

Overfishing, uncertainty, and ocean
governance:
Lord Perry's question revisited

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Declaration

This work was carried out at the University of Tasmania, under a university postgraduate scholarship. Where used, quotes or extracts taken from published literature or other sources are duly acknowledged in the text.

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Responsibility for the views expressed, matters of judgement, and any factual or logical errors, remains of course my own.

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Overfishing, uncertainty, and ocean governance: Lord Perry's question revisited.

We must place biodiversity conservation at the center of ocean governance.

Sylvia Earle & Dan Laffoley, 2006

Abstract:

“Why does overfishing persist in the face of regulation?” This question, the subject of intense interest and discussion, has no easy or palatable answer. While trawling over old ground, this thesis hopefully offers new insights, and adds weight to important arguments advanced by other writers. I argue here that overfishing, a fundamental cause of the crisis facing our oceans, is the result of the failure of our fishing management agencies (ultimately our politicians and communities) to embrace a small suite of powerful tools (more correctly strategic approaches) which have been developed to account for *uncertainty*.

Broad success in managing fisheries to achieve sustainability goals will (I argue) only come *if these tools are enthusiastically applied*. Moreover, I suggest that this will not happen until organisational cultures within fishery management agencies undergo a major shift. In my view, the only way this shift will occur is for asset-based biodiversity conservation, rather than resource exploitation, to be placed at the centre of ocean governance.

This thesis examines these issues in the context of case studies covering regional, national and provincial (State) fishery management agencies. With the exception of the case study of a regional fishery (the southern ocean krill fishery) all case studies are drawn from Australian experiences. Commercial and recreational fisheries are considered.

The central recommendation of the thesis is that fishery management agencies, worldwide, should be replaced by biodiversity asset management agencies. While recognising that many factors affect biodiversity assets (some well outside the control of current fishery agencies) such a strategy would mesh with the increasing acceptance of integrated coastal zone management, and in general the need for integrated and precautionary management of natural resources.

Keywords: ocean governance, ethics, overfishing, uncertainty, precautionary principle, precautionary approach, ecosystem approach, ecosystem based fisheries management, adaptive management, krill, orange roughy, northern prawns, western rock lobster, abalone, spearfishing.

1. Introduction:

In 1995, in response to the deteriorating condition of the British fishing industry, the House of Lords held a series of hearings on *Fish Stock Conservation and Management*. Lord Perry of Walton asked the apparently straight-forward question of why regulation had not succeeded in controlling overfishing (Eagle & Thompson 2003:649).

While the question seems simple, any serious attempt to answer it immediately confronts great complexity – in the ecologies supporting fish populations, and in the cultural, economic and legal frameworks within which the fisheries lie. There is a well-known saying that “for every complex question there is a simple answer – and it is always wrong” (attributed to HL Mencken 1917)¹.

Much has been written on the subject, both before and after Lord Perry posed his question, and several of the arguments and answers suggested will be discussed below. Ultimately, the issues are so complex that explanations inevitably rest on case studies, and the conclusions which may, or may not be drawn from them. In spite of the large amount of information and discussion devoted to this question, forming a view as to the real explanation will always rest on judgment as well as logic. Wherever there is judgment, there will be argument. Any thesis resting on case studies can be criticised on the basis that all the facts were not considered, and that the author chose examples biased towards the argument he wished to make.

It is, however, safe to say that there is general agreement amongst fishery scientists, and substantial agreement amongst fishery managers, that “governance, and not science, remains the weakest link in the [fisheries] management chain” (Browman & Stergiou 2004:270).

An important point of definition arises immediately. Overfishing is defined in this discussion as *a level of fishing which puts at risk values endorsed either by the fishery management agency, by the nation in whose waters fishing takes place, or within widely accepted international agreements*. A point of critical importance in this regard is that a level of fishing intensity which successfully meets traditional stock sustainability criteria (for example fishing a stock at maximum sustainable yield) is likely to be considerably higher than a level of fishing intensity which meets maximum economic yield criteria (Grafton et al. 2007) which in turn is likely to be considerably higher than a level designed to protect marine biodiversity (Jennings 2007, Walters et al. 2005, Murawski 2000, May et al. 1979). The wide international endorsement of the *Convention on Biological Diversity 1992* implies that the latter level is the critical level by which overfishing should be measured. This important argument is revisited in the concluding chapter.

The central conclusion of the thesis is that government fisheries agencies (focused on harvesting) need to be replaced by asset management agencies (focused on the protection of the value of marine biodiversity assets). Looking back over the last century, government wildlife agencies in many countries have, over long periods, undergone important name changes and changes in focus. In Victoria (Australia), for instance, the late 19th century “Department of Hunting and Game” evolved into the 20th century “Department of Wildlife” which is now part of a large “Department of Sustainability and Environment”. The activities and priorities of a department, and the culture of its staff, are importantly shaped by department name, charter and statutory focus – which in this example has evolved from a harvesting charter to a conservation charter. Fishery Departments around the world have not evolved in the same way, to the great detriment of marine biodiversity, and, in many cases, to the great detriment of the viability of the fisheries themselves.

While recognising that many factors affect biodiversity assets (some well outside the control of current fishery agencies) such a strategy would mesh with the increasing acceptance of integrated coastal zone management, and in general the need for integrated management of natural resources.

Method and approach:

This is a desk study – a literature analysis. The analysis was supported by interviews with a key group of informants, while a larger group of specialists were consulted on the issues discussed in individual chapters. A key aspect of the thesis is the development of benchmarks relating to the precautionary and ecosystem approaches, and the application of these benchmarks to case studies of particular fisheries (see below). The use of this technique (scoring against benchmarks) is increasingly common: for example in Marine Stewardship Council fishery assessments. The development of the benchmarks themselves (with 0-3 linear scoring) is the result of a substantial survey of both peer-reviewed and grey literature. While the choice of benchmarks is largely a matter of judgment, and of course can be disputed, any given set of benchmarks, evenly applied, will provide a relative yardstick.

Australian case studies were chosen for ease of access to both documentation and staff in the fishery management agencies themselves. Staff were generally helpful in locating and supplying documentation not readily available through libraries or the internet. In addition, Australia is sometimes seen at the forefront of innovative fisheries management, which makes the case studies relevant from a global perspective. Both Commonwealth and State fishery agencies have used the CSIRO and academic scientists, and Australia's scientific capacity in fisheries management science appears to be well-respected globally.

The individual case studies themselves were chosen for different reasons. First, I wanted to include those of different scale – regional, national and provincial. I also wanted to include recreational fishery examples. I chose to examine the Victorian Government's management of recreational spearfishing as I had spent my childhood in Victoria, and in my teenage years was an enthusiastic participant in this 'sport'. The two State fisheries – for lobster and abalone – were chosen on the basis of access to information, as well as examples of well-regarded management. The Western Australian lobster fishery, in particular, was well documented partly through the fishery's participation in the Marine Stewardship Council accreditation program. The two Commonwealth fisheries case studies – northern prawns and orange roughy, were chosen because of the existence of a substantial body of documentation. As it turns out, the history of Australia's orange roughy fishery is a classical example of overfishing under regulation.

Basing an argument on case studies cannot prove that the adoption of specific management strategies produces a particular result, but it can amass information lending weight to particular arguments. Sometimes a case study example can disprove a particular point about the effects of a management approach – if, for example, an approach was carefully followed, but did not produce the desired outcome (other factors being conducive). The mirror of this argument too, allows a negative theory to be disproved. It cannot be argued that a particular approach will prohibit result 'x', if at least one case study can be found in defiance of the proposition.

While the three management approaches which form a theme in this thesis (the precautionary and ecosystem approaches, and active adaptive management) are by no means recent developments, the complexities and uncertainties of the world of fisheries management means that there is not unanimous agreement on how the approaches should be applied, or what they really mean to a management agency. In fact, there will probably never be unanimous agreement – at least not in the foreseeable future. Nevertheless all three approaches have been the subject of a large body of literature, and, at least in the minds of many scientists and managers, there is general agreement on key principles behind the approaches (discussed in more detail below). There is also an important distinction between active adaptive management and passive adaptive management, discussed in more detail below.

The thesis, in its analysis of different fishery management regimes, develops and applies benchmarks relating to the three approaches, and these benchmarks are drawn from academic and fisheries literature.

The thesis centers on addressing Lord Perry's question, and the role that the three modern management approaches play in answering that question. The thesis does not set out to prove or disprove a hypothesis, but rather to investigate the intriguing complexities involved in trying to answer not only the question itself, but in trying to look into a global fisheries future of many possibilities, with some very different outcomes.

While the conclusion of the thesis is straightforward, and specific recommendations are made in the final chapter, there will always be room for argument and disagreement – as there must in situations of great biological and cultural complexity.

It must also be noted that a thesis resting almost entirely on publicly available information ignores the hidden detail within confidential documents or in-house correspondence. As Simeon (1972:19) noted: “[r]esearch on live political issues ... has many pitfalls. Much documentation remains hidden to the researcher until long after the event.” Some documentation, and the perhaps important perspectives contained there-in, remains entirely out-of-reach.

Thesis structure:

The thesis is divided into three parts, each part containing a number of chapters. The first part is global in scope and establishes the themes which recur over the remainder of the work; the second part is mainly devoted to Australian case studies, while the third part (which comprises only three short chapters) draws together themes, provides a discussion of the role of the ecosystem and precautionary approaches in particular, and presents a conclusion – which the reader may or may not agree with.

The first part opens with a chapter which examines the crisis facing the world's oceans, moves on to discuss issues of ethics, then examines the evolution of fisheries management paradigms. The next chapter lists the most important international agreements which relate directly to management of the marine realm, and examines the appearance of the thematic approaches within these important and influential documents. The final chapter in Part One deals with a critical feature of fisheries management: uncertainty, discussing both its causes and consequences.

The second part is devoted to seven case studies, and starts with a literature review relating to the three 'modern' management approaches which form a theme in this thesis. This review is used to establish benchmarks by which fisheries chosen as case studies may be judged. The case studies themselves encompass regional, national and provincial fisheries, and include five commercial and two recreational fisheries. Examination of the management of recreational fisheries exposes an immediate problem: there is almost no refereed or official literature relating to their management. These case studies lack substance on this account, but nevertheless reveal interesting insights. The five case studies resting more firmly on a review of management literature are:

- the Southern Ocean krill fishery;
- the northern prawn trawl fishery;
- the orange roughy fishery;
- the South Australian abalone fishery; and
- the western rock lobster fishery in Western Australia.

The third Part of this thesis draws on findings and themes from the earlier chapters, develops a conclusion, and makes a small number of specific recommendations relating to global ocean governance themes.

Chapter outlines:

Part One:

- *Oceans in crisis* looks at the state of the world's oceans, and identifies the key threats both immediate and future.
- *The ethics of marine governance* leans heavily on Aldo Leopold's *Land Ethic* in suggesting that humans should provide substantial spaces to protect the ocean's ecosystems, habitats and species purely because they exist and share this planet with us – a strategy which coincidentally aligns with the recommendations of many conservation biologists.
- *The evolution of fisheries paradigms* discusses the origin of our fisheries governance frameworks in mind-sets based on historic concepts of the seas as unlimited. The chapter introduces the idea of biodiversity resources as capital assets – an idea whose time has not yet come.
- *The international context of ocean governance* covers the most important international agreements and initiatives focused on ocean governance. These provide a framework within which more detailed management regimes sit, and may be assessed.
- *Uncertainty in fisheries management: sources and consequences*: discusses the origins of uncertainty pertinent to fisheries management, and the importance of uncertainty in explaining why regulation has not succeeded in controlling overfishing. In the final part of this section the historic concept of the freedom to fish is set against the core governance weaknesses created by the tragedy of the commons (Hardin 1968), the tyranny of small decisions (Odum 1982) and Ludwig's ratchet (Ludwig et al. 1993).

Part Two:

- *Benchmarks for modern management*: provides an overview of three core tools for managing uncertainty in fisheries: (a) the precautionary approach (b) the ecosystem approach, and (c) active adaptive management, including the use of decision rules, and best available science.
- *Case studies*: this discussion is presented in seven sections examining the implementation of the three tools within the seven case studies. This discussion is highly structured and consequently presented in tabular format examining:
 - the krill fishery managed by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR);
 - the northern prawn trawl fishery managed by the Commonwealth of Australia;
 - the orange roughy fishery managed by the Commonwealth of Australia;
 - South Australian's abalone fishery;
 - Western Australia's western rock lobster fishery;
 - Tasmania's gill-net recreational fishery, and
 - Victoria's recreational spearfishing fishery.

Part Three:

- *Case study discussion*,
 - provides an overview of the case studies, highlighting key differences and similarities.
- *Australian fisheries: living up to our reputation*
 - acknowledges Australia's enviable reputation as a world leader in marine management, and asks if this reputation is at risk due to poor implementation of key national strategies.

- *Conclusions and recommendations.*

- revisits the key findings and arguments of the thesis, draws conclusions, and provides a number of recommendations aimed at developing and maintaining sustainable fisheries.

Appendices:

The body of the thesis is supplemented by six detailed appendices: the first dealing with broad principles of ocean governance, while the second deals with the precautionary principle in particular. Both these appendices are used to support chapters five, seven, eight and nine. The third appendix deals with the Australian Governments' sustainable fisheries guidelines, which are used to assess individual fisheries under the provision of the *Environment and Biodiversity Protection Act 1999* (EPBC Act). The fourth appendix provides background information on deep-sea bottom trawling, supporting chapter 12. The fifth appendix discusses the use of the EPBC Act guidelines to assess the South Australian abalone fishery, providing detailed support for arguments presented in chapter 13. The sixth appendix reports on a literature review and a longitudinal survey examining the impacts of recreational spearfishing. This appendix supports chapter 15: the case study dealing with the management of recreational spearfishing.

Endnotes:

¹ I have not been able to obtain Mencken's original essay "The Divine Afflatus", however it is often referred to (eg by Wikipedia 2/5/2009) as containing words to the effect that: "There is always an easy solution to every human problem—neat, plausible, and wrong."

Part One: a global perspective

2. Threats to marine biodiversity

2.1 Introduction:

In broad terms, the living inhabitants of the marine realm face five major threats:

- *climate change*: changes to oceanic temperatures, acidity, patterns of water movement (including currents, eddies and fronts), storminess and sea level, largely caused by *increasing atmospheric carbon dioxide*, as well as impacts from damage to the ozone layer;
- *overfishing* with attendant bycatch problems, both from commercial fishing, recreational fishing, illegal unregulated or unreported fishing (IUU), and ghost fishing²;
- *habitat damage* largely caused by fishing gear, especially bottom trawling, but also including the effects of coastal development: destruction of coral reefs, mangroves, natural freshwater flows (and passage), coastal foreshores, coastal wetlands and sometimes entire estuaries – which all support coastal marine ecosystems;
- *pollution* (in-sea and land-based, diffuse and point source) including nutrients, sediments, plastic litter, noise, hazardous and radioactive substances; discarded fishing gear, microbial pollution, and trace chemicals such as carcinogens, endocrine-disruptors, and info-disruptors; and
- ecosystem alterations caused by the introduction of *alien organisms*, especially those transported by vessel ballast water and hull fouling.

Amongst these five major threats to marine biodiversity, fishing has, until the present time, been the most damaging on a global scale. The destructive impacts of fishing stem chiefly from overharvesting, habitat destruction, and bycatch. Over the coming century the threats posed by increasing atmospheric greenhouse gases pose huge dangers to the marine environment (Veron 2008, Koslow 2007, Turley et al. 2006). At smaller scales, other threats (particularly pollution and habitat damage) are dominant at different localities. Coral reef, mangrove, estuarine, seagrass, mud-flat, and sponge-field habitats have been (and are being) extensively damaged. River passage, essential for anadromous and diadromous species, has been impaired or destroyed around the globe.

Overharvesting is probably as old as human civilization. There is evidence that ancient humans hunted many terrestrial animals to extinction (eg: Alroy 2001). Historically, fishing has rarely been sustainable (Pauly et al. 2002). On the global scene, modern fishing activities constitute the most important threat to marine biodiversity (Hiddink et al. 2008, Helfman 2007:8; MEA Millennium Ecosystem Assessment 2005a:67, 2005b:8, 2005c:12; Crowder & Norse 2005:183; Kappel 2005:275; Myers & Worm 2003; Pauly et al. 2002; Reynolds et al. 2002; Jackson et al. 2001; Leidy & Moyle 1998 - noting contrary views from Gray 1997). Of all recently documented marine extinctions, the most common cause has been excessive harvesting activities (Malakoff 1997, Carlton et al. 1999, VanBlaricom et al. 2000).

