declining water quality

Declining water quality and increased sedimentation were regarded as probably the most serious issues affecting Australia's marine and coastal environments. Land and sea are closely linked in the coastal zone. Elevated nutrients and sedimentation are largely the result of inappropriate catchment land use practices, sewage discharges and urban run-off.[(1,6,40, 42-47,51-57)]

Nutrients and sediments

Elevated nutrients and sediments come from land-run-off. Land erosion is the major source in rural areas, and sewage and urban run-off is the major source in urban areas. Sediments alter estuaries and shores and smother marine life. Elevated nutrients cause eutrophication, the harmful growth of algae. Blooms of blue-green algae are now common in many estuaries and bays. Blooms of introduced and native species of toxic dinoflagellates (microscopic algae probably introduced in ships' ballast waters) are a serious problem in Victoria and Tasmania, and threaten other States. Eutrophication is a serious threat to estuaries, temperate seagrass and tropical corals (below).[(1,4,6,10, 12, 42, 51-56)]

Oil pollution

The major source of oil entering the marine environment is urban run-off. Small but frequent spills from fuelling vessels in ports; and operational discharges from ships are also a significant source. Australia has been lucky so far; only two major spills (over 1,000 tonnes) have occurred, and these resulted in little long term damage. A series of smaller spills since 1990 has caused greater damage to wildlife.[(36-39,43)]

[1] By Dr L. Zann, SOMER Coordinator, from the material in these chapters. Note: Superscript annotations refer to source chapters in this book, and to the technical papers from which they were written.

Heavy metals
Pollution from mercury, cadmium, lead and other heavy metals is a localised problem. Levels of heavy metals are high in seafood in Torres Strait; while mines in Papua New Guinea were implicated, preliminary research suggests that high levels are natural. Localised heavy metal 'hotspots' include Lake Macquarie (NSW), Corio Bay (Vic), Derwent and Macquarie Estuaries (Tas) and Port Pirie (SA). Tributyl tin from ships' antifouling paints is also a problem in many ports and marinas. Controls on industrial discharges and ships' antifouling paints have reduced levels in most areas monitored. [44,52-57]

Organochlorines
Some organochlorines or chlorinated compounds used as herbicides and insecticides in industry are toxic to marine life and are bioaccumulated or magnified in marine food chains. Away from farm lands and cities in Australia, levels are very low. Local 'hotspots' include Sydney's sewage outfalls and Homebush Bay and off Melbourne's Port Phillip Bay sewage outfalls and Corio Bay.[45,52,53]

Beach and ocean litter
Litter is a growing and very conspicuous problem on our beaches. Urban beaches are most affected but not even the remotest beach is free from litter. Litter reduces the scenic and recreational values of areas, and may affect wildlife. Turtles and whales may die from eating plastic bags. The incidence of seal entanglements in net fragments and other synthetic material in Tasmania is one of the highest in the world.[18,46,53,54]

2. Loss of marine and coastal habitats
Many of the environmental issues identified are related to water quality and loss of habitat, and are overlapping in nature.[7-14,51-57]

Degradation of estuaries and coastal lakes
Estuarine environments in much of eastern and southern Australia are declining because of eutrophication and sedimentation, acid soil run-off, coastal developments, loss of habitat and overfishing. South-eastern and south-western coastal lakes, which have limited ocean water exchange, have been particularly affected by terrestrial run-off.[6-8,51-57]

Declines in temperate seagrass
Seagrass beds are very important ecosystems. Elevated nutrients and sediments have caused serious die-backs of temperate seagrass beds in southern Australia. Around half of the seagrass in the estuaries of New South Wales has been lost. The majority of seagrass in Victoria's Western Port has been lost. Tasmania, the South Australian Gulfs and south-western Western Australia have also suffered locally serious declines in seagrass. A major loss of subtropical seagrass occurred in Hervey Bay in Queensland, causing a serious decline in the dugong population.[10,42,51-56]

Loss of mangrove and saltmarsh habitats
Significant losses of saltmarsh and mangroves have occurred near urban areas through reclamations, drainage and other developments. This affects fish and other sea life which use these as nurseries and feeding grounds.[6-8,51-57]

Inappropriate and unsustainable coastal development
Urban, industrial and port development, tourism and other uses have been responsible for significant degradation in the coastal strip in many areas around Australia, particularly in the south-east and south-west.[1,29,40,51-56,62]

Effects of fishing on sea floor communities
There is widespread concern about the environmental effects of trawling and scallop dredging on the sea floor community, on juvenile fish, on the waste of by-catch (the incidental catch), and on changes in marine food webs resulting from the discarded catch. The effects of fishing on the ecosystem is little known, but is likely to be significant. The large number of seabirds caught on tuna longlines is also of concern.[30,32,34,51-56,69]

Introductions of foreign species
The introduction of exotic pests and diseases via ships' ballast water is a potentially very serious problem in Australia's long isolated marine environment. Around 55 species are known to have been introduced, largely via ships' ballast waters and on ships' hulls. Blooms of introduced toxic marine algae and the ravenous Northern Pacific seastar threaten marine communities and aquaculture farms. Concerns exist on the introduction of diseases such as cholera via ships' ballast waters.[14,47,48,53,54]

Population increases in native species
Outbreaks of the coral-eating crown-of-thorns starfish has resulted in significant loss of corals in the central one third of the Great Barrier Reef, and on the Tasman Sea reefs. Similar outbreaks of the coral-eating *Drupella* snail have effected large areas of Western Australia's Ningaloo Reef. The causes of the outbreaks are unknown.[49,50,51,56,69,70]

3. Unsustainable use of marine and coastal resources
Overharvesting of fish and other marine life, coastal developments, and conflicting resource use, are critical issues around Australia.[29-35]

Declines in fish stocks
Australia is not rich in fisheries. We have experienced declines in some commercial fisheries over the past few years. Serious overfishing has occurred of

southern bluefin tuna, southern sharks, gemfish, rock lobsters and other species. There is also a serious lack of accurate catch data on many of Australia's fisheries.[30-34]

Inappropriate fisheries practices
Harvesting practices used in certain fisheries are causing significant impacts on marine ecosystems and habitats. Of particular concern are the practices of trawling and scallop dredging on sea floor communities.

4. Lack of strategic planning
Many of the problems identified in SOMER stem from the lack of integrated, long-term planning in the coastal and marine environments[1-47,51-57]. Australia does not have a clear direction or agreed national strategy for managing its marine or coastal environments.

The lack of strategic planning in the coastal zone has been identified as a major problem in a number of Commonwealth and State inquiries, most recently the Resource Assessment Commission's Coastal Zone Inquiry. Coastal zone management must consider the high degree of connection of land and sea (particularly catchment uses), the many human activities which span the land/sea interface, the wide dispersal of marine organisms and pollutants by currents, and the different administrative jurisdictions involved.[1-47,51-57,62]

5. Lack of marine science policy
Little geographically comprehensive and long-term scientific information is available on the marine environment. Without this it is difficult to accurately assess its condition, to identify trends, and to design and assess management programs. Many of the findings in SOMER are therefore based on limited data sets, descriptive information and expert scientific opinion.[1-57,63]

Lack of long-term research and monitoring of Australia's marine environment
Difficulties in establishing long-term research and monitoring programs include: high cost of marine studies; difficulties in obtaining long-term funding for research and monitoring; lack of coordinated data acquisition and storage; and lack of standardised, cost-effective, statistically based scientific sampling techniques and indicators.[6-18,28-57]

Lack of applied scientific knowledge on the marine environment
Local government environmental managers are highly critical of the lack of information on local marine environments, and the lack of simple, descriptive maps and inventories[51-57,62].