Fisheries in the deep sea have "undoubtedly had the greatest ecological impact to date" of all known threats (Thiel & Koslow 2001:9). Fishing was identified as the main threat to marine ecosystems in the northwest Atlantic over the period 1963-2000 (Link et al. 2002). The fisheries of the Bering Sea have long been recognised as among the world's best managed (Aron et al. 1993); however Greenwald (2006) in a study of the region's vertebrates, identified commercial fishing as the most important threat, followed by climate change, habitat degradation, ecological effects and pollution.

Historically, the impacts of fishing activities, even when regulated by governments, have in many cases caused major, often irretrievable damage to marine ecosystems (Jackson et al. 2001, Ludwig et al. 1993). The benthic ecosystems of large areas of the ocean seabed have

been destroyed or damaged (Watling & Norse 1998, Watling 2005). The genetic effects of fishing may be substantial, yet are commonly ignored (Law & Stokes 2005). The failure of managers to learn from past mistakes appears to be a notable feature of the history of fisheries management (Mullon et al. 2005) in what Agardy (2000) has called the "global, serial mismanagement of commercial fisheries".

"In many sea areas, the weight of fish available to be harvested is calculated to be less than one tenth or even one one-hundredth of what it was before the introduction of industrial fishing." (MEA 2005c:16)

On the Australian scene, fishing activities appear to be the primary threat to fishes (Pogonoski et al. 2002) and the second most important threat to marine invertebrates (Ponder et al. 2002) after habitat degradation.

Overfishing is defined in this discussion as *a level of fishing which puts at risk values endorsed either by the fishery management agency, by the nation in whose waters fishing takes place, or within widely accepted international agreements*. A point of critical importance in this regard is that a level of fishing intensity which successfully meets traditional stock sustainability criteria (for example fishing a stock at maximum sustainable yield) may well be considerably higher than a level of fishing intensity which meets criteria designed to protect marine biodiversity (Jennings 2007). The wide endorsement of the *Convention on Biological Diversity 1992* implies that the latter level is the critical level by which overfishing should be measured.

Amongst fishery scientists (and to lesser extent fishery managers) it is widely believed that "governance, and not science, remains the weakest link in the [fisheries] management chain" (Browman & Stergiou 2004:270). To a large extent fisheries managers, like bankers, do not learn the lessons of the past, they simply repeat them.

The core impacts of **climate change** are caused by:

- an increase in the temperature of ocean waters - causing, for example, coral bleaching (Veron 2008);
- the increase in the acidity of ocean waters, causing a rising aragonite saturation horizon, particularly in the North Pacific and Southern Ocean - with resulting impacts on organisms using calcium carbonate body structures (Turley et al. 2006), and
- a reduction in ocean overturning circulation, risking, for example, impacts on deep ocean oxygen content (Koslow 2007).

Important reviews of **pollution** in the marine environment are provided by:

- nutrients – a general review: Rabalais (2005), Carpenter et al. (1998); – in the Caribbean: Siung-Chang (1997); – on shallow coral reefs: Koop et al. (2001); – on the Great Barrier Reef: Alongi & McKinnon (2005); – on the Gulf of Mexico: Rabalais et al. (2002)
- plastic litter – Derraik (2002); Goldberg (1997); Koslow (2007); Gregory (1991, 1999)
- noise – Cummings (2007); Firestone & Jarvis (2007); NRC (2005); Koslow (2007)
- radioactive waste – Koslow (2007)
- armaments – Koslow (2007)
- heavy metals – Islam & Tanaka (2004); Hutchings & Haynes (2005)
- discarded fishing gear – Matsuoka et al. (2005); Brown & Macfadyen (2007)
- microbial pollution – Islam & Tanaka (2004)
- endocrine disruptors – Lintelmann et al. (2003); Porte et al. (2006)
- info-disruptors – Lurling & Scheffer (2007)
- other hazardous materials – Islam & Tanaka (2004); Koslow (2007).

Important papers on marine and estuarine **habitat damage** include:

- estuaries and rivers – Ray (1996, 2004, 2005), Jackson et al. (2001), Blaber et al. (2000), Lotze et al. (2006), Collett & Hutchings (1978), Kappel (2005); Drinkwater & Frank (1994);
- impacts of bottom trawling – Koslow (2007), Gray et al. (2006), Jones (1992), NRC (2002), Gianni (2004);
- coral ecosystems – Aronson & Precht (2006), Pandolfi et al. (2003), Gardiner et al. (2003), Hughes et al. (2003), McClanahan (2002), Jackson et al. (2001), McManus (1997);
- mangroves – Duke et al. (2007), Alongi (2002), Valiela et al. (2001); Ellison & Farnsworth (1996);
- seagrasses – Orth et al. (2006), Duarte (2002);
- kelp – Steneck et al. (2002), Dayton et al. (1998).

For a general introduction to the problem of **alien species**, see Mooney & Hobbs (2000), McNeely (2001), and Mack et al. (2000). General references on marine issues include Hewitt & Campbell (2007), Streftaris & Zenetos (2006), Carlton & Rutz (2005), Bax et al. (2003), and Rutz et al. (1997).

2.2 Threats and controls:

Over the last thirty years, broad controls have been proposed or developed relating to the five major threats. Controls can be categorised with threats (Table 2.1 below). Many nations have commendable statutes and policies; however implementation failures are widespread.

Table 2.1 Threats and controls: overview of general strategies:

<i>Threats</i>	<i>Controls</i>
Overfishing and bycatch	<p>Restricted entry to fishery, catch quotas, limits or requirements on gear, limits on fishing seasons, limits on fishing areas, no-take areas, prohibitions on dumping or discarding gear.</p> <p>Attempts to reduce or eliminate government subsidies contributing to fishing over-capacity.</p> <p>Control by flag States of high seas fishing particularly in regard to compliance with international and regional fishing agreements.</p> <p>Market-based fishery accreditation systems such as that of the Marine Stewardship Council.</p> <p>Government control programs based on minimising ecosystem effects.</p> <p>Surveillance and compliance programs including VMS³ and remote surveillance (video surveillance, and electronic catch recording and tracking, for example).</p>
Habitat damage	<p>Limits on gear, limits on fishing areas, no-take areas.</p> <p>Fixed mooring systems in sensitive (eg coral) environments. Surveillance and compliance programs.</p> <p>Land-based zoning schemes combined with project assessment and approval provisions aimed at minimising the loss of coastal habitat resulting from land-based developments. Special protection for high conservation value estuaries. Zoning of key migration rivers to exclude dams, weirs and other impediments to fish passage. Protection of the catchment of high conservation value estuaries and rivers to maintain natural water flows and water quality.</p>

<i>Threats</i>	<i>Controls</i>
Climate change	International agreements, such as those focussed on greenhouse gasses or chlorofluorocarbons or (eg: the Kyoto Protocol, Montreal Protocol) - and the implementation programs which follow, including incentives, prohibitions and market-based schemes aimed at reducing greenhouse gas emissions.
Pollution	Controls focussed on fixed point sources, mobile point sources and diffuse terrestrial sources – including dumping and emissions to air and water. Controls on marine noise. Controls focused on specific pollutants, such as plastics or highly toxic or radio-active substances. Integrated coastal and river basin planning, including objectives to limit the passage of nutrients and other pollutants to the marine environment. Surveillance and compliance programs.
Alien organisms	Controls on ballast water and hull fouling based on risk minimisation rather than prevention. Import prohibitions relating to aquaculture stocks. Infestation monitoring and removal programs. Surveillance and compliance programs.

Good general references covering threats and management options are Koslow (2007) and Norse & Crowder (2005).

2.3 Three core management concepts of modern marine management

Any overview of threat control programs would be incomplete without mentioning the evolution of three core concepts which have been endorsed (at least in principle) by most national marine conservation policy frameworks, and (at least in the case of protected area networks) many practical control programs:

- *ecosystem-based fishery management* (EBM);
- the *precautionary principle* (PP) and the closely-related precautionary approach (PA); and
- the *strategic development of networks of marine protected areas* (MPAs).

Active adaptive management, although the subject of much academic discussion for over 20 years, has yet to appear in operational fisheries management programs in any substantial way (see Chapter 9).

Several fishery experts made comments during the nineteenth century to the effect that the resources of the ocean were so vast as to defy any possible damage from human activities. These views, although proved incorrect more than a century ago, still linger on, particularly in fisher cultures. Within government fishery agencies and academic circles, the need to take into account the effects of fishing for particular species on marine ecosystems has been accepted for several decades. Promotion of ecosystem-based management was a core feature of the FAO *Code of Conduct for Responsible Fisheries* 1995. Although the concept is now embedded in key international and national law, fishery agencies have generally been slow to incorporate EBM in fishery controls, often citing the need for more research as the primary reason for the delay.

The precautionary principle, and its 'softer' version the precautionary approach, appeared in international discussions some decades ago⁴, and have been accepted, like EBM, into international and national law. Article 174 of the Treaty establishing the European Community requires, inter-alia, that Community policy on the environment be based on the

precautionary principle. The principle was one of the core environmental principles contained in the Rio Declaration 1992 (UN Conference on Environment and Development) as well as the earlier World Charter for Nature 1982. A generic definition of the principle may be stated as follows:

Where the possibility exists of serious or irreversible harm, lack of scientific certainty should not preclude cautious action by decision-makers to prevent such harm. Decision-makers needs to anticipate the possibility of ecological damage, rather than react to it as it occurs.

Like EBM, use of the precautionary principle in practical control strategies has lagged behind its adoption in policy, not only in the EU but around the world. This remains the case, in spite of the prominence given to the principle on the FAO Code of Conduct.

Marine protected areas were largely unknown in an era when it was generally considered that the oceans needed no protection. However, as the damage to the marine environment became more widely understood, marine protected area programs have featured in international agreements as well as national conservation programs. The FAO Code of Conduct stresses the need to protect critical habitat in aquatic environments, for example.

One of the most widely quoted international statements calling for the acceleration of marine protected area programs around the world is that from the World Summit on Sustainable Development (WSSD) (Johannesburg 2002). The marine section of the WSSD Key Outcomes Statement provides basic benchmarks for the development of marine protected areas as well as other key issues of marine governance:

Encourage the application by 2010 of the ecosystem approach for the sustainable development of the oceans.

On an urgent basis and where possible by 2015, maintain or restore depleted fish stocks to levels that can produce the maximum sustainable yield.

Put into effect the FAO international plans of action by the agreed dates:

- for the management of fishing capacity by 2005; and
- to prevent, deter and eliminate illegal, unreported and unregulated fishing by 2004.

Develop and facilitate the use of diverse approaches and tools, including the ecosystem approach, the elimination of destructive fishing practices, the establishment of marine protected areas consistent with international law and based on scientific information, including representative networks by 2012.

Establish by 2004 a regular process under the United Nations for global reporting and assessment of the state of the marine environment.

Eliminate subsidies that contribute to illegal, unreported and unregulated fishing, and to over-capacity.

The same statement also contains a commitment: "Achieve by 2010 a significant reduction in the current rate of loss of biological diversity."

Two years later the 2004 Conference of the Parties to the *Convention on Biodiversity 1992* agreed to a goal of: "at least 10% of each of the world's marine and coastal ecological regions effectively conserved" (by 2012) (UNEP 2005:44).

2.4 Protection of representative marine ecosystems:

Attention needs to be given to the use of the word "representative" in the WSSD text above. Requirements to provide adequate and comprehensive protection for representative

examples of all major types of ecosystems date back many years. Clear requirements for action are contained in:

- the 1972 Stockholm Declaration of the United Nations Conference on the Human Environment.
- the 1982 World Charter for Nature (a resolution of the UN General Assembly); and
- the 1992 United Nations international Convention on Biological Diversity;

Principle 2 of the Stockholm Declaration 1972 states: “The natural resources of the earth, including the air, water, land, flora and fauna and especially representative samples of natural ecosystems, must be safeguarded for the benefit of present and future generations through careful planning or management, as appropriate.”

The 1982 World Charter for Nature states: “Principle 3: All areas of the earth, both land and sea, shall be subject to these principles of conservation; special protection shall be given to unique areas, to representative samples of all the different types of ecosystems, and to the habitat of rare or endangered species.”

An examination of the wording of both the Charter and the Declaration reveals that they place wide obligations, not only on governments, but on all agencies of governments as well as individuals. These instruments are however soft law, and as such carry no explicit reporting requirements or sanctions for non-compliance.

2.5 Summary

The oceans of the world are being severely damaged. Five major threats continue to undermine biodiversity values across the marine realm. According to a United Nations advisory committee (GESAMP 2001):

The state of the world's seas and oceans is deteriorating. Most of the problems identified decades ago have not been resolved, and many are worsening. New threats keep emerging. The traditional uses of the seas and coasts – and the benefits that humanity gets from them – have been widely undermined.

Damage identified in 2001 has generally worsened. Since the 2001 report was written, a major new threat has emerged: ocean acidification. The international goal of ‘at least 10% of the world's ecological regions effectively protected’ by 2010 will almost certainly not be met (Wood 2005).

It is generally believed that the major failings of national programs to protect marine biodiversity rest on failures of governance rather than failures of science. The three core governance concepts discussed above are crucial to all serious attempts to address marine conservation issues in a strategic way. However, in general, attempts to apply them have often been poorly resourced, badly planned and ineffectually implemented.

The primary ingredient missing from national programs across the globe is political commitment to address the issues in the face of short-sighted resistance from vested interests, such as polluters, fishers and coastal developers. This failure in turn rests on widespread ignorance of the severity of the issues amongst the general community in all nations, rich and poor alike.

In many cases, the degradation which is occurring now cannot be reversed within the timescale of a human life. Decisive and intelligent action by politicians and community leaders is urgent. Such action must be underpinned by programs aimed at developing an increased awareness of the issues amongst the general population.

Endnotes:

- ². Ghost fishing refers to the continued effects of lost and abandoned fishing gear.
- ³. VMS refers to Vessel Monitoring Systems – compulsory fitting of satellite tracking and reporting devices.
- ⁴. The precautionary principle appears in one of its many variations in the *World Charter For Nature 1982*, a resolution of the UN General Assembly, and was more formally endorsed in the Rio Declaration 1992 (United Nations Conference on Environment and Development).

3. Ethics, fisheries, and marine protected areas

A system of conservation based solely on economic self-interest is hopelessly lopsided. It tends to ignore, and thus eventually to eliminate, many elements in the ... community that lack commercial value, but are (as far as we know) essential to its healthy functioning. It assumes, falsely I think, that the economic parts of the biotic clock will function without the uneconomic parts”

Aldo Leopold 1948

Learning to coexist with the rest of nature presents us with a huge challenge, requiring not only technical solutions but more importantly a profound shift in our own attitudes and philosophy.

Nik Lopoukhine, Chair of the World Commission on Protected Areas (Dudley et al. 2005:2)

3.1 Introduction

The planet's biodiversity is in decline, and marine ecosystems are in urgent need of protection. Fishing (in its many manifestations) is currently the single most important threat to marine biodiversity – from a global perspective (Chapter 2). In the coming decades the destruction caused by fishing will almost certainly be overshadowed by ocean acidification.

The creation of marine protected areas is usually justified in terms of utilitarian needs relating to the conservation of biodiversity or the protection and enhancement of fish stocks. Could such reserves also be justified in terms of ethics? In spite of the general absence of discussion of ethics within areas of marine science or fisheries management, a substantial and long-standing literature exists from which an ethical basis for the establishment of protected areas could be drawn. This chapter briefly reviews some of the landmarks within this literature, and – without apology for an explicit ethical position – recommends increased discussion and use of ethical arguments within the marine community. Far from harvesting other life forms in a sustainable way, humans are gradually but inexorably killing the wild living inhabitants of our planet, and destroying the places in which they live. It can be argued that the time to adopt a new ethical position has already passed with some talk but almost no action.

Many factors affect human behaviour, and to a large extent the remaining chapters of this thesis consider the reaction of fishery scientists and managers to knowledge about fish populations and the ecosystems in which they reside. However, the cultures in which people work are also important determinants of action, and this chapter explores ethical questions which permeate, or are excluded from, organizational cultures. This chapter argues that *humans need to accord a right to 'peaceful coexistence' to at least a fair proportion of the other living residents of the planet* – an approach which in fact aligns with the scientific recommendations of many conservation biologists. I argue that the matter is now so urgent that it requires the attention of every marine scientist.

Australia has declared its entire Exclusive Economic Zone (EEZ) as a whale sanctuary, and has proposed the creation of a South Pacific Whale Sanctuary at meetings of the International Whaling Commission (IWC). Australia's international stance on whaling rests partly on two government-funded investigations: the Frost Inquiry (Frost 1978) and the National Task Force on Whaling (NTFW 1997) – both relying partly on ethical arguments to support their anti-whaling recommendations. These ethical arguments related to the perceived 'special nature' of whales and other cetaceans: their intelligence, their family behaviours, their ability to communicate, and their occasional voluntary contacts with humans. Both inquiries drew the conclusion that we should accord these animals greater rights than other sentient animals – *essentially a 'right to life' and a right to a peaceful home*. However, while the Australian government supported the recommendations of both inquiries, it appears noticeably reluctant to engage in any direct discussions of an ethical nature⁵.

The Australian Government and Australian scientists have criticised Japan's scientific whaling program (Gales et al. 2005). Interviewed in a Australian Broadcasting Commission (ABC) 'Four Corners' program screened in July 2005, a Japanese government spokesman asked a very reasonable question: "Australians eat cows, pigs and sheep. Why shouldn't we eat whales?". Although this question was tangential to the immediate discussion, I found it interesting that it remained without discussion or reply, although it lies at the heart of the Japanese position. An ethical position underlies the Australian point of view, yet Australians seem reluctant to talk about it. In discussing the issue later with a colleague (a marine scientist) I asked: "have you ever heard a marine scientist talk about environmental ethics?" The reply was negative.

In this chapter I examine the reluctance of marine scientists to involve themselves with questions of ethics. I suggest that many marine scientists may be ignorant of the extensive environmental ethics literature, or see it as irrelevant. I argue that, while this is entirely understandable, it is now counter-productive. It is not un-scientific to adopt an explicitly ethical position, and I argue that discussion of ethics within the community involved in the management of marine resources should be strongly promoted until it seeps through to the level of the general community and thus to political decision-making.

3.2 Justifying marine protection

Terrestrial scientists do have a track record, if somewhat uneven, in using ethical arguments to justify the creation of protected areas – with Aldo Leopold being one of the most celebrated (more below). A well known example from more recent times is the controversial judgement of Justice Douglas (US Supreme Court) who argued that the moral rights of nature should be given legal recognition – based partly on the arguments of terrestrial ecologists (see Stone 1996). Jim Chen, a prominent academic US lawyer, continues to press such arguments (Chen 2005) again based on the findings of terrestrial biologists.

As a fairly typical example of a marine scientist arguing for the creation of marine protected areas, Professor Terry Hughes argued that a substantial proportion (30% or more) of coral reef ecosystems need to be protected from harvesting pressures in order to ensure ecosystem stability. According to Hughes (2004) (my emphasis): "Our final recommendation, the most challenging, is for the creation of institutional frameworks that align the marketplace and economic self-interest with environmental conservation. *The ultimate aim is to secure future options for social and economic development*" (my emphasis). It should be noted, however, that Professor Hughes on other occasions has adopted an explicitly ethical position in arguing for the need for major change in reef management around the world (Hughes et al. 2002) – unlike most other marine scientists who generally avoid taking ethics into public discussions.

The reliance on utilitarian arguments is of course not restricted to discussions of marine protected areas. Alfred Duda and Kenneth Sherman, in calling for urgent changes to existing fishery management strategies, state (my emphasis): "Fragmentation amongst institutions, international agencies and disciplines, lack of cooperation among nations sharing marine ecosystems, and weak national policies, legislation and enforcement all contribute to the need for a new imperative for adopting ecosystem-based approaches to managing human activities in these systems *in order to avoid serious social and economic disruption*" (Duda & Sherman 2002).

Verity et al. 2002, in a review of both the status of pelagic ecosystems and the scientific and political paradigms underpinning resource exploitation, conclude that "*use of resources for the benefit of humanity*" is the prime driver. In spite of finding the paradigms of resource exploitation unsustainable, Verity et al., in recommending paradigm changes, do not attempt to expand this narrow ethic (2002:226).

Sissenwine and Mace (2001) in defining 'responsible fisheries' state: "...we believe 'responsible' means *sustainable production of human benefits*, distributed fairly, without causing unacceptable changes in marine ecosystems."

In their review of marine pollution, Islam & Tanaka (2004) stated: “Effective and sustainable management of coastal and marine environments should be initiated... to ensure .. the best possible utilization of resources *for the broader interest and benefit of mankind.*”

The FAO published a report *Ethical issues in fisheries* in 2005. The words “deep ecology” and “humanism” are not mentioned in the entire document, which revolves almost completely around the ethics of distributing fishery benefits between existing and future human populations (FAO 2005a). While these are important issues, they are not the subject of this chapter.

All these human-focused views are expressed by eminent and well-respected scientists, and their reliance on utilitarian motives, and their avoidance of any discussion of ethical motives is typical of the approach of marine scientists generally. Almost certainly each of these scientists speaks from an underlying ethical position; however this is seldom or never articulated.

There are, thankfully, exceptions. Unusual papers by Balon (2000) and de Leeuw (1996) take a strongly ethical position in opposing recreational fishing - based partially on arguments of unnecessary cruelty and the trivial destruction of life.

Coward et al. (2000) discuss fisheries ethics at length, focussing on “four kinds of justice: distributive, productive, restorative and creative.” Of these, the most relevant to the present discussion is “restorative justice” which refers to a need to restore degraded ecosystems, both for the benefits of the plants and animals which live in the ecosystem, and the humans which depend on the ecosystem for food and livelihood. In conclusion, they suggest: “Recognizing that we have the right to use our environment as a necessary resource... we must also recognize the concurrent responsibility not to abuse that right by taking more than we need, or more than the ecosystem can sustain...” Their recommendations include promotion of the precautionary principle, and promotion of marine protected area development.

Another important exception (directly relevant to the subject of this chapter) is a paper by Bohnsack (2003), while the well-respected American philosopher Callicott has specifically addressed the ethics of marine resource use (Callicott 1991, 1992). After examining the roll of shifting baselines in undermining public expectations of what constitutes a healthy marine environment, Bohnsack concludes: “marine reserves not only protect marine resources but can help restore human expectations and provide a basis for new conservation ethics by providing a window on the past and a vision for the future.” These thoughts are echoed by Safina (2005) in an eloquent plea to extend Leopold’s land ethic to the ocean.

3.3 Environmental ethics and the development of an ecological conscience

Many religions contain concepts of care which extend beyond responsibilities to other humans. As Bohnsack (2003) points out, indigenous people in many parts of the world have strong beliefs that man is a part of, and not dominant over, nature. Traditional belief systems in many parts of Oceania, for example, have emphasised cultural and social controls and taboos on fishing, with strict and enforced codes of conduct (Johannes 1984). Buddhism combines a core ‘ecological’ concept, the ‘inter-connectedness of all things’ with an admonition to avoid causing suffering to any sentient being (BDK 1966). Hill (2000:161) has argued that Judeo-Christian teaching contains the concept that “nature serves something beyond human purposes, and as such it must be respected and honoured”. The recently-developed Baha’i faith advocates responsibilities relating to maintaining the health of the planet, while Pantheism is more explicit in its ‘unity of all life’ teaching (refer www.comparative-religion.com). More contemporary authors such as Birch (1965, 1975, 1993) argue for the recognition of intrinsic values in nature, rather than its purely instrumental value to mankind.

These concepts have appeared in popular western literature for well over 100 years (see for example Tolstoy 1903), without significant influence on government or corporate decision-

making, which are pervaded (globally) by John Stuart Mill's anthropocentric 'enlightened self-interest' (Mills 1863). Callicott traced the roots of the now widely held 'resource conservation' ethic, which essentially aims at "the greatest good for the greatest number for the longest time" (Callicott 1991:25). Bohnsack (2003) provides an excellent summary of Callicott's detailed chronology of schools of resource ethics.

In a classic essay "The historical roots of our ecologic crisis" Lynn White (1967) argues that modern technology and its application, the immediate cause for the twentieth century's environmental problems, emerged from an anthropocentric culture of thought which rests in large part on Judaism. The particular passage cited is the 'dominion' passage of the Book of Genesis 1:26,28):

Then God said "Let us make man in our image, in our likeness, and let them rule over the fish of the sea and the birds of the air, over the livestock, over all the earth, and over all the creatures that move along the ground". So God created man in his own image, in the image of God he created him: male and female he created them. God blessed them and said to them, "Be fruitful and increase in number; fill the earth and subdue it. Rule over the fish of the sea and the birds of the air and over every living creature that moves along the ground."

White's essay continues to create discussion and controversy. Many support his basic contention (eg: McKibben 1989). Christian writers (eg: Birch 1993, Hill 2000) inheriting in part a Judaic foundation, have argued for the expansion of Christian philosophy to encompass strong environmental stewardship ethics. However, such arguments appear to have limited sway over the bulk of the Christian churches or their leaders. Consider, for example, the Christian 'Cornwall Declaration on Environmental Stewardship' 2000, which criticises "*unfounded and undue concerns [including] fears of destructive manmade global warming, overpopulation, and rampant species loss*". The evidence suggests that these three issues are in fact three of the most important facing the immediate future of our planet (MEA 2005, Novacek & Cleland 2001). On July 14, 2008, the Catholic Archbishop of Sydney, Cardinal Pell, appeared on the ABC TV Seven O'clock News, calling on people in countries where the birth rate was slowing to "have more babies". It is also noticeable that modern Buddhist leaders, in spite of the inherent environmental concepts within their philosophy, do not speak strongly for comprehensive environmental stewardship concepts (see for example The Dalai Lama 1995 and other works by the same author). For a detailed discussion of various religious positions on the environment, see Nash (1990).

Henry James Thoreau, John Muir and Aldo Leopold (referred to by Callicott 2003 as "the three giants of American environmental philosophy) all advocated a reverence for nature, and argued the need to set aside large areas away from human impact (wilderness areas) in order to preserve intrinsic natural values.

3.4 Aldo Leopold's "land ethic"

Of the writings of these three, Aldo Leopold's 'Land ethic' (Leopold 1948) has made perhaps the most lasting impression, and continues to be extensively quoted. I consider his views to be powerful and coherent, and warrant examination in more detail.

Suppose no law prevented you from killing your neighbour and taking his land – would you do it? Hopefully not. Suppose your 'neighbour' belonged to a different racial or cultural group, and lived in another land. Would you kill him and take his land? Would you enslave him? Again, hopefully not. Yet that is exactly what our forefathers did – and what they did seemed 'right' within the moral framework of the time. In certain parts of the modern world, slavery still continues (www.antislavery.org). These questions are not far-fetched. If you discovered an uncharted island, populated only by a forest and its animals, would you take possession, clear the land, kill the animals, build a house and plant crops? Maybe you would. If everyone else acted in the same way, where would it end? With increasing human domination of the planet's ecosystems (MEA 2005; Vitousek et al. 1997) that end is now in sight.

I agree with Balint's view (2003:14): "Scientists often do not recognize, or hesitate to raise relevant ethical issues when participating in environmental policy debates, relying instead on scientific theories, models, and data."

As Balint also points out, Leopold urges humanity to undergo a change of heart towards the environment and extend society's ethical structure to include the natural world. Leopold reminds us that slavery, including the killing of slaves as property, was once considered normal and right. Leopold equates movement towards a "land ethic" with previous cultural changes that led, for example, to abolishing slavery and recognizing the rights of women. In contrast to anthropocentric utilitarian views of nature, in which morally right acts are those that protect or increase human well-being, Leopold offers the following recommendation:

...quit thinking about decent land-use as solely an economic problem. Examine each question in terms of what is ethically and esthetically right, as well as what is economically expedient. *A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise* (Leopold 1948:240 – my emphasis).

In a rare paper focused directly on fishery ethics, Callicott (1991:25) called Leopold's words (quoted above) "the golden rule of the land ethic".

Leopold wrote, "There is as yet no ethic dealing with man's relation to the land and to the animals and plants which grow upon it ... The land-relation is still strictly economic, entailing privileges but not obligations." Movement toward such an ethic, he suggested, is "...an evolutionary possibility and an ecological necessity ... Individual thinkers since the days of Ezekiel and Isaiah have asserted that the despoliation of land is not only inexpedient but wrong. Society, however, has not yet affirmed their belief. I regard the present conservation movement as the embryo of such an affirmation." (Leopold 1948:218)

Apart from the immediate issue of technological capability, the planet's environmental crisis stems from the way humans act as if they own the planet – dubbed by Ehrenfeld (1981) the "arrogance of humanism". Balint concludes (2003:22) "Leopold argued that the unlimited prerogative to own nature – defined to include 'soils, waters, plants, and animals, or collectively: the land' – that humans have bestowed upon themselves should be replaced by a constrained set of rights and an expanded set of responsibilities founded on principles of membership and citizenship in – rather than domination and exploitation of – the community of nature."

It is this concept of mankind as part of a 'community of nature' which provides the essential basis for the ethic we now so badly need.

It is one thing to catch a fish and eat it, but it is another to over-fish that species to extinction, and yet another to destroy the place where that species lives. Do humans have the right to do all three?

3.5 Contemporary environmental ethics

Why are contemporary biologists and ecologists generally unwilling to engage in discussions of ethics? There are, of course, exceptions. According to Balint (2003:21): "Michael Soule has listed the postulate "Biodiversity has intrinsic value," as one of four key tenets in the field of conservation biology, which he helped found, giving the idea that all life has intrinsic value the status of a first principle."

Like White, David Ehrenfeld, in his critique of humanism (1981) argues that management of the planet's resources is almost universally founded on the idea that the features and objects of the natural world were created primarily for the benefit of humanity, and that it is the responsibility of humanity to accept this gift and accept stewardship of the natural world. Stanley (1995) in applying Ehrenfeld's arguments to ecosystem-based management, finds ample evidence that humanity's belief that *effective ecosystem management is both possible and necessary* lacks a strong factual basis – the history of such management being paved

with failures. Stanley suggests that such failures will continue without a change in underlying ethics: "Humanity must begin to view itself as part of nature rather than the master of nature. It must reject the belief that nature is ours to use and control" (Stanley 1995).

Arne Naess and George Sessions are often seen as the founding fathers of 'deep ecology' – an ecology explicitly based on ethics which acknowledge the intrinsic value of non-human life forms. According to Naess & Rothenburg (1989:c1) "The inability of the science of ecology to denounce such processes as the washing away of the soil of rainforests suggests that we need another approach which involves the inescapable role of announcing values, not only 'facts'." Deep ecology is based on a 'deep' consideration of the values behind human use and abuse of the natural environment.

James Lovelock proposed the 'Gaia hypothesis' which sees the entire planet as resembling a single organism in the inter-connection of its biological components: "the self-regulation of climate and chemical composition is a process that emerges from the tightly coupled evolution of rocks, air, and ocean - in addition to that of organisms. Such interlocking self-regulation, while rarely optimal - consider the cold and hot places of the earth, the wet and the dry - nevertheless keeps the Earth a fit place for life" (Lovelock 1995). The ethical extension of this concept involves care of the planet as a living organism – with, Lovelock argues, reverence, humility and caution.