Lack of scientific understanding of the functioning of marine ecosystems
Marine scientists are more concerned about the lack of understanding of how marine ecosystems function. They argue that effective management must be based on this.[6-18]

6. Social issues
Lack of consideration of indigenous interests in the coastal zone
Outside the Northern Territory, the legal uncertainty as to the existence of customary sea rights for Aboriginal and Torres Strait Islander peoples, their general lack of involvement in environmental management and lack of commercial opportunities in fisheries and tourism are important social issues. The 1993 Native Title Act caters for both customary land and sea rights. However the issue of the existence of sea rights has not yet been the subject of an authoritative decision by a court.[20-22,84]

Lack of consideration of social and cultural values of the coastal zone
Despite the obvious great importance of the coast and sea to Australians, knowledge of the social or cultural values of the marine environment is limited. Social and cultural values are generally inadequately considered in coastal zone planning and management.[23]

7. Management issues
Lack of non point-source (diffuse) pollution controls
Guidelines and standards have been developed for point-source discharges. However, no guidelines have so far been developed for the multiple, non-point source or diffuse discharges from catchments. Constant, low levels of a range of different types of pollutants can have very serious chronic and synergistic effects.[42]

Deficiencies in environmental impact assessment
While EIA is an important instrument in Commonwealth, State and Local Government environmental policy in Australia its potential contribution of EIA to the overall management of the marine environment has not yet been fully realised. Deficiencies include: inconsistency of application; lack of total transparency in decision-making; failure to systematically incorporate cumulative impacts; questions of resource allocation; biases of environmental consultants towards the proponent (their client); and the complexities of jurisdiction, legal and policy instruments in the coastal zone.[59]

Insufficient representation of marine protected areas (MPAs)
About 5.2% of Australia's marine environment has some level of protection (<<1% has total protection).

However, a very large proportion of this (74%) is the Great Barrier Reef Marine Park. Many of Australia's marine bioregions are not sufficiently represented in MPAs.[67,77-80]

8. Regional issues

Hundreds of regional issues were raised in SOMER. The most serious include:

Condition of marine and coastal environments in south-east and south-west

The widespread degradation of estuaries, coastal lakes and bays in New South Wales, Victoria, Tasmania, South Australia and south-western Western Australia is a serious local and national problem. Major causes are elevated nutrients, sedimentation, pollution, coastal strip development and overfishing. Of particular concern are the unique coastal lakes which are not found in the less populated and less degraded north.[42-47,51-56]

Condition of 'urban' marine environments

Estuaries and coastal waters near the State capitals are generally the most disturbed parts of the marine environment. Some parts of Sydney Harbour, Port Phillip Bay, and the Derwent Estuary are so polluted by sewage, urban run-off and industrial discharges that they are frequently closed for bathing and fishing. However, controls on discharges are having an effect and most contaminated areas are showing signs of improvement.[42-47,51-56]

Threats to the Great Barrier Reef

Elevated nutrients from land run-off may be threatening the inner Great Barrier Reef. Corals are particularly sensitive to elevated levels of nitrates and phosphates. Some scientists fear the Great Barrier Reef lagoon, the waters between the mainland and the Great Barrier Reef, is eutrophic.[42,51,69] Also of concern are continuing outbreaks of the crown-of-thorns starfish[49, 69] and effects of fishing [32, 69].

Management implications

The most serious issues in Australia's marine environment stem from catchment use, and therefore declining water quality. Increased levels of nutrients and sediments are the major problems.

The most serious consequences of these are the die-back of seagrasses in temperate Australia[10] and threats to inshore corals in the wet tropics[12].

The major causes are soil erosion and declining inland water quality, two of our greatest problems on land[1]. The crisis in Australia's inland waters is well accepted. Elevated nutrients from soil erosion, agricultural fertilisers, live stock, sewage and urban run-off has resulted in regular blooms of toxic algae[14,42,53-55]. Not so well accepted is that this then becomes a problem in estuaries, coastal lakes, bays and coastal waters. Degradation of estuaries and die-back of seagrass cause declines in coastal fisheries[31].

The key issues in Australia are thus interrelated. Because the major source of marine environmental threats lie inland in the catchments, strategic, integrated planning and management in the coastal zone is of paramount importance. Integrated catchment management is probably almost as important to the sea as it is to the land.

Overview: the state of Australia's marine environment

It is not possible to simply and precisely assess the state of Australia's marine environment because of its vast size and great diversity, the diversity and complexity of issues affecting it, and the great gaps in our scientific knowledge of it.

However, on the basis of the existing limited information, and in comparison with both neighbouring countries and equivalent developed countries in the northern hemisphere, the condition or 'health' of Australia's marine environment might be rated as ***'generally good'***, but with many important caveats or qualifiers.

The condition of specific areas ranges from 'almost pristine' in very remote, undeveloped areas[12,42-47,73,75,76,81], to locally 'poor' off many highly developed urban, industrial and intensively farmed areas in the south-east[42-47,51-55], and south-west[56] of the continent. The condition of offshore environments is better than inshore environments because of dilution of pollutants[45].

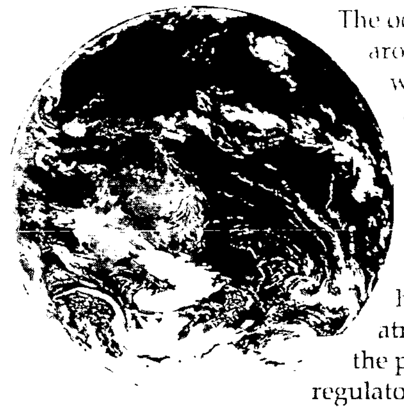
Undeveloped areas little affected

Most of our marine environment is far removed from the major population centres and is little affected by most human activities. The northern[57], far north-eastern[51,69] and most of the western coasts[57] of the continent, the Great Australian Bight[55] and Australia's External Territories[73] in the Indian Ocean, South Pacific, Southern Ocean and Antarctica[75] are amongst the least polluted places on earth.

Highly developed areas more seriously affected

Australia's population is highly concentrated in coastal cities in the south-east and south-west. Here the state of the adjacent marine environment may be locally poor[51-56]. So while the state of Australia's marine environment is on average, good, the state of the marine environment near where the urban Australian lives is often 'not good'.

A global perspective: the state of the world ocean



The ocean covers around 75% of the world's surface and contains over 90% of its water. It is an essential part of the biosphere. The hydrosphere and atmosphere are the planet's climate regulators. The ocean plays a key role in the nitrogen, oxygen, hydrogen, carbon and hydrological cycles. The ocean is also the cradle of life and is rich in biodiversity. The majority of phyla are exclusively marine, and species diversity is very high in many marine ecosystems. Ocean productivity is roughly equivalent to that of the land. The ocean has also long been a source of food and other resources for coastal and island people, and a source of enjoyment and inspiration.

Our world is fast shrinking. The first photographs taken by the lunar astronauts back in the 1960s gave us an important new perspective of our world, of a finite and fragile beauty, and the colour blue - the atmosphere and ocean - which makes this planet different from others in our solar system. This picture was dramatically reinforced in the 1980s with the discovery atmospheric changes, and the threat of global climate and sea level changes. The United Nations Conference on Environment and Development in 1992 reinforced the concept of the 'global village'. Australians can no longer take solace from our geographic isolation.

Growing alarm at state of world's seas

In 1990 the Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) reported on the state of the world's marine environment. It found chemical contamination and litter from the poles to the tropics and from beaches to the abyss. Coastal areas were most seriously affected, with the major contaminants, in order of seriousness, being nutrients from urban sewage and rural run-off, and sediments from changing land uses; microbial contaminations from sewage; plastics from land and sea disposal; synthetic organic compounds such as pesticides and industrial chemicals; and oil from routine transport and spills. The open ocean was relatively clean except for floating tar and plastic debris in shipping lanes and drift lines.