These ethical positions are broadly termed "biocentric". Those opposing the extension of such ethics to the management and protection of planetary ecosystems are apt to highlight extreme versions as manifestly unworkable. For example, according to Hill (2000:161):

[T]he effort to move beyond an anthropocentric to a biocentric view neither fits with our moral sensibilities nor yields useful policy prescriptions. First of all, the various attempts to derive a biocentric theology have been stymied in determining agreed-upon stopping points for the rights of nature. Although early efforts concentrated on the concept of sentience, philosophers and theologians have been unable to present a workable definition of what sentience includes. Edward Abbey, a leading deep ecologist, has said, "unless the need were urgent, I could no more sink the blade of an axe into the tissues of a living tree than I could drive it into the flesh of a fellow human." Rene Dubos, a prominent bacteriologist, believes that just as people and wolves should coexist, so should people and germs. Philosopher Paul Taylor argues, "The killing of a wildflower, then, when taken in and of itself, is just as much a wrong, other-things-being-equal, as the killing of a human." But even granting rights to living creatures does not solve the problem, since several leading figures in the environmental movement now argue, in the words of Michael J. Cohen, that "rocks and mountains, sand, clouds, wind, and rain, all are alive. Nothing is dead..."

Most environmental philosophers, however, take more defensible, moderate positions. Stone (1987, 1996) in addressing questions relating to the standing of those without voices, argues for increasing weight to be placed on intrinsic biological values in reducing further erosion of natural ecosystems, as well as the need (Stone 1995) to develop institutional protection for the rights of future generations of humans. Chen (2005) argues within a traditional but precautionary ethical framework for the development of stronger legal mechanisms to protect global biodiversity. The modern philosopher Peter Singer (1993) echoes the earlier approach by Passmore⁶ (1974) in grounding his ethical framework largely on enlightened self-interest informed by long-term and precautionary ecological science, with a generally accepted need to reduce suffering of sentient beings⁷. Such views are anything but radical.

3.6 Ethics in international instruments and government policy

With a few environmental philosophers expressing apparently extreme views, perhaps the reluctance of marine scientists and managers to adopt explicit ethical positions is in some way understandable. The university courses in marine biology that I am familiar with contain little or no formal exposure to issues of environmental ethics – which seem generally left within social science faculties. Keeping up with current science, past graduation, is a demanding task, and practising scientists mostly have little time to explore ethical issues. Where a scientist holds an ethical position (as many, even most perhaps do) it will often

seem more useful to couch arguments about ecosystem protection in terms which are clearly understandable within the utilitarian framework of politics and economics. I argue, however, that this approach is now unnecessarily conservative. We can, in fact, look to international agreements and documents to legitimise an explicit ethical position.

The *World Charter for Nature* 1982 (a resolution of the United Nations General Assembly) was supported by the Australian Government in its development through the UNGA. Although hortatory and without compliance provisions, and thus non-binding, the Charter nevertheless represents an important commitment. Commitment obligations apply not only to government agencies, but, through article 24, to corporations and individuals.

In the preamble, the Charter notes that “civilization is rooted in nature... and living in harmony with nature gives man the best opportunities for the development of his creativity, and for rest and relaxation”. Importantly, the Charter also notes “*Every form of life is unique, warranting respect regardless of its worth to man, and, to accord other organisms such recognition, man must be guided by a moral code of action*”.

Foreshadowing the Convention on Biological Diversity⁸ which was to develop a decade later, Article 1 of the Charter requires that “Nature shall be respected, and its essential processes shall not be impaired”. Article 2 focuses on the protection of genetic diversity, and article 3 requires that “all areas of the earth, both land and sea, shall be subject to these principles of conservation; special protection shall be given to unique areas, to representative samples of all the different types of ecosystems, and to the habitat of rare or endangered species.” Article 10, perhaps particularly relevant to fishery management, states in part: “Living resources shall not be utilized in excess of their natural capacity for regeneration”. I suggest that flagrant violation of these principles has become such common practice that we now think of these transgressions as ‘normal’.

The *Earth Charter* was developed to extend the World Charter for Nature by adding social objectives, including the eradication of poverty and the universal adoption of democracy. The Earth Charter was developed over many years following a 1987 initiative of the United Nations. An *Earth Charter Commission* was formed in 1997 with help from influential UN figures and funds from the Dutch Government. After many years and much consultation, the Charter was endorsed by the Commission in 2000, and was put to the 2002 World Summit on Sustainable Development in Johannesburg - with a view to it being endorsed by the United Nations General Assembly.

The Earth Charter is important, as it embodies an explicit ethic of respect for the planet. The preamble states: “The protection of Earth’s vitality, diversity and beauty is a sacred trust”. Both Taylor (1999) and Bosselmann (2004) consider the Charter to be of considerable significance in regard to its long-term ability to influence both international law, and environmental law in general⁹. According to Bosselmann (2004): “Among its ground-breaking principles are ecologically defined concepts of sustainability, justice, rights and duties.”

Article 1 advocated the recognition “that all beings are interdependent, and every form of life has value regardless of its worth to human beings”, and article 15 requires that “all living beings” be treated with respect and consideration. Many fishery practices flagrantly violate these requirements – consider, for example, the habitat damage routinely caused by trawling operations (Appendix 4) or the incidental kill caused by prawn fisheries (Chapter 11).

Although it is a conservative document, shying away from important issues such as the need to reduce the human population of the planet, and the need to reform democratic governance, the Earth Charter has nevertheless failed – so far – to get widespread government endorsement. It has, however, considerable support amongst the global community (including the scientific community) within many nations, and remains open for public endorsement. Over three thousand organisations worldwide have endorsed the Charter, including UNESCO and the World Conservation Union (IUCN) (www.earthcharter.org).

Writing shortly before the UN Johannesburg summit, Callicott had high hopes for the Earth Charter: "The prospective adoption of the Earth Charter by the General Assembly of the United Nations may have an impact on governmental environmental policy and performance similar to the impact on governmental social policy and behaviour of the adoption by the same body in 1948 of the Universal Declaration of Human Rights." (Callicott 2002). It is to be hoped that Callicott's expectations in this regard will ultimately be fulfilled – however for this to happen there will need to be a growing awareness, particularly within agencies which provide direct advice to politicians, of the need to articulate the policy implications of ethical positions.

Australia's *National Strategy for the Conservation of Australia's Biological Diversity* (DEH 1996:2) underwent wide agency consultation prior to publication, and, in its final form, was endorsed by the Australian (Commonwealth) Government, all State and Territory Governments, and by Local Government's peak body. In it we find an articulate ethical statement:

There is in the community a view that the conservation of biological diversity also has an ethical basis. We share the earth with many other life forms which warrant our respect, whether or not they are of benefit to us. Earth belongs to the future as well as the present; no single species or generation can claim it as its own.

This clear expression (in a widely-endorsed government policy document) of the beginnings of a 'land ethic' provided Australian scientists with an opportunity to build discussion and use of deeper ethical positions, yet almost nothing has happened, and nearly a decade has passed, since this statement was published.

3.7 Oceans in crisis

Global trends:

Driven by the demands of an expanding human population combined with increasing per capita resource consumption, global ecological assets and processes are being seriously eroded. As the Millennium Ecosystem Assessment puts it: "Human activities have taken the planet to the edge of a massive wave of species extinctions" (MEA 2005c:3). Outside protected areas (IUCN categories I-VI) which cover about 12% of the terrestrial areas and about 1.4% of the marine realm (www.unep-wcmc.org) humans have already affected almost all terrestrial and freshwater habitats (Cracraft & Grifo 1999, Wilson 2002). About half of all natural terrestrial ecosystems have been destroyed or severely damaged, with this percentage escalating (Vitousek et al. 1997). Most of the remaining terrestrial natural habitat is significantly degraded (MEA 2005a, 2005b), and major degradation is occurring inside many protected areas, particularly in underdeveloped countries (Carey et al. 2000).

About one-quarter of the Earth's 'modern' bird species have already been driven to extinction (Vitousek et al. 1997), with notable marine species such as albatrosses currently on extinction trajectories (Baker et al. 2002, Dulvy et al. 2003). Of the planet's vertebrates, amphibians are the most threatened, followed by freshwater fishes (Helfman 2007). Helfman estimates one quarter to one third of all freshwater fish species are threatened. Marine fishes are the least endangered, with possibly 5% threatened (Leidy & Moyle 1998).

Considerable uncertainty surrounds estimates of threatened terrestrial plants, as poor data exists for the tropical regions where the bulk of plant species reside. Estimates by Pitman and Jorgensen (2002) suggest that "as many as half of the world's plant species may qualify as threatened with extinction under the IUCN classification scheme". Recent anthropogenic changes to the earth's atmosphere may not produce smooth changes in the earth's major ecosystems or the processes which underpin climate itself (such as the global thermohaline circulation – Koslow 2007). The resilience of the planet is being undermined; abrupt changes could occur and could prove to be both damaging and effectively irreversible (Steffen 2004).

The oceans as well as the planet's terrestrial areas are being severely damaged. According to a United Nations advisory committee (GESAMP 2001):

The state of the world's seas and oceans is deteriorating. Most of the problems identified decades ago have not been resolved, and many are worsening. New threats keep emerging. The traditional uses of the seas and coasts – and the benefits that humanity gets from them – have been widely undermined.

After two intensive workshops examining global fisheries, the FAO editors concluded:

Over the last 15 years, the marine fishery resources of the world have been increasingly subjected to overexploitation, detrimental fishing practices, and environmental degradation. The phenomenon now affects a majority of fisheries worldwide, with very severe consequences in terms of resource unsustainability, massive economic waste, increasing social cost and food insecurity (Swan & Greboval 2003:1).

The workshops found that “poor governance” – including importantly a lack of political and managerial will – was the “major cause for the inability to achieve sustainable fisheries” (Swan & Greboval 2003:2).

Winter & Hughes(1997:22) characterised loss of biodiversity as “one of the four greatest risks to natural ecology and human well-being”.

Overfishing

Overfishing is one of the greatest threats to the marine environment (GESAMP 2001:1) – and fishing overall is the greatest threat when attendant effects of habitat damage, overfishing, IUU¹⁰ fishing and bycatch are taken into account (Dulvy 2003, MEA 2005).

Overfishing, far from being a modern phenomenon, has been occurring in certain regions for a considerable time. Overfishing has been the rule rather than the exception, even in artisanal fisheries. As Jackson (2001) points out: “Untold millions of large fishes, sharks, sea turtles and manatees were removed from the Caribbean in the 17th to 19th centuries. Recent collapses of reef corals and seagrasses are due ultimately to the losses of these large consumers as much as to more recent changes in climate, eutrophication, or outbreaks of disease.” According to Pauly et al. 2002: “Fisheries have rarely been ‘sustainable’. Rather, fishing has induced serial depletions, long masked by improved technology, geographic expansion and exploitation of previously spurned species lower in the food web”.

Populations of ocean fishes have been hugely reduced over the last two centuries. Historical evidence suggests that earlier stocks may have been an order of magnitude¹¹ greater than stocks in the last half-century (Steele and Schumacher 2000) – which themselves have now often been reduced by another order of magnitude (see below). The last few decades have witnessed accelerating inroads into marine habitats, which in many instances are now broadly approaching ecological collapse. Many coastal ecosystems have already passed the point of collapse when compared with their pristine state – some well past, like the Black Sea (Daskalov 2002, Daskalov et al. 2007) and the Baltic Sea (Osterblom et al. 2007). The dramatic decline of coastal fisheries is the signal we see (Jackson et al. 2001) – masked to some extent by shifting baselines (Pauly 1995) where each generation of fisheries scientists forgets (or never learns) about the state of the oceans before their own lifetimes.

According to Jackson (2001): “Ecological extinction caused by overfishing precedes all other pervasive human disturbance to coastal ecosystems, including pollution, degradation of water quality, and anthropogenic climate change”. Duda & Sherman (2002) express similar concerns: “Continued over-fishing in the face of scientific warnings, fishing down food webs, destruction of habitat, and accelerated pollution loading – especially nitrogen export – have resulted in significant degradation to coastal and marine ecosystems of both rich and poor nations.”

Subsidization of national fishing fleets continues, in spite of warnings by scientists (eg: Pauly 1995) and the FAO¹² (www.fao.org) that excessive fishing pressures are the primary cause of fisheries collapse. Global fishing fleets are two or three times the size necessary to

harvest the approximate reported annual global catch of around 90 million tonnes. Many fisheries have “staggering levels of discarded bycatch” which, when combined with unreported, unregulated and illegal fishing, pushes the true global annual catch to around 150 million tonnes (Pauly & Christensen 1995). These figures, although a decade old, are still roughly accurate if Chinese reports of fishing take are excluded. This estimate does not include ‘ghost fishing’ – the take by lost or abandoned fishing gear. While difficult to estimate, ghost fishing may be causing significant damage. The plastics used in many nets, once removed from the effects of UV radiation in sunlight, last virtually indefinitely.

Many marine animals have suffered dramatic declines due to over-fishing. Roman & Palumbi (2003) estimate that “pre-whaling populations [of fin and humpback whales in the northern Atlantic] [were] 6 to 20 times higher than present-day population estimates”. Jennings and Blanchard (2004) in their study applying macro-ecological theory to the North Sea, suggest that the current biomass of large fishes is over 97% lower than it had been in the absence of fisheries exploitation.

Dayton et al. (1998) describing the kelp forest communities of western USA, state: “...fisheries have had huge effects on the abundances, size-frequencies, and/or spatial distributions of sheephead, kelp bass, rays, flatfish, rock fish, spiny lobsters and red sea urchins. Now even sea cucumbers, crabs and small snails are subject to unregulated fishing. ...most of the megafauna have been removed with very little documentation or historical understanding of what the natural community was like.”

Studies by Myers and Worm (2003) have estimated “that large predatory fish biomass today is only about 10% of pre-industrial levels”. This decline may have caused serious damage to ocean ecosystems, and species extinction is a real possibility (Malakoff 1997). Baum and Myers (2004) estimate that oceanic whitetip and silky sharks, formerly the most commonly caught shark species in the Gulf of Mexico, “have declined by over 99% and 90% respectively”. Grey nurse sharks were the second most commonly caught shark on Australia’s eastern seaboard in the early 1900s (Roughley 1951); today their total population is estimated at 400 individuals and is continuing to decline (Otway et al. 2004). Worm et al. (2005) confirms the generality of declines in large predators across the world’s oceans.

As Botsford et al. (1997) point out, it is abundantly clear that, at a global level, “[fishery] management has failed to achieve a principal goal, sustainability”.

Habitat damage

In spite of the admonitions of many international agreements and national policies aimed at the protection of habitats and ecosystems, trawling continues to cause massive damage to fragile benthic communities (Dayton 1998, Koslow et al. 2000, NRC 2002, Koslow 2007). The advent of recent technologies in navigation, sonar and deep fishing gear have permitted damaging fishing of the deep sea (Roberts 2002). Due to very slow recovery times in deep sea ecosystems, damage already caused by deep sea trawling is likely to take many hundreds of years to repair, if full recovery is possible at all.

Vulnerable coastal habitats, such as mangrove, salt marsh, seagrass, and coral reefs have been seriously – in many cases irrevocably – damaged by human activities through pollution, alteration of tidal flows, and deliberate damage (e.g. from blast fishing or mining operations – Oakley 2000).

Coral, global warming and biogeochemistry

Coral reef ecosystems have been declining globally for many decades (Wilkinson 2004, Pandolfi et al. 2003, Jackson 1997). Average coral cover in the Caribbean region has declined from about 50% to 10% in the last 30 years (Gardner et al. 2003), and similar declines are common in heavily fished reef ecosystems globally. Even given these dramatic declines, for coral ecosystems the worse is yet to come.

The concentration of carbon dioxide in the Earth's atmosphere has increased by about 30% since the beginning of the industrial revolution (Vitousek et al. 1997) with a continued massive increase effectively unavoidable over the coming decades. Carbon dioxide levels are now higher than any time in the last 400,000 years, and possibly the last 50 million years (Koslow 2007, Veron 2008).

According to the Royal Society (2005) many marine organisms dependent on calcium carbonate structures, including corals, are unlikely to survive increases in ocean acidity predicted at the close of the next century, if global emission rates of carbon dioxide continue along current trajectories. Coral reefs are already degrading under the effects of overfishing, increasing sea surface temperatures, and nutrient-laden runoff from the agricultural and urban development of nearby coasts (Bellwood et al. 2004, Hughes et al. 2003). According to Pandolfi et al. (2003): "[Coral] reefs will not survive without immediate protection from human exploitation over large spatial scales". Veron (2008) is even more pessimistic.

Pollution

Excessive anthropogenic nitrogen inputs to coastal marine ecosystems are causing 'dead zones' (oxygen-depleted zones) of substantial size. Moffat (1998) reported a zone "the size of the State of New Jersey, expanding westward from the coast of Louisiana into Texas waters". Since then other similar zones have been identified (Diaz & Rosenberg 2008). As mentioned above, shallow coral ecosystems are readily damaged by nutrients (Harrison & Ward 2001) sediment, and pesticides in runoff from adjacent agricultural land (Hutchins et al. 2005). Trace metal pollution may also be important; copper for example has been found to inhibit coral spawning even at very low concentrations (Reichelt-Brushett & Harrison 2005). Pollution from plastic litter has reached epidemic proportions (Islam & Tanaka 2004). Ingested plastics accumulate in the guts of some marine animals, causing starvation. Most plastics do not degrade once removed from UV radiation, making the problem of plastic accumulation particularly severe in marine environments.

According to Islam & Tanaka (2004): "Coastal and marine pollution has already caused major changes in the structure and function of phytoplankton, zooplankton, benthic and fish communities over large areas... Most of the world's important fisheries have now been damaged to varying extents..."

Trophic cascades: catastrophic shifts in ecosystems

The Millennium Ecosystem Assessment biodiversity synthesis (2005a:25) highlights damage which can occur to ecosystems by removing species which supply local services critical to key ecosystem processes, such as grazing in coral reefs, or pollination in terrestrial ecosystems. Examples of damaging trophic cascades in the marine environment listed in MEA include overharvesting of Californian sea otters, Alaskan sea lions, Kenyan trigger fish, and Caribbean reef fish (MEA 2005a:27).

3.8 Conclusion

Human activities are undermining the biological fabric of planet Earth. Critical problems identified decades ago by the international community have not been addressed in any effective way, and are worsening. "Business as usual" – resting on existing anthropocentric cultures within science, government and the community at large – is not working.

As Callicott (1991:27) argued more than ten years ago: "The public conservation agencies [read: fishery management agencies] are still ruled by the 19th century *Resource Conservation Ethic*, but as Aldo Leopold realized some 40 years ago, the Resource Conservation Ethic is based upon an obsolete pre-ecological scientific paradigm. Since the Land Ethic is distilled from contemporary evolutionary and ecological theory it should, therefore, be the new guiding principle of present and future conservation policy."

The single most important issue the world faces today is the need to develop an ecocentric ethic of planetary stewardship, based on notions of participation in the community of nature rather than domination of it – as advocated by Leopold (1948). Such ethics need to be

underpinned by a reverence for the beauty and complexity of our "water planet" and its diversity of life forms. Without this ethic, the forces behind our industrial-consumer society are pushing global resource consumption to higher and higher levels, eroding the essential life support systems of the planet. The expansion of 'human habitats' is now so pervasive that it is quite simply destroying the homes of other inhabitants of our planet on a massive scale.

Much is at stake. The human onslaught on the marine environment has, until the last few decades, been concentrated in estuaries and coastal oceans – through overfishing, habitat damage, pollution and the introduction of invasive species. This has, however, changed dramatically in recent times. While coastal marine areas continue to suffer, massive damage is now being inflicted over oceanic environments, primarily by industrial over-fishing (Gianni 2004).

As Ludwig et al. (1993:17) argued: "There are currently many plans for sustainable use or sustainable development that are founded upon scientific information and consensus. Such ideas reflect ignorance of the history of resource exploitation and misunderstanding of the possibility of achieving scientific consensus concerning resources and the environment. Although there is considerable variation in detail, there is remarkable consistency in the history of resource exploitation: resources are inevitably over-exploited, often to the point of collapse or extinction." In the decade since Ludwig wrote, evidence is still accumulating that over-exploitation of marine resources remains the rule rather than the exception (Koslow 2007; Kieves 2005; Verity et al. 2002; Wilson 2002).

A voluminous and long-standing literature on environmental ethics exists, but is seldom referred to by marine scientists. While little of this discussion has permeated international and national policies, a few notable documents, such as the UN World Charter for Nature 1982, the Earth Charter, and Australia's national biodiversity strategy (Commonwealth of Australia 1996) do contain statements reinforcing the idea of respect and reverence for nature. But where is this concept being expressed? What part should it play in strategies and programs to protect natural ecosystems which continue to be exploited and degraded by the incremental expansion of human activities?

Over the thousands of years of human civilization, it is only recently that a 'right to life' has become a universally accepted part of the way humans treat each other – along with rights to property and ownership of land. At present we humans accord the rest of the living world scant rights. Fish, for example, are not even accorded the right to a humane death, nor have we provided a right to an undisturbed home: no-take reserves (as of 2004) amount to only a minuscule proportion of the marine realm. Humans, like other predators, have always eaten plants and animals; however humans are now destroying both species and ecosystems.

A few nations are, at present, moving along a path which would accord a 'right to life' to whales and other cetaceans (Commonwealth of Australia 2002, 2004). However this extension of rights is hotly debated by other nations, and international agreement (even in the long-term) seems unlikely (Danaher 2002, Molenaar 2003).

Given the pressing need to put ethics into action to protect the planet's ecosystems, a search for a right to life for particular species – resting as it does on highly controversial arguments – is a path which we have no time to explore. *However, I believe scientists and the community generally need to extend the concepts of respect for and community with nature (concepts which have at least some wide general acceptance) to rights of peaceful coexistence.* This concept, in practice, means setting aside large parts of the planet where human impacts are kept to a minimum, and consumptive harvesting does not occur.

There is scope to do this in the marine realm – if we are willing to pay for it. At present only 1.5% of the oceans have protective management regimes (meeting the IUCN protected area criteria I-VI), and only 0.18% of the ocean is protected to the criteria I level (no-take zones). The World Parks Congress 2003 (WPC) recommended the establishment of national networks of marine no-take areas (NTAs) covering 20-30% of habitats by 2012. Many scientists support such a target purely on ecosystem management grounds

(www.onlyoneplanet.com.au). As Pimm et al. (2001) have said: “Enforceable protection of remaining natural ecosystems is an overarching recommendation”.

Providing refuges for at least a substantial part of marine biota is an idea that finds support amongst many conservation biologists. Browman & Stergiou (2004:270) ask “...why is it so difficult to recognize the inherent rights that marine fauna have to a safe haven?”. The fact of the matter is that the establishment of marine protected areas will place short-term costs on those who have traditional (or formal) rights to harvest from the sea. These rights must be recognised and compensation must be paid.

Victoria (Australia) established no-take areas over 5.3% of its coastal seas (to 3 nm) in 2002. The program of establishing these protected areas nearly failed due to intense political pressure applied by fishers incensed by the government’s lack of compensation provisions. The State government was at first unwilling to formalise a compensation program for fear of excessive costs – which no-one had bothered to estimate in any detail. Three years later, the lesson from the Victorian program is that compensation costs need not be high: claims have in fact amounted to only half a million dollars (Phillips 2005), much less than many had predicted, and trifling in the circumstances¹³.

There is a desperate need to protect marine environments. While utilitarian arguments must continue to be used, I believe it is now essential that scientists and policy-makers enter into ethical debate. Our species is gradually but inexorably killing the other wild living inhabitants of our planet, and destroying the places in which they live. The time to adopt a new ethical position has already passed with some talk but no action. The matter is now so urgent that it demands the attention of every marine scientist. In Callicott’s words: “we ... must rise to the challenge of our time” – requiring an explicit change of the underlying ethics of our use of marine ecosystems (Callicott 1991:27).

My conclusion is that biological scientists are amongst the few residents of the Earth who can appreciate the gravity of the changes which are taking place. We need to speak for the planet, and we need to use ethical as well as scientific arguments to do so. The ‘right to peaceful coexistence’ is a concept in need of urgent and widespread discussion. We need to discuss “the arrogance of humanism” and the ethics of resource use on a planet whose ecosystems are in crisis. Marine protected areas need to be developed for many reasons, one of which is to provide peaceful and secure homes to other living residents of this planet, in addition to their role in safeguarding the integrity of ecosystem processes we barely understand.

Endnotes:

⁵ While the Australian position at the IWC’s Scientific Committee must rest on scientific arguments (see IWC 2001) arguments supporting whale sanctuaries on the government’s website (www.deh.gov.au) also avoid addressing ethical issues directly. In successfully arguing for the creation of the Southern Ocean Whale Sanctuary, and in unsuccessfully arguing for the creation of the South Pacific Whale Sanctuary, Australia has been constrained by the mandate of the IWC to argue in terms of rebuilding whale stocks (Gales, pers. comm. 2005). The mandate of the International Whaling Commission, as the name suggests, revolves around the central concept of sustainable harvesting. The IWC is not the International Whale Protection Commission, as the Japanese IWC delegation have correctly pointed out. So – although the Australian position on whale conservation *appears* to be underpinned by a wider ethic of protection of species for their own sake, the actual arguments used to establish protective measures are in fact based on traditional harvesting paradigms. See Government of Australia 2002, 2004.

⁶ Comment by Scoresby Shepherd 12/1/06: Passmore at a philosophic level set out to show that the modern West leaves more options open than most societies. He said: “Its traditions, intellectual, political, and moral, are complex, diversified and fruitfully discordant. That gives it the capacity to grow, to change. It is inventive, not only technologically, but politically, administratively, intellectually.” However, later in a perceptive historical analysis of the prospect of moral improvement of man, gives little reason to hope that man is likely to be any less greedy in the future than he is now, or will ever be more ready to revive well known ethics, or embrace new ones.

⁷ Singer later extended these arguments to more controversial ground when he claimed: “The only ethical approach to Australia’s wild animals is one that gives their interests equal consideration alongside human interests.” Singer (1996).

⁸ The first sentence of the *Convention on Biological Diversity 1992* explicitly recognises the “intrinsic value of biological diversity”. The importance of intrinsic values was reinforced a decade later by the *Strategic Plan* of the CBD Conference of the Parties (CoP). Decision VII/5 of the CoP in 2004 explicitly incorporates intrinsic values into its statement on the goals of marine no-take areas: “The key purpose of these areas would be to provide for intrinsic values...” as well as anthropocentric values. (Annex I Appendix 3 paragraph 10). In my view, marine scientists need to make use of these international commitments to the protection of intrinsic values in discussions at all levels, from grass-roots stakeholders to the highest political level.

⁹ According to Bosselmann: “I would argue that the state-centred model of governance is on its way out to be replaced by a multi-layered system with civil society at its core. The Earth Charter is the founding document for this.” Pers. comm. 11 May 2006.

¹⁰ IUU: illegal, unregulated and unreported.

¹¹ Used here, the term ‘order of magnitude’ means approximately a factor of ten.

¹² FAO: the United Nations Food and Agriculture Organization, based in Rome.

¹³ It should be noted, however, that compensation costs for fishers in the Great Barrier Reef, displaced by the expansion of representative areas in 2004, were underestimated. Clearly estimating compensation costs needs to be undertaken with care.

4. Evolution of fisheries governance paradigms

Who hears the fishes when they cry? It will not be forgotten by some memory that we were contemporaries.

Henry David Thoreau, 1849.

4.1 Introduction:

The dominant paradigm of the fishing industry today sees the activity as essentially one of resource extraction – the production of wealth from a natural resource – like timber harvesting or mining. While philosophers (and occasionally broad national policies) may discuss intrinsic value, such concepts appear rarely (if ever) in fishing industry dialogs. Nevertheless the concerns of conservation biologists regarding ecosystem protection and precautionary management have entered fishing industry literature – if not fishing industry practice.

This chapter outlines the main features of the mould in which the dominant paradigm has been formed over the last half-century. Attention is drawn to the development of the precautionary, ecosystem and adaptive approaches within modern fisheries management. It has been suggested that the management tools which were lacking at the start of the twentieth century are now available, and that the essential challenge of the industry over the coming decades is one of implementation. However, fishery damage to productive ecosystems, and overfishing in the face of regulation, remain pervasive. These problems, as well as the freedom to fish the high seas under flags of convenience, remain as thorns in the side of such optimism.

4.2 Current fisheries paradigms:

Humans have been fishing for many thousands of years. Modern fisheries, and the mentalities behind them, have evolved from, but are hugely different from those ancient artisanal fisheries. Today, fisheries are characterised by paradigms totally dominated by a homo-centric view of the world – fish are a resource to be used. Left in the ocean, their intrinsic value is negligible or non-existent.

Ragnar Arnason (a professor of fisheries economics at the University of Iceland) expresses a typical view from the fisheries economics discipline:

...[F]ishing is fundamentally a production activity. As such it is no different from other industries. It follows that its social purpose is to maximize the net value of production, i.e. the difference between the value of landings and the cost of producing these landings. In this way the contribution of the fisheries to the GDP and, hence, general welfare is maximized. Anything else implies economic waste. Economic waste means that goods that could have been used to increase someone's personal utility are squandered. That, of course, is morally reprehensible (Arnason 2000:1).

Fish habitat has also been seen by the commercial industry, until very recently, as having no economic value, indeed no value at all – at least when it gets in the way of a trawl¹⁴. This view has allowed bottom trawling over vulnerable habitat to continue (Gray et al. 2006, NRC 2002) – a practice which may be compared to clearfelling a forest to catch a herd of deer (Watling & Norse 1998). In spite of protests dating as far back as the fourteenth century (Jones 1992) this outrageous practice continues today under the official sanction of fisheries management agencies around the world¹⁵.

There are other ways to view the world and the place fisheries have in it.

In his paper *Traditional marine conservation methods in Oceania and their demise* Johannes described the way in which central Pacific island cultures viewed fishing through the lens of spiritual beliefs and long-standing traditions – with the result that fishing did not occur at

many sites and times important for the lifecycles of harvested fish, turtles and seabirds – and traditional systems of tenure also helped prevent overfishing (Johannes 1978). Western philosophers, such as Thoreau (quoted above) Lynn White (White 1967) and Aldo Leopold (Leopold 1948) argued for a deep respect for nature, irrespective of its direct benefit to man. This view was put forward, if not officially endorsed, by Australia's national biodiversity strategy in 1996 (Commonwealth of Australia 1996:2) The argument is still being put forward (see, for example, Callicott 1991, 2002) although with no apparent impact on fisheries cultures or frameworks (FAO 2005a).

4.3 Hunting game and catching fish:

There are obvious similarities between the hunting of game on land, and the capture of wild marine animals (here referred to as 'fishing'). The differences, however, are stark. Hunting on land is now tightly controlled in developed countries, where many large animals were pushed to extinction by hunting pressures over the last millennium (eg: Marshall 1966, Myers 1979, Holdaway 1989, Rosser & Mainka 2002). Available evidence suggests extinction through hunting has been a pattern for millennia (eg: James 1995, Alroy 2001, Roberts et al. 2001, Prideaux 2007). In this respect the oceans lag behind terrestrial environments (Cury & Cayre 2001).

The names of Australian government departments reflect changes in the place wild harvesting has had in western (not just Australian) culture. In the century following the British invasion of Australia¹⁶, hunting wild animals moved from uncontrolled to partially controlled by State governments. At the close of the nineteenth century, the colonies of Victoria and South Australia each created a *Department of Fisheries and Game* to control and promote these activities¹⁷. The Victorian Department, many decades later, was replaced by two departments: a *Department of National Parks and Wildlife*, and a *Department of Fisheries*. These departments, years later, were subsumed by the creation of larger departments – fisheries into the *Department of Primary Industries*, and wildlife into the current *Department of Sustainability and the Environment*. Victorian statutes also reflect this trend. The *Game Act 1890* underwent several major revisions until the *Wildlife Act 1975* replaced the *Game Act 1958*. While the *Fisheries Act 1890* similarly underwent several major revisions, it remains the direct predecessor of the *Fisheries Act 1995*. The changes in name and focus of both statutes and departments illustrates a progression which is not unique to Victoria, but represents, I believe, a global trend in Western cultures.

These changes reflect an increasing awareness of the impact of human activities on wild *terrestrial* animals, leading to programs for their care and conservation (allowing certain harvesting activities to continue under increasingly tight controls). Of interest to the current discussion, while the impact of human harvesting on the marine environment has been well documented in scientific circles, public and political awareness of these impacts remains low. In spite of the parlous state of our marine environment (Chapter 3 and below) it may be some time before we see *Fisheries Acts* around Australia (or around the world) replaced by *Marine Asset Management Acts* – although such a change might already have wide support in academic circles..