Nutrients: a worldwide coastal problem

Much of the wastes produced by human activities eventually find their way to the sea. Each year rivers carry around 10 billion tonnes of silt and waste into coastal waters. Storm drains and outfall pipes, and winds carry additional contaminants. GESAMP found that eutrophication was globally widespread and algal blooms, including red tides and toxic marine algae, and fish kills were common. Eutrophication was worst in the Baltic Sea and German Bight of the North Sea; the Black Sea; in the Northern Adriatic, Gulf of Lyons, Lake of Tunis, and Bay of Ismir in the Mediterranean; along the Japan's central and western Pacific coast and Inland Sea; and in the Louisiana, Chesapeake and New York Bight coasts of the US Atlantic.

During the 1970s and 1980s the United States and other developed nations initiated controls on point-source pollution from municipal and industrial sources but non point-source pollution remained a major problem.

Waste water discharges may also have a direct, and potentially grave effect on humans. A 1987 study by the United Nations Environment Program (UNEP) found that microbial contamination was a serious concern around the world, including off Australian cities (GESAMP 1990).

Petroleum

Around 3,200,000 tonnes of petroleum enters the marine environment each year, 45% from transportation and spills, and 36% from industrial and municipal discharges. Declines in sea transportation and size of vessels have reduced the number of serious spills by 74% between 1974 and 1986. Major oil spills have had catastrophic effects on marine life, particularly on seabirds and marine mammals. The corpses of over 36,000 seabirds and 1,000 sea otters were found after the 1989 *Exxon Valdez* oil rig spill, these representing an estimated 6-10% of the actual mortality.

Damage beneath the surface is usually more significant as dispersed oil kills plankton and benthic organisms, and may cause abnormalities in behaviour, feeding and reproduction which persist for decades. The blow out of the *Ixtoc 1* killed crabs and molluscs over several hundred kilometres of the Gulf of Mexico (World Resources Institute 1990).

Synthetic organic compounds
Globally, pesticides make a major contribution to human food production but it is estimated that around 25% of residues find their way to the sea where they pose a serious world problem. Non-degradable chlorinated hydrocarbon pesticides are found from the poles to the tropics, and have been detected, usually in trace levels, in most species, including man. Accumulated in fatty tissues, they are concentrated up the food chain in the top predatory fish, birds and mammals. The insecticides DDT and lindane and the fungicide HCB (hexachlorobenzene) are most widespread. Although they have been replaced with more degradable organo-phosphorus and carbamate pesticides in developed countries, organochlorines are still widely used in Africa and Asia (World Resources Institute 1990).

Organometal compounds used as biocides and fungicides also pose a serious problem around harbours and marinas. Tributyl tin (TBT), widely used as a marine antifoulant since the mid-1960s, causes deformities or death in a wide range of marine invertebrates. Its use has now been restricted in most developed countries.

Heavy metals
Metals directly enter the marine environment through industrial discharges, dumping and mining, and indirectly through stormwater drains, rivers and the atmosphere. These enter food chain and are bioaccumulated in certain tissues. While the levels in the ocean remain considerably below the toxic level, concentrations are high off developed coastlines and cities, particularly in the Northern Hemisphere (GESAMP 1990).

Marine litter
Increasing amounts of litter from coastal refuse dumps and shipping are appearing in the marine environment, harming marine life, interfering with shipping and degrading the aesthetic quality of beaches. The most serious problem are the plastics which are non-biodegradable and may persist for 50 years in the ocean, are buoyant, and are widely distributed by ocean currents and winds. Each year around 150,000 tonnes of synthetic fishing gear, including nets, ropes, and floats, are lost or discarded in the ocean. This lost netting may continue to 'ghost fish' or entangle fish, birds and marine mammals for several years. Ingestion of plastic bags by turtles and whales may be fatal. Plastic particles have been found in 25% of the seabirds surveyed around the world (GESAMP 1990).

Decline in marine wildlife
While there have been few (known) extinctions of marine species in the world's oceans, a number of species are threatened or endangered, and others have become locally extinct. Populations of some long-lived, slow growing species with low fecundity such as the turtles, sea cows, some seals, and the great whales have been seriously depleted by overhunting. Species of giant clams are now extinct over much of their natural ranges.[15,16,18]

Decline in world fisheries
Grave concerns are held on the status of the world's fisheries, and on their general impacts on marine ecosystems. In early 1995, the United Nations Food and Agriculture Organization (FAO) reported that 70% of the world's fish stocks are now 'either fully-exploited, overexploited, depleted or are recovering from previous overfishing'. The report pointed out that although there had been a slight decline in total catches after 1989, catches soared to a record 101.3 million tonnes in 1993. Ministers at the FAO meeting in Rome agreed on the need to reduce the size of fishing fleets to preserve stocks (Pearce 1995).

The effects of fisheries on the world's marine ecosystems are also of growing concern. A recent study suggest that as much as 8% of the entire primary production of the world ocean is needed to support the world's fisheries, and as much as 35% in the most heavily fished areas. Another study suggests that if fishing continues at today's levels, marine ecosystems will be radically altered, becoming less biologically diverse. With the disappearance of top predators such as cod and tuna, seas will become increasingly dominated by organisms lower in the food chain, causing economic difficulties, losses in biodiversity and conservation problems for higher species in the ecosystem, including marine mammals (Pearce 1995).

Future directions in marine environmental management

Coastal and marine environmental management, encompassing many different ecosystems, processes, resources and uses, is an evolving process. A number of important international and national initiatives since 1990 have stressed the importance of ecologically sustainable development and large-scale, long-term, integrated ecosystem management of the coastal and marine environment.

Global concerns: UNCED conference

The 1992 United Nations Conference on Environment and Development (UNCED) was convened because of widespread concerns about the degradation of the environment and the loss of global biodiversity.

With respect to the ocean, UNCED recommended that all nations: (1) prevent, reduce, and control degradation of the marine environment so as to maintain and improve its life-support and productive capacities; (2) develop and increase the potential of marine living resources to meet human nutritional needs, as well as social, economic, and development needs; and (3) promote the integrated management and sustainable development of coastal areas and the marine environment.

UNCED recognised that the achievement of these will require new strategies in marine environmental management, ones that can overcome geopolitical and interdisciplinary divisions. These should be based on principles of ecology and of ecologically sustainable development.

Ecologically sustainable development

The concept of 'sustainable development' was placed on the global agenda through the 1987 report of the World Commission on Environment and Development entitled 'Our Common Future' (often known as the Brundtland Report). This report defined sustainable development as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. (WCED 1987, p.43)

The concept of ecologically sustainable development (ESD) has been embraced by many Australian environmental managers, conservationists, economists and industrialists as an important unifying goal for conservation and development. ESD is seen as a means of managing increasing human demands on the ultimately limited capacity of the natural environment.

The development of the National Strategy on Ecological Sustainable Development provided a framework through which all stakeholders, governments and community groups worked together to help achieve integrated economic social and environmental goals.[61]

National Strategy for Ecologically Sustainable Development

The Goal

'Development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depend'.

The Core Objectives

- 'to enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations'
- 'to provide for equity within and between generations'
- 'to protect biological diversity and maintain essential ecological processes and life support systems'

The Guiding Principles

- 'decision making processes should effectively integrate both long and short-term economic, environmental, social and equity considerations'
- 'where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation'
- 'the global dimension of environmental impacts of actions and policies should be recognised and considered'
- 'the need to maintain and enhance international competitiveness in an environmentally sound manner should be recognised'
- 'cost effective and flexible policy instruments should be adopted, such as improved valuation, pricing and incentive mechanisms'
- 'decisions and actions should provide for broad community involvement on issues which affect them'
- 'the need to develop a strong, growing and diversified economy can enhance the capacity for environmental protection should be recognised'

'The objectives and principles need to be considered as a package with no objective or principle predominating over the others.'