Although the culture of the bigger players in the commercial industry has undoubtedly changed to some extent, as a recreational fisher it is my impression that recreational fishing cultures in Australia remain in much the same state as they were many decades ago. The ecological impacts of recreational fisheries should not be dismissed. Lewin et al. (2006) and Cooke & Cowx (2004) have drawn attention to the potential of recreational fisheries to cause major ecosystem damage, and Balon (2000) has discussed related ethical issues. This thesis supports arguments by these authors in suggesting Australian regulation of recreational fisheries falls well short of clearly stated international and national standards (Chapters 15 & 16).

4.4 Overfishing:

Overfishing is defined in this thesis as *a level of fishing which puts at risk values endorsed either by the fishery management agency, by the nation in whose waters fishing takes place, or within widely accepted international agreements*. A point of critical importance in this

regard is that a level of fishing intensity which successfully meets traditional stock sustainability criteria (for example fishing a stock at maximum sustainable yield) may well be considerably higher than a level of fishing intensity which meets criteria designed to protect marine biodiversity (Jennings 2007). The wide endorsement of the *Convention on Biological Diversity 1992* implies that the latter level is now the critical level by which overfishing should be measured. However overfishing (for almost all of the twentieth century) was defined in practice as a fishing level which exceeded the estimated maximum sustainable yield. The current Australian Government definition of overfishing is further discussed in Chapters 11 and 17 below.

As with other examples of the 'tragedy of the commons' (Hardin 1968) the beneficiaries of overfishing are fishers interested in short term profits. In the long term there are no beneficiaries, only losers, with the fishing industry itself heading the list (Sumaila & Suatoni 2005; Sethi et al. 2004, Sissenwine & Rosenberg 1993).

Many writers (eg: Johannes 1978) have recognised that overfishing may be expected in the 'commons' of the oceans, where the benefits of over-exploitation accrue to the exploiter, but the costs of the resulting degradation are shared across the owners of the commons. An obvious question, then, is 'have regulators anticipated overfishing, or reacted to it?'

In an examination of four of Iceland's most important fisheries, Matthiasson (2003:1) found that "serious attempts to reform management practices only got underway when the fishery had collapsed or was close to collapse". This pattern seems to have typified most major fisheries worldwide (Pauly et al. 2002, Rosenberg 2003). Fisheries have had a long history of overharvesting and ecosystem damage (Jackson et al. 2001) and this important feature deserves scrutiny – explaining in part the advocacy of ecosystem-based management approaches in the latter half of the twentieth century.

Overfishing occurred before the advent of industrial fishing. Saenz-Arroy et al. (2005), Barrett et al. (2004), Jackson (2001), Steele & Schumacher (2000), and Pitcher (2001) for example discuss archaeological and anecdotal evidence of historical overfishing, including that by artisanal cultures and recreational fishers. In the United Kingdom "overfishing was already an issue in the 1850s" (Schwach et al. 2007:798). At the very start of the era of industrial fishing, Roughley (1951:179ff) describes several major instances of overfishing along the east coast of Australia commencing in the early 1920s.

Seventy years later, Ludwig et al (1993) – looking back over a long history of resource over-exploitation, concluded (my italics):

There are currently many plans for sustainable use or sustainable development that are founded upon scientific information and consensus. Such ideas reflect ignorance of the history of resource exploitation and misunderstanding of the possibility of achieving scientific consensus concerning resources and the environment. *Although there is considerable variation in detail, there is remarkable consistency in the history of resource exploitation: resources are inevitably overexploited, often to the point of collapse or extinction.* We suggest that such consistency is due to the following common features: (i) Wealth or the prospect of wealth generates political and social power that is used to promote unlimited exploitation of resources. (ii) Scientific understanding and consensus is hampered by the lack of controls and replicates, so that each new problem involves learning about a new system. (iii) The complexity of the underlying biological and physical systems precludes a reductionist approach to management. Optimum levels of exploitation must be determined by trial and error. (iv) Large levels of natural variability mask the effects of overexploitation. *Initial overexploitation is not detectable until it is severe and often irreversible.*

Fishery managers were quick to respond to Ludwig's paper. Both Rosenberg et al. (1993) and Aron et al. (1993), while not contesting Ludwig's essential logic, pointed out that there were a number of outstanding examples of well-managed and apparently sustainable fisheries.

Sixteen years have passed since these arguments appeared in the pages of *Science*. With the benefit of the passage of time, have events supported the view that Ludwig's pessimism was overstated? The answer is 'yes and no'. Some of the specific fisheries cited by Rosenberg and Aron in 1993 are still relatively healthy and producing high yields – these are oceanic pelagic fisheries of species with short lifespans, rapid growth, and powerful reproductive strategies (squid being a good example¹⁸). However other cited fisheries have experienced marked declines in some areas, as well as notable ecosystem damage¹⁹. Ludwig's final point that "*Initial overexploitation is not detectable until it is severe and often irreversible*" was in fact played out in Australia's orange roughy fishery in the years immediately following the publication of Ludwig's paper (Chapter 12). It would appear on balance that the passage of time has, if anything, added weight to Ludwig's views. The term 'Ludwig's ratchet' (used in the paper) has now entered the scientific literature (eg: Pitcher & Haggan 2003, Hennessey & Healey 2000).

Fisheries managers, if nothing else, are remarkable for their optimism²⁰ in the face of a long and well documented global record of resource over-exploitation (eg Jackson et al. 2001) accompanied by widespread and direct damage to marine habitats from fishing gear (Gray et al. 2006, Gianni 2004). The high level of uncertainty inherent in fishing lies at the heart of this optimism, and at the heart of management failures which continue the long-standing tradition of optimism in the face of contrary evidence. The role of uncertainty in fisheries management is examined in more detail in Chapter 6 below.

4.5 Fisheries governance in the latter twentieth century:

Following the Second World War (which had given many north Atlantic fish and whale stocks a temporary reprieve from harvesting pressures) the expansion of State fishing fleets created considerable tensions between fishing nations, resulting, for example, in gunboat diplomacy between Iceland and the UK (Matthiasson 2003). These pressures led some nations to declare sovereignty over an extended fishing zone (eg: 200 miles by Peru in 1947) and to the formation of the first regional fisheries management organisations (RFMOs) – some with a history of slow and ineffective management coupled with both industry and member-State non-compliance (Anderson 1998). Later, the adoption of the UN-sponsored Law of the Sea 1982 (in force in 1994) allowed coastal States to manage fisheries on their surrounding waters with confidence that their operations would not be challenged by fleets from neighbouring States. This of course provided national fishing agencies with challenges new in both scope and nature. The Law of the Sea, and subsequent deliberations by the UN General Assembly (and particularly the UN Fish Stocks Agreement' 1995) also provided both a framework and an impetus for further development of RFMOs in other parts of the world. However, of all regional ocean authorities, the CCAMLR Commission stands alone in having a charter primarily resting on ecosystem conservation (Chapter 10 below).

Writing on the history of fisheries management frameworks, Garcia (1995) divided the later half of the twentieth century into five stages:

- 1946-58, post-war reconstruction;
- 1958-72, fishery and fishery research expansion;
- 1973-83, establishment of a new economic order (the Law of the Sea);
- 1984-92, transition to addressing global social, economic and environmental concerns (particularly fleet overcapacity and IUU); and
- 1993-2000, meeting the challenge of global sustainability.

It could be argued that Garcia's fourth category got off to a slow start, bearing in mind the collapse of the Canadian cod stocks came in 1993 (see below) – and of course the issues which mark this category are still ongoing, with no real signs of successful closure in sight even now.

The later part of the last century saw huge changes in the technology available to fishers, partly as a result of technical breakthroughs (including military spin-offs) and partly due to commercialisation driven by expanding global markets. These include radar, depth sounders and fish finders, large and sophisticated plastic nets and longlines, improved refrigeration

and onboard processing, satellite navigation and space observation systems. Expanding fisheries out-paced scientific investigations, nowhere more apparent than in the deep sea, where entire seamount habitats were destroyed before any scientific investigations could be conducted (Koslow 2007).

Garcia underlines the importance of two international 'forums' – the United Nations Food and Agriculture Organisation (FAO), and the United Nations General Assembly. The General Assembly is the birthplace of influential resolutions, together with the resulting conventions and agreements. These two institutions (the UNGA and the FAO) have been (and continue to be) vital to the negotiation and promulgation of fishery reforms – and more generally ocean governance reforms.

Caddy & Cochrane (2001) also provide a critical examination of international fisheries governance developments of the second half of the twentieth century, highlighting the importance of:

- exclusive economic zones under the Law of the Sea;
- the UN Conference on Environment and Development 1992, and the subsequent implementation program (Chapter 17 of Agenda 21);
- the voluntary FAO Code of Conduct for Responsible Fisheries 1995; and
- the UN 'Fish Stocks Agreement' 1995 (in force 2001).

The UN Conference on Environment and Development also saw the birth of the international Convention on Biodiversity 1992, at a time of increasing interest in marine matters by conservation biologists.

This period was also marked by an important event which "spread alarm amongst fishery scientists, managers and environmental groups around the world" – the collapse of the huge Canadian northern cod fishery (Caddy & Cochrane 2001:660). Prior to the sudden collapse and closure of the fishery in 1992, Canadian fisheries had been seen as a model of good management. This event was partially responsible for the way in which the FAO subsequently championed the precautionary approach – explicitly included in both the Code of Conduct, and the Fish Stocks Agreement 1995.

The collapse of the cod fishery also promoted an interest in management theory and systems amongst both fishery scientists and managers. Prior to this time, most fishery managers had at least a rudimentary background in fish biology, but little interest (and less knowledge) of management science. Managing single-species fisheries for maximum sustainable yield (MSY) was still generally accepted practice, in spite of obvious shortcomings (Larkin 1977). Basic field-based biology and simple mathematical models prevailed. All this was to change, albeit fairly slowly.

Writing shortly after the collapse of the northern cod, Stephenson and Lane (1995) suggested:

Recent fishery failures, combined with changing views on management, point to the critical and urgent need for a new approach to fisheries management. Future management should focus on integrated fisheries, rather than solely on fish populations, and will require an appropriate combination of biological considerations with operational, social, and economic considerations of the fishery. We propose integration of the traditional fields of fisheries science and management with the scientific approach of management science to form Fisheries Management Science. Fisheries management science provides the framework and methodologies for defining multiple objectives and constraints, modelling alternative management scenarios, and assessing and managing risk. This framework accepts diverse information sources toward anticipatory decision making and consensus building, and offers a new paradigm within which effective fisheries management can emerge.

The plight of the northern cod also prompted the listing of the species – although still widespread – in the IUCN Red List of Threatened Animals 1996. This caused a good deal of controversy, and highlighted the very different views of fisheries managers and conservation biologists on the importance of precaution (Mace & Hudson 1999). This difference between these groups remains substantially unchanged and unresolved today (Rice & Legace 2007).

4.6 The precautionary, ecosystem and adaptive management approaches:

The idea of the vast oceans as naturally resilient to human disturbance must be partly responsible for the continued optimism of fishers and fishery managers. In 1883 T.H. Huxley, addressing the International Fisheries Exhibition in London, famously declared that: ‘*Any tendency to over-fishing will meet with its natural check in the diminution of the supply... this check will always come into operation long before anything like permanent exhaustion has occurred.*’ (quoted by Tittensor et al. 2006). It would seem likely that this idea, now so thoroughly discredited, lives on in the hearts, if not the minds of many fishers and fishery managers.

Uncertainty creates risk. Three major risk management strategies of great significance have been developed: the precautionary, ecosystem, and adaptive management approaches. It is important to briefly outline their history.

There are many definitions of the precautionary principle (Appendix 2). Precaution may be simply defined as ‘caution practised in the face of uncertainty’. All definitions of the precautionary principle have two key elements. The first is an expression of a need by decision-makers to anticipate harm before it occurs. Within this element lies an implicit reversal of the onus of proof (Dayton 1998). Under the precautionary approach it is the responsibility of an activity proponent to establish (through reference to evidence and logic) that the proposed activity will not (or is unlikely to) result in significant harm. The second key element is the establishment of an obligation, if the level of harm may be high, for action to prevent or minimise such harm even when the absence of scientific certainty makes it difficult to predict the likelihood of harm occurring. The need for anticipatory control measures increases with both the level of possible harm *and* the degree of uncertainty (Preston 2006).

According to Cooney (2004) “the precautionary principle is widely recognised as emerging from the *Vorsorgeprinzip* (directly translated as “fore-caring” or “foresight” principle) of German domestic law, although it has earlier antecedents in Swedish law”. Under English law a ‘duty of care’ (which applies strictly to people not the environment) carries, to a limited extent, the anticipatory elements of the precautionary principle.

The need for precautionary management was formally discussed at the 1973 FAO Technical Conference on Fishery Management and Development (Caddy & Cochrane 2001:659). The first appearance of the precautionary principle in international law was in 1982, when a version of the principle appeared in *The World Charter for Nature*, a resolution of the UN General Assembly. Importantly, it was later incorporated in the FAO *Code of Conduct for Responsible Fisheries 1995*, leading to inclusion in the UN Fish Stock Agreement and the subsequent development of FAO guidelines for the application of the principle. Thanks to the FAO, guidance on the application of precaution to management is more fully developed for the fishing sector than for any other industrial sector – bearing in mind that the development of guidelines is not the same as their implementation (see case study chapters below).

The ecosystem approach also has a considerable history. According to Hutchings (2000:300) “the potential utility of an ecological and evolutionary framework in which to assess the effects of fishing was proffered as early as the 1880s...” Apparently no-one was listening. The ecosystem approach as it is referred to today grew out of the development of the science of ecology, refined (after slow beginnings in the nineteenth century) in the first half of the twentieth century by scientists such as Odum (eg: Odum 1953) and Wilson (eg: MacArthur & Wilson 1967). Its first appearance in international law was in the *Convention on the Conservation of Antarctic Marine Living Resources 1980* (CCAMLR) in force 1982.

Article II(3) of that Convention defined three “principles of conservation”, of which the second and third principles identify the need for harvesting management to (a) protect entire ecosystems, and (b) take a cautious approach to ecological risk. While this last principle lacks the explicit anticipatory element of the precautionary principle, it has in practice been interpreted as mandating both an ecosystem approach and a precautionary approach (Kock 2000).

In spite of these important beginnings, widespread adoption of the ecosystem approach has been slow. In a major review of US fisheries, the National Research Council (NRC 1994) found that fisheries managers had given little consideration to ecosystem considerations – or the use of ‘best available science’ (Stone 1994) another keystone in CCAMLR management protocols. Two major US reviews following the NRC report both highlighted a pressing need to adopt the ecosystem approach to fisheries (Levin & Lubchenco 2008:28), as did a major UK review (RCEP 2004).

The active adaptive management of natural resources was pioneered by Walters (eg: Walters & Hilborn 1976) in a direct attempt to address longstanding problems of uncertainty in the fishing industry. Passive adaptive management, or ‘learning by doing’ is closely related to active adaptive management, but distinct from it (Chapter 9). Active adaptive management involves conscious experimentation.

The fundamental ideas of adaptive management are basic to industrial quality control, where, for example, they underpinned Japan’s economic recovery following the Second World War. ‘Quality is not an accident’ is a well known phrase within quality engineering circles – referring to an iterative procedure of setting targets, implementing programs to meet these targets, monitoring the results, and adjusting program details accordingly so as to achieve the stated targets. Adaptive management is often defined to encompass an additional ‘continual improvement’ principle, where targets are refined and raised as the adaptive cycles progress. These principles, transferred from industrial engineering to natural resource management, remain the same, and are now incorporated into International Organization for Standardization²¹ (ISO) procedures for quality assurance and environmental management system planning which have global acceptance (the ISO 9000 and ISO 14000 series standards).

Adaptive management applied to industrial quality control is far simpler than active adaptive management applied to complex and continually changing ecological systems (even without added complexity of the human components of fisheries management). However the fundamental principles remain the same, although the techniques may be very different. Hilborn has continued to underscore the necessity to use modern modelling and estimation approaches in the practical application of active adaptive management (Hobbs & Hilborn 2006, Punt & Hilborn 1997)

4.7 Compliance:

Ensuring compliance with fishing regulations has been a long-standing problem world-wide. Fishing is an industry where a large proportion of the activity is controlled by individual operators rather than corporate boards. Until the adoption of observer programs (and the more recent adoption of remote monitoring) vessel skippers operated under little surveillance, and with few market or port controls. The financial incentives to ignore State and international fishing regulations have often been high. Under such conditions it would not be unexpected to see major non-compliance occurring – and that has in fact been the case (see Chapters 11 & 12). Lack of regulation or recording requirements on the high seas has exacerbated the problems (Gianni 2004, Gianni & Simpson 2005). Illegal, unreported and unregulated (IUU) fishing in the area of the Southern Ocean falling under the CCAMLR convention is estimated as equivalent to, or slightly greater than the authorised catch (Miller 2007 pers. comm.). Some nations (eg: France, Spain, Ireland and Portugal²²) have condoned fishing industry non-compliance with international and regional regulations (Pastor 2006). United Nations agreements, such as the 1991 ban on driftnetting, continue to be ignored by important sections of the fishing industry (Tudela et al. 2005a) with serious ramifications for marine biodiversity. FAO audits of fishing industry performance continue to

reveal failures on the part of States and RFMOs to adopt strategies agreed on through the UN – including implementation of the precautionary, ecosystem and adaptive approaches (eg: FAO 2005b).

4.8 Fisheries governance at the close of the twentieth century:

While there had been fisheries declines for many years, the 1990s saw the continuing decline or collapse of more major fisheries, of which the north Atlantic cod fishery is one of the most well known. Declines occurred worldwide – including the south Atlantic, Indian, Pacific and Southern oceans – occurring in the face of ‘improved’ fishery management practices. These declines prompted a number of senior ocean scientists to express concern in the scientific literature – Daniel Pauly, Jeremy Jackson Ray Hilborn and Ransom Myers, for example. Concern moved to alarm as the twenty-first century unfolded. Pauly et al, writing in 2002 stated:

Fisheries have rarely been ‘sustainable’. Rather, fishing has induced serial depletions, long masked by improved technology, geographic expansion and exploitation of previously spurned species lower in the food web. With global catches declining since the late 1980s, continuation of present trends will lead to supply shortfall, for which aquaculture cannot be expected to compensate, and may well exacerbate. Reducing fishing capacity to appropriate levels will require strong reductions of subsidies. Zoning the oceans into unfished marine reserves and areas with limited levels of fishing effort would allow sustainable fisheries, based on resources embedded in functional, diverse ecosystems. (Pauly et al. 2002:689)

It is widely believed that “governance, and not science, remains the weakest link in the [fisheries] management chain” (Browman & Stergiou 2004:270).

Over the last 50 years, many of the world’s major fisheries have moved from management approaches based on a total allowable catch (set on an annual basis) to rights-based approaches using quotas or other mechanisms for allocating the ‘right to fish’ to fishing entities (Hannesson 2005, Huppert 2005). Another complementary shift in management regimes over this period has been a move from ‘command and control’ to various forms of industry consultation or co-management, driven by a belief that increasing stakeholder ownership of decisions will enhance compliance (Hilborn et al. 2005a). However implemented, catch limit determinations have not been released from political pressures anywhere in the world, and the distortion or disregard of fisheries science advice by pressures from vested interests has been well documented (Reeves & Pastoors 2007, Tilzey & Rowling 2001, Anderson 1998).

Many writers (eg: Hilborn et al. 2005b) have drawn attention to the fact that fish are a public resource, and that the profits of exploiting the resource (as well as the costs of managing and conserving the resource) need to be widely and fairly shared. While this is a complex issue (Hannesson 2004) fisheries agencies generally have been slow to provide transparency or leadership on this issue.

The management of national economies offers an interesting contrast to the management of national fisheries. Modern governance models used in economic management – for example the setting of interest rates by an independent authority (usually a central national bank) – have sometimes been considered by fisheries managers²³ but so far not adopted. The application of such a governance framework would see harvesting levels set by an independent government-funded authority charged with specific statutory responsibilities to achieve long term goals, including protection of the ocean’s biodiversity assets.

4.9 Governance in the twenty-first century:

There is no doubt that today, in spite of some major advances in fishery management practices over the last three decades, the precautionary, ecosystem and adaptive approaches (along with effective compliance programs) remain without effective implementation across global fisheries (Tittensor et al. 2006, FAO 2005b, Tudela et al. 2005b). Although many of the key elements of sustainable ocean governance frameworks

have in fact been in place in some areas for nearly three decades (eg: CCAMLR) fisheries managers at both national and regional levels have been slow to follow these signposts to the future (Caddy & Seijo 2005).

Caddy & Cochrane (2001) argued that the beginning of the last century saw national governments without the governance or scientific tools necessary to manage marine fisheries. In a thoughtful and important review, they go on to argue that passage of one hundred years has seen the development of most, if not all, of the necessary tools – leaving the essential challenge of the twenty-first century as one of effective implementation. Hilborn (2007) and Beddington et al. (2007) also argue that existing tools, properly applied, can solve fishery management failures.

My own view is quite different. There is no doubt that IUU fisheries still present huge problems world wide (Sumaila et al. 2006, Gianni & Simpson 2005, Gianni 2004), and overfishing in the face of regulation remains pervasive, even in Australia (see Chapters 11 & 12, and Shaw 2008 on serial overfishing). While the difficulties of effective implementation of national and regional management regimes should not be underestimated, it may well be that fundamental governance problems remain, resting on the conceptual mind-set of *fish as the resource* rather than ocean habitat as the resource, combined with the idea of the *freedom to fish* (not just the high seas). The idea of 'the freedom to fish' lives on amongst Australian domestic fishers, as well as high seas fishers, the people who fund them, and the governments and bureaucrats who attempt to control them (see case study chapters) .

I suggest that we need to move to a system of ocean zoning, in both domestic waters and the high seas, as recommended, for example by Walters (2000) and Russ & Zeller (2003)? Could this be done through regional agencies with 'ownership' over their waters? And would such agencies need a charter based primarily on conservation or 'asset management'? If this was to happen, how would costs, benefits and responsibility be shared amongst nations? I return to this question in Chapter 19 of the thesis.

The coming decades may see changes in line with Earle & Laffoley's (2006) call that "we must place biodiversity conservation at the center of ocean governance". The work of Pitcher & Pauly (1998) and Pitcher (2001) support this call in arguing that the proper goal for fisheries management should not be catch optimisation or sustainable harvests, but ecosystem rebuilding. Mangel & Levin (2005) recommend that community ecology should be the basic science for fisheries, and Pikitch et al. (2004) recommend that "the framework of fishery management must be broadened to include environmental effects, food web interactions and the impacts of fishing on ecosystems". Worm et al. (2007) emphasize "that the protection and restoration of biodiversity must be a cornerstone of any rational management regime." Walker & Salt (2006) argue that protecting ecosystem resilience must be the primary goal of natural resource management (see section 6.13 below).

I suggest that such views herald major changes to both fishery science and fishery management in coming decades.

The day may come when fishery management agencies around the world are replaced by *marine asset management agencies*, with charters to assess and report on the value of marine biodiversity assets, sponsor research, fund conservation programs, control and monitor extractive use, and collect resource rents – all in close consultation with *both* active and passive users of the marine environment. Decisions on allowable catch would be taken by independent authorities charged with long-term statutory charters, and operating under decision rules agreed to in advance – at arm's length from vested interests and their political allies. Stakeholder consultation programs would explicitly include persons with a statutory mandate to represent the interests of future generations. Such consultation programs might even include a 'representative of the fish' – a person charged to "hear fishes when they cry", as Thoreau said so long ago²⁴.

--ooOoo--

Endnotes:

¹⁴ The continued trawling of the fragile Darwin Mounds, after their vulnerability and scientific importance had been established (Koslow 2007:128) provides an example of a fishing mentality apparently comfortable with the destruction of important marine habitat. Recovery of these deep water coral habitats takes place over time-scales of centuries to millennia (Koslow 2007).

¹⁵ 'Vulnerable habits' here means here complex biogenic benthic habitats with long recovery times, such as those found in many deep sea seamounts; these seamounts have recovery times measured in decades to millennia (Koslow 2007). A precautionary approach to bottom trawling would see the practice halted pending sufficient mapping of jurisdictional vulnerable habitat – thus allowing future spatial controls. The only nation that I am aware of with controls in line with this approach is Palau. It should be recognised that some sections of the bottom trawling industry have voluntarily closed areas – this occurred when a group of trawler operators declared some seamounts in the south Indian Ocean 'out of bounds' to their vessels in 2007. The New Zealand trawling industry also initiated area closures within the NZ fishing zone in 2006.

¹⁶ The term "invasion" is used as in Reynolds, H (2006) *The other side of the frontier: Aboriginal resistance to the European invasion of Australia*, University of New South Wales Press, Sydney.

¹⁷ The Victorian Department administered the *Fisheries and Game Act* which pre-dated the creation of the Department by about 15 years – the Act was earlier administered by a Fisheries and Game Branch in the Department of Agriculture.

¹⁸ See next footnote.

¹⁹ In their reply to Ludwig et al. (1993) Rosenberg et al. (1993) cited examples of well managed and apparently sustainable fisheries: Atlantic striped bass (*Morone saxatilis*), herring (*Clupea harengus*) and mackerel (*Scomber scombrus*) on the Georges Bank, North Sea herring, and the Falkland Islands squid fishery. The latest information I could obtain for these fisheries (data varying in currency between 2001 and 2005) indicates that all these fisheries are still relatively healthy and producing high yields. The Falkland's squid fishery has recovered from a collapse in 2005/06 (W. Dimmlich pers.comm. 2008, Fisheries Department, Stanley, Falkland Islands), noting that the ecological impacts of the fishery are not fully understood, or impacts (for example on seabirds) resolved (Barton 2002). Ecosystem effects aside (where for the most part I was unable to obtain information) it would appear that these are indeed well managed and sustainable fisheries, and were so at the time in question (1993).

Aron et al. (1993) cited fisheries of the northeast Pacific, particularly those of the Bering Sea. The authors also cited the halibut fishery on the west coast of USA and Canada, as well as pink and sockeye salmon from the Fraser River in British Columbia. The west coast halibut fishery remains healthy to this day, in the face of widespread declines in Atlantic halibut. It would seem that Aron's point in regard to this fishery was well made. There have been widespread declines in salmon fisheries, especially on the west coast of the USA, and to a lesser extent in Canada. Unfortunately the Fraser River fishery has not been immune to these effects (Healey & Hennessey 1998) – noting that overfishing is by no means the only important factor in salmon fishery declines.

While the total annual catch from the Bering Sea has declined unevenly since a peak in 1987 (FAO 2005b), most fisheries here remain large and productive, continuing to supply about half the catch for the entire USA. Bering Sea fisheries were, in Aron's view, the most important example of sustainable regional fisheries: "Current fisheries management in this area contradicts the conclusions of Ludwig et al. ..." (Aron et al. 1993:814).

However, while many Bering Sea fisheries targeted at individual species remain healthy, there were important concerns about ecosystem effects expressed in the mid-1990s (CBSE

1996) which have increased rather than decreased with the passing years. Greenwald (2006) in a review of the status of vertebrates in the Bering Sea region, identified 11 fish, 21 marine mammals and 34 bird species as having undergone significant recent population declines. He identified commercial fishing operations as the most important and pervasive threat, along with climate change, habitat degradation, ecological effects and pollution (Greenwald 2006:1).

Several important Bering Sea invertebrate fisheries remain closed (Alaska Oceans 2005) after experiencing rapid declines under fishing pressure (Orensanz et al. 1998). Targeted trawl fisheries for Pacific ocean perch, northern rockfish, shortraker rockfish, rougheye rockfish, and 'other rockfish' (identified in FAO 2005b), as well as Greenland turbot remained closed in 2008 (NOAA 2008). Northern abalone (*Haliotis kamtschakana*) populations are at low abundance, with no sign of recovery after the fishery closed in 1990 (FAO 2005b). Overfishing was a primary driver behind all these closures.

Hutchings & Baum (2005:315) provide a more general picture of northern-hemisphere fisheries: "Based on data for 177 populations (62 species) from four north-temperate oceanic regions, 81% of the populations in decline prior to 1992 experienced reductions in their rate of loss thereafter. [However] with some possible exceptions, rate of decline among the most severely affected fish has accelerated throughout the latter half of the twentieth century when reductions of more than 80%, relative to recorded (as opposed to true) historical levels, were not uncommon, particularly among large predators ..."

While there are obvious dangers in drawing general conclusions from complex and contradictory trends, on balance it seems that the passage of time has strengthened, rather than weakened Ludwig's arguments.

²⁰ See the Epilogue to Chapter 12.

²¹ The ISO is correctly named the Organisation Internationale de Normalisation.

²² Portugal and Spain, appear – by their repeated failures to enforce compliance on flagged vessels – to actually encourage non-compliance. In July 2005, the European Court of Justice fined the French Government 20 million euros with a recurring fine of 58 million euros pending cessation of fishery regulation breaches. France had been found guilty of similar offences in 1991. The court heard evidence of two decades of adverse inspection reports and Commission letters threatening legal action. The court issued a statement in part: "The persistence ... of the practice of offering undersize fish for sale and the absence of effective action by the national authorities are such as to prejudice seriously the Community objectives of conserving and managing fishery resources." Small (immature) fish are prized in French cuisine, and are caught using illegal fine-mesh nets. European investigators found juvenile fish being openly auctioned in all six French ports inspected, sometimes in the presence of French fishery inspectors (information on the European Court of Justice case is drawn from The Times Online (March 2, 2006, www.timesonline.co.uk), and AFX News (December 7, 2005, www.afxnews.com).

The same month (July 2005) the Court of Justice found Portugal guilty of failing to enforce fishery quotas. The Commission announced that it had, at that time, 81 fisheries infringement notices pending against Member States. (FishFiles Newsletter July 2005). In January 2006 the Commission published records of overfishing by member States, with Ireland and Spain at the top of the list (FishFiles Newsletter, January 2006). In March 2006 France was ordered to pay 58 million euros for continuing failure to comply with the July 2005 court ruling (FishFiles Newsletter, March 2006).

²³ See paragraph 7 of Caddy & Agnew 2003 – with reference to "non-discretionary legislation".

²⁴ Christopher Stone (1993) has offered a guardianship model where humans would legally represent nonhumans in courts and policy arenas.

5. Core 'approaches' in international agreements

5.1 Introduction:

This chapter aims to present an overview of the most important international instruments influencing the protection of marine biodiversity, focusing largely on certain central commitments which nation-States have accepted under such instruments. These relate to: (a) the strategic establishment of protected area networks, (b) the use of ecosystem-based management, and (c) the precautionary approach (including commitments to the prior assessment of activities). The conservation of high seas biodiversity is currently a major issue for the international community, and some information on this issue is also presented.

While there is some repetition in this chapter of issues previously discussed, this is necessary to cater for readers 'dipping' into the thesis. The repetition is necessary to present the chapter's material in a logical context. Readers needing more comprehensive coverage of international ocean governance issues should refer to detailed reviews such as Kimball (2001).

5.2 Overview:

The most important vehicles for international programs and initiatives in regard to the protection of the marine environment are:

- International agreements, such as treaties and conventions, sponsored by the United Nations (or major associated bodies, such as the UN Food and Agriculture Organisation, FAO²⁵);
- Regional agreements sponsored by the United Nations or large regional State groupings, such as the European Union (eg: regional planning or fisheries agreements²⁶);
- Decadal global conferences on the environment sponsored by the United Nations; (most recently the World Summit on Sustainable Development 2002), and
- Resolutions of the United Nations General Assembly²⁷.

These statements and agreements influence the programs that States develop to conserve the marine environment within their own jurisdictions. They also influence the flow of funds into special-purpose international programs - for example those targeting under-developed nations. The Global Environmental Facility (GEF) for example, channels a portion of its funds into the Global Programme of Action (or to use its full title: the *Global Programme of Action for the Protection of the Marine Environment from Land-based Activities*). The GEF is a UN initiative, funded by about 30 donor States, with project money channelled through the programs of the World Bank, UNEP and UNDP.

Large international Non-Government Organisations (NGOs) - such as the World Conservation Union (IUCN) or WWF-International - seek to influence these vehicles. Various global and national agencies - such as the FAO - also seek to influence the larger of these vehicles, along with international industry lobby groups and nation-state groupings.