(Commonwealth of Australia 1992)

The ESD working group on fisheries emphasised the importance of maintaining ecosystem function. Its recommendations included the development of a national marine conservation strategy incorporating a system of marine protected areas. The multi-use Great Barrier Reef Marine Park was cited as a model for large-scale, integrated marine management.[61]

The implementation of ESD poses particular challenges to the disciplines of economics and ecology. Its implications to marine environmental management include the necessity to maintain ecosystem function; the requirements of a large-scale or 'systems' approach; the necessity to maintain water quality; the importance of large marine protected areas; and the importance of monitoring because of scientific uncertainty.[61]

The objective of ESD has become incorporated into the goals of many management agencies. The Ocean Rescue 2000 program itself is a formal part of the ESD response. The recommended national network of marine protected areas is now being developed, and the Australian Marine Conservation Plan will be based on the principles of ESD. The concept of large ecosystem management is currently being adopted by fisheries managers in Australia[30].

A model for integrated, large ecosystem management: the Great Barrier Reef World Heritage Area

The Great Barrier Reef is the largest complex of coral reefs in the world. It consists of around 2,900 separate reefs and is 2,500 kilometres in length. The Great Barrier Reef Marine Park (GBRMP) has an area of around 344,000 square kilometres. This is three quarters of the total area of marine protected areas in Australia. The GBRMP is also the world's largest marine protected area and the only large marine ecosystem which is comprehensively managed with the explicit goal of ensuring that its use is ecologically sustainable, in perpetuity.[69]

The GBRMP Authority, together with over 60 user and interest groups and government agencies and Aboriginal and Torres Strait Islander communities has recently developed a 25 Year Strategic Plan for the Great Barrier Reef World Heritage Area. The objectives of the strategic plan are a healthy environment, sustainable multiple-use, maintenance and enhancement of values, integrated management, knowledge-based but cautious decision making in the absence of information, and an informed, involved, committed community. The plan will be reviewed regularly by its creators and its objectives will be adopted by the participating organisations. The Strategic Plan was launched formally by the former Prime Minister, the Hon. Paul Keating, on 20 July, 1994. It is believed to be a world first in joint decision making, and is a good example of integrated management and ecologically sustainable development in action.[69]

Integrated planning in the coastal zone: recommendations of the Coastal Zone Inquiry

Almost sixty government reports and inquiries have been undertaken on Australia's coastal zone since 1960, reflecting the continuing crisis in coastal management in this country. The Resource Assessment Commission (RAC) Coastal Zone Inquiry (1993) made many recommendations on management of the coast[62].

Principal Aims for National Coastal Action Program proposed by RAC[62]

- reduce degradation caused by urban sprawl and activities in urban and remote locations in the coastal zone;
- provide better facilities for recreation in the coastal zone;
- provide better management and preservation of natural processes in coastal areas;
- achieve more effective and rational use of land in the zone for building, development, tourism and other uses;
- improve recognition by the community of the value of the resources of the zone;
- improve recognition of indigenous peoples' interests in management of the zone;
- improve water quality in streams, estuaries and coastal seas;
- improve management of fisheries through more effective management of sea-based resources of the zone.

The major recommendation was that a National Coastal Action Program for the management of the resources of Australia's coastal zone be adopted by the Council of Australian Governments. This Plan would be implemented by the three spheres of government in consultation with community and industry groups that have responsibility for and interests in coastal zone management.[62]

At the time of writing, the Commonwealth response to the RAC Report was being finalised and discussions are being held with State and local governments.

Integrated catchment management

Catchment management programs to reduce soil erosion are underway throughout Australia (e.g. the Total Catchment Management program in New South Wales; Integrated Catchment Management programs in Queensland, Victoria and Western Australia). The programs involve local land holders, local government and State organisations and include strategies such as minimum tillage, control of stocking rates, contour cultivation, improved fertiliser management, revegetation of stream banks, buffer strips along stream banks, control of road side erosion, sewerage system upgrades, preservation of wetlands as sediment and nutrient 'traps', and reduction of erosion during urban development[(42)]. The RAC Report suggests a 'Coastcare' program similar to Landcare be developed for coastal areas to complement the catchment activities[(62)].

Declaration of Australia's 200 nautical mile Exclusive Economic Zone

Australia's 200 nautical mile Exclusive Economic Zone (EEZ) was declared on 1 August 1994 and came into force on 16 November 1994. With an area of over 11 million square kilometres, it is one of the largest EEZs in the world[(58)].

In addition to providing rights to exploit the natural resources in the EEZ, the 1982 United Nations Convention on the Law of the Sea (UNCLOS) also obliges Australia to protect and preserve the marine environment in its EEZ (Art 192).

UNCLOS requires Australia to cooperate to prevent land-based marine pollution and to work internationally to achieve this. It requires further action to prevent marine pollution by dumping and from ships.

The Convention also requires Australia to further advance knowledge of its EEZ by undertaking marine scientific research. It also promotes the sustainable use and conservation of the living resources of the high seas(Michaelis 1994).

National State of the Environment Reporting

Environmental managers require accurate, long-term quantitative information on the state of the environment in order to identify pressures and appropriate responses. Several Australian States have produced state of the marine environment reports in recent years, although these are dissimilar in approach.[(52,53,55,56)]

The Commonwealth Government has recently commenced a National State of the Environment reporting program based on a pressure-state-response model. Under this model, reports are structured in terms of the pressures on the environment arising from human activities and impacts, the state or condition of the environment and individual and institutional responses. It is intended that a national set of environmental indicators is then developed for future, quantitative reporting. The first descriptive report is scheduled for late 1995[(64)]. SOMER is providing much of the baseline information on marine and estuarine environments for the National State of the Environment Report.

The Ocean Rescue 2000 program

The Ocean Rescue 2000 program, which began in 1991, is a Commonwealth Government initiative to promote the conservation and sustainable use of the marine and coastal environment of Australia. It builds on existing marine conservation and management programs and is part of the national strategy for Ecologically Sustainable Development.

The principal objective of the program is to develop and implement a marine conservation plan to guide the use and management of Australia's marine resources. Other objectives[(83)] include:

- ensuring adequate baseline and monitoring information on the marine environment, activities and management, and ensuring its accessibility to decision-makers and managers;
- fostering an educated, informed and involved community; and
- developing and implementing a national representative system of marine protected areas.

The program consists of the following elements:

- National Representative System of Marine Protected Areas;
- Australian Marine Conservation Plan;
- State of the Marine Environment Report (SOMER);
- National Marine Education Program;
- National Marine Information System; and
- Marine and Coastal Community Network.

SOMER findings endorsed by the Marine Environment Conference, 1995

The Marine Environment Conference, attended by over 280 Australian and international marine scientists, environmental managers and others, was held at the University of Queensland in February 1995 to discuss the major findings of SOMER, as released in 'Our Sea, Our Future'. The conference considered in particular the state of inshore ecosystems and the problem of declining water quality in many areas.

The Conference endorsed the findings of SOMER and made the following recommendations:
(1) immediate action for the management of Australia's coastal and marine environments should be undertaken;
(2) this management should occur at the large marine ecosystem level;
(3) a nationally coordinated system of monitoring should be established; and
(4) a national coordinating body for integrated large marine ecosystem management should be established.

(Source: Johnson 1995)

Conclusion: setting sail for the future

The close connections between ecosystems, processes, resources, uses and issues in the coastal zone require that coastal zone management occur at an appropriate time and spatial scale and is closely integrated at all geographic and geopolitical levels.

The goals of marine environmental management are to maintain biodiversity and ecologically sustainable development. The alternatives are continuing environmental degradation and ecological collapse.

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Note: Superscript annotations refer to source chapters in this book, and to the technical papers from which they were written.

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