Broadly speaking, the living inhabitants of the marine realm face five major threats (Chapter 2 above):

- *climate change*: changes to oceanic temperatures, acidity, patterns of water movement (including currents, eddies and fronts), storminess and sea level, largely caused by *increasing atmospheric carbon dioxide*, as well as impacts from damage to the ozone layer;
- *overfishing* with attendant bycatch problems, both from commercial fishing, recreational fishing, illegal unregulated or unreported fishing (IUU), and ghost fishing²⁸;

- *habitat damage* largely caused by fishing gear, especially bottom trawling, but also including the effects of coastal development: destruction of coral reefs, mangroves, natural freshwater flows (and passage), coastal foreshores, coastal wetlands and sometimes entire estuaries – which all support coastal marine ecosystems;
- *pollution* (in-sea and land-based, diffuse and point source) including nutrients, sediments, plastic litter, noise, hazardous and radioactive substances; discarded fishing gear, microbial pollution, and trace chemicals such as carcinogens, endocrine-disruptors, and info-disruptors; and
- ecosystem alterations caused by the introduction of *alien organisms*, especially those transported by vessel ballast water and hull fouling.

National and international programs aimed at protecting marine biodiversity attempt to address these major threats.

International commitments to protect the planet's biodiversity, especially marine biodiversity, can be found in many global statements and agreements – too many to discuss here²⁹. The most important, from the viewpoint of the discussion in this thesis, are:

- the Stockholm Declaration 1972 (UN Conference on the Human Environment);
- the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) 1980, in force 1982;
- the World Charter for Nature 1982 (a resolution of the United Nations General Assembly (UNGA));
- the UN Convention on the Law of the Sea 1982 (UNCLOS), in force 1994;
- the Rio Declaration 1992 (UN Conference on Environment and Development),
- the Convention on Biological Diversity 1992, in force 1993;
- the FAO Compliance Agreement 1993¹, in force generally 2003, in force for Australia 2004;
- the FAO Code of Conduct for Responsible Fisheries 1995;
- the UN Fish Stocks Agreement 1995², in force 2001; and
- the Johannesburg Declaration 2002 (UN World Summit on Sustainable Development).

Notes: full titles:

1. Agreement to promote compliance with international conservation and management measures by fishing vessels on the high seas; FAO Rome November 1993;
2. Agreement for the implementation of the provisions of the United Nations convention on the law of the sea of 10 December 1982 relating to the conservation and management of straddling fish stocks and highly migratory fish stocks; 1995.

Nations endorsing international agreements have an obligation to apply the provisions of these agreements domestically prior to the formal 'in force' date (see the Vienna Law of Treaties 1969).

The above list includes both soft and hard law instruments, and is not comprehensive³⁰. Hard law instruments carry compliance responsibilities, usually in the form of reporting requirements and dispute resolution provisions. Although soft law instruments carry no such responsibilities, they can sometimes be equally effective in influencing member State programs if enthusiastic attempts are made to incorporate their goals and principles into State legislation, policies or budgets. For example, the Rio goals are soft law, however many nations, including Australia and the EU, undertook national reporting against the Rio goals.

Three management concepts of particular importance to the protection of marine ecosystems have developed over the last few decades, and have been accepted broadly by the international community through inclusion in strategic commitments made in major statements and agreements (more below). Implementation of these international commitments, however, has been slow. These three key concepts are:

- the strategic³¹ development of networks of marine protected areas;
- ecosystem-based management (particularly of fisheries, but applying broadly to the marine environment); and
- the precautionary principle or its softer version the precautionary approach.

In the main, commitments to the adaptive management of natural resources do not appear in the instruments listed above, with the notable exception of the Rio Conference's *Agenda 21* (1992) paragraphs 17.5d and 17.6d (more below).

The key statements and agreements listed above are discussed below, focussing on these three concepts. Two other important related concepts are discussed in passing:

- anticipatory assessment of the environmental impacts of proposed activities, and
- control of the activities of nationals (including flagged vessels) on the high seas.

As with the earlier three management concepts, these latter two have also proved difficult to implement in practice. Prior ecological assessment of proposed activities is often seen as an essential component of the precautionary approach.

While the history of marine protected areas dates back well over a century³², the advocacy of ecosystem based management in international agreements appears to date from 1980, while similar advocacy of the precautionary approach appears to date from 1982 (see discussion below). Both these concepts were in currency years or decades before appearing in international agreements, however³³.

The following section discusses each instrument from the above list, in chronological order.

Key instruments:

5.3 Stockholm Declaration 1972 (UN Conference on the Human Environment)

Principle 2 of the Stockholm Declaration states: "The natural resources of the earth, including the air, water, land, flora and fauna and *especially representative samples of natural ecosystems*, must be safeguarded for the benefit of present and future generations through careful planning or management, as appropriate" (my emphasis).

The emphasised section provides, essentially, a commitment to the development of protected area networks partly focused on the conservation of representative examples of major natural ecosystems. An examination of the wording of the Declaration reveals that it places wide obligations, not only on governments, but on all agencies of governments as well as individuals to act so as to achieve the stated objectives (preamble para. 7).

The Stockholm Declaration does not advocate precautionary action, nor does it advocate ecosystem-based management.

5.4 Convention on the Conservation of Antarctic Marine Living Resources 1980

The Convention, although a regional rather than a global instrument, is extremely important in a global context. Even though the Convention is now over 25 years old, it remains as the only regional marine convention (with the arguable exceptions of the Barcelona Convention in the Mediterranean, and the Helsinki Convention in the Baltic) focused on ecosystem protection rather than resource exploitation. The Commission to the Convention was the first marine management agency to begin implementing an ecosystem-based management approach.

The Convention, through Article I, attempted to define an area of responsibility based on ecosystem boundaries (the Antarctic Convergence, or Polar Front) rather than using political or administrative approaches³⁴.

Article II(3) defined three “principles of conservation”, of which the second and third principles identify the need for harvesting management to (a) protect entire ecosystems, and (b) take a cautious approach to ecological risk. While this last principle lacks the explicit anticipatory element of the precautionary principle (see below), it has in practice been interpreted as mandating a true precautionary approach (Kock 2000: executive summary).

Article IX(2)g allows the Commission to establish areas closed to exploitation, including “special areas for protection and scientific study” – thus enabling (but not requiring) the Commission to establish marine protected areas.

Article XV(2)d, relating to the activities of the Scientific Committee, establishes an obligation to prior impact assessment of harvesting activities.

In summary, the provisions of the Convention contain (or have been interpreted to contain) requirements for precautionary, ecosystem-based management of the living marine resources of the region. The subsequent activities of the Commission have, in fact, set global benchmarks in this regard.

The Convention, importantly, emphasises the role of ‘best available science’ in determining management decisions. Article IX confers a duty on the Convention Commission to: “formulate, adopt and revise conservation measures on the basis of the best scientific evidence available... “

On the matter of marine protected areas, it can be argued that (IUU fishing activities and non-Party States aside) the whole of the CCAMLR region qualifies as a category IV marine protected area under the IUCN’s definitions (IUCN 1995). However, CCAMLR itself, while recognising issues of IUCN classification, has not requested entry to the World Database on Protected Areas.

Articles X, XXI and XXII establish obligations for States to control the activities of their nationals (including flagged ships) in regard to compliance with the requirements and the principles of the Convention, thus anticipating the later requirements of the Law of the Sea in this regard (see below).

5.5 World Charter for Nature 1982 (a resolution of the United Nations General Assembly)

Although a voluntary statement, without any suggestion of the need for compliance monitoring, the Charter is an important document, as it firmly establishes a number of fundamental management approaches on the international agenda:

- the need for an ethical approach to utilising natural ecosystems (preamble para. four);
- the need for protected area networks including representative ecosystems (see below);
- the need to apply an ecosystem-based approach to managing natural ecosystems (see below);
- a duty to use a precautionary approach where there are significant risks of ecosystem damage (see below);
- the need for prior assessment of likely environmental impacts (articles 11c, 16);
- the need for general education programs to encompass ecosystem issues (article 15);
- the need for inventories of ecosystem assets (article 16); and

- the need for monitoring programs, including assessments of ecosystem conservation status (article 19).

The World Charter for Nature states (Article three): “All areas of the earth, both land and sea, shall be subject to these principles of conservation: special protection shall be given to unique areas, to representative samples of all the different types of ecosystems, and to the habitat of rare or endangered species.”

This article provides a repetition of the earlier Stockholm commitment to the development of protected area networks partly focused on the conservation of representative examples of major natural ecosystems.

Article four, continuing from the above quote, states: “Ecosystems and organisms, as well as the land, marine and atmospheric resources that are utilized by man, shall be managed to achieve and maintain optimum sustainable productivity, but not in such a way as to endanger the integrity of those other ecosystems or species with which they coexist.”

This article provides a broad commitment to ecosystem-based management.

Article 11 provides a commitment to the precautionary principle and to prior impact assessment, including a specific commitment to the reversal of the burden of proof:

Activities which might have an impact on nature shall be controlled, and the best available technologies that minimize significant risks to nature or other adverse effects shall be used; in particular:

(a) Activities which are likely to cause irreversible damage to nature shall be avoided;

(b) Activities which are likely to pose a significant risk to nature shall be preceded by an exhaustive examination; their proponents shall demonstrate that expected benefits outweigh potential damage to nature, and where potential adverse effects are not fully understood, the activities should not proceed;

(c) Activities which may disturb nature shall be preceded by assessment of their consequences, and environmental impact studies of development projects shall be conducted sufficiently in advance, and if they are to be undertaken, such activities shall be planned and carried out so as to minimize potential adverse effects;

Again, an examination of the wording of the Charter reveals that it places wide obligations, not only on governments, but on all agencies of governments as well as individuals to act so as to achieve the stated objectives (Article 21).

5.6 United Nations Convention on the Law of the Sea 1982 (UNCLOS)

The United Nations Convention on the Law of the Sea is a comprehensive and impressive instrument of international law, the result of decades of discussion, argument and negotiation in international arenas. It contains several important, although general, provisions relating to the conservation of the marine environment.

UNCLOS consolidated the CCAMLR provisions of 1980 regarding State control of the activities of nationals (including vessels) - see below. UNCLOS established the core jurisdictional provisions which provide the framework for marine management today.

Under UNCLOS the national jurisdiction of coastal States over the oceans extends generally to the outer margin of the 200 nm exclusive economic zone (EEZ). Continental margins may extend coastal States' jurisdiction further to a maximum of 350 nm from baselines. Coastal

states enjoy sovereign rights for the purpose of exploring, exploiting and managing natural resources within the limits of their EEZ. Related rights over continental shelf extensions are limited to the mineral and other non-living resources of the seabed and subsoil together with sedentary species of living organisms.

The high seas (areas beyond national jurisdiction) generally commence at the outer limit of the EEZ except for sedentary species. There are however, exceptions. In the Antarctic, except for the waters adjacent to State-managed sub-Antarctic islands, high seas start at low water mark – as the provisions of the Antarctic Treaty have effectively set aside national differences over territorial claims. This has not prevented some nations (eg: Australia) from declaring EEZs adjacent to their Antarctic ‘territories’. Australia has, perhaps understandably, been reluctant to enforce national laws in these areas.

Areas beyond national jurisdiction states enjoy, *inter alia*, a freedom of fishing and a freedom of scientific research. UNCLOS establishes responsibilities as well as rights. For example, on the high seas States have a general obligation to cooperate in the conservation and sustainable use of marine living resources; to protect the marine environment; and to regulate the activities of vessels under their flag. As well, (subject to the Vienna Convention on the Law of Treaties 1969³⁵) various regional and international organisations and arrangements have introduced additional obligations for States conducting activities on the high seas.

Part XI of UNCLOS declares that the high seas seabed (‘the Area’) and its resources (all solid, liquid or gaseous mineral resources *in situ* in the Area at or beneath the seabed, are the common heritage of mankind. The International Seabed Authority (ISA) has been established to regulate use of the Area³⁶. Article 145 requires the protection of the marine environment of the Area. The ISA provisions do not extend to the marine living resources of the Area. However, under UNCLOS and the Convention on Biological Diversity 1992, coastal states enjoy sovereign rights of the marine living resources within areas under national jurisdiction.

Coastal States have both rights to resources within the 200 nm EEZ, and obligations to protect EEZ living resources (Article 61). Paragraph 61(4) requires States to “take into consideration the effects on species associated with or dependent upon harvested species...” - a responsibility to apply a simplified ecosystem approach. Special considerations apply to highly migratory species, marine mammals, anadromous species, catadromous species, and sedentary species (Articles 64 to 68 and 77).

Vessels can be flagged to a State provided there is a “genuine link” between the vessel and the State. Article 94 (duties of the flag State) relates to controls on the high seas, and specifically considers *inter alia* measures for the prevention of pollution. This section is somewhat weak from the point of view of ecosystem protection, as a duty to control State-flagged vessels to achieve conservation objectives is not explicitly stated, although clearly implicit considering obligations placed by other Articles such as 192 and 194. Articles 117 to 119 place obligations on flag States to control the activities of their citizens so as to achieve “conservation of the living resources of the high seas”. Article 119 in particular requires flag States to adopt a simplified ecosystem approach, using the same form of words as Article 61.

Part XII obliges States generally to protect and preserve the marine environment (Article 192). In particular, States have to adopt, individually or jointly as appropriate, all measures that are necessary to prevent, reduce and control pollution of the marine environment from any source (Article 194 para. 1). Although there is an emphasis on controlling pollution, pursuant to Article 194 para. 5, the measures taken in accordance with Part XII shall include those necessary to protect and preserve rare or fragile ecosystems as well as the habitat of depleted, threatened or endangered species and other forms of marine life. This provision may be read as promoting an ecosystem approach (especially bearing in mind Articles 61 and 119) and at least obliquely encouraging the designation and the establishment of marine protected areas.

Further, Article 197 obliges States to co-operate on a global and regional basis in formulating and elaborating international rules, standards and recommended practices and procedures for the protection and preservation of the marine environment. This provision is the basis on which a wide range of regional agreements dealing with the prevention and elimination of pollution of the marine environment, as well as the protection and preservation of marine ecosystems and habitats, has been adopted.

The Convention does not advocate a precautionary approach to marine ecosystem protection, even though the World Charter for Nature (above) which contains a commitment to caution, dates from the same year. It can be argued that a precautionary approach is implicit in the principles of CCAMLR (see above) predating UNCLOS by two years. It is also of note that the only references to precaution in UNCLOS relate to the placement of infrastructure (such as submarine cables) and to the prevention of pollution from vessels carrying nuclear or noxious materials.

In regard to the prior ecological assessment of harvesting activities, again an approach incorporated into CCAMLR two years earlier, UNCLOS paragraph 61(4) confirms the need to take into account wider ecosystem impacts. The broader principles and obligations of UNCLOS (especially those noted above with respect to the conservation of marine living resources) entirely support a prior assessment approach, which is now being broadly, if slowly, adopted by RFMOs. The International Seabed Authority (see endnote below) has developed guidelines for prior assessment of possible seabed mining projects.

In summary, UNCLOS, although not specifically requiring a precautionary approach, does require at least a simplified version of ecosystem-based management to be applied broadly not only to fisheries but to the conservation of marine living resources generally. Although not explicitly requiring the development of marine protected areas, UNCLOS at least provides encouragement to such activities, as it does to prior impact assessment. UNCLOS provides the primary legal framework for the high seas control of flagged vessels and the activities of State citizens (State nationals).

5.7 Rio Declaration 1992 (UN Conference on Environment and Development)

The two most important outcome documents from the United Nations *Conference on Environment and Development* are the Rio Declaration and Agenda 21³⁷.

The Rio Declaration lists the fundamental principles agreed as necessary for sustainable and equitable development. Within the terms of the present discussion, Principles 2, 7, 8, 15 and 17 are relevant:

2. States have, in accordance with the Charter of the United Nations and the principles of international law... the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States *or of areas beyond the limits of national jurisdiction*. (my emphasis)
7. States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. [...]
8. To achieve sustainable development and a higher quality of life for all people, *States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies*. (my emphasis)
15. In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

17. Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.

At the State level, with regard to the marine environment, these principles provide clear commitments to:

- apply the precautionary approach, including prior impact assessment;
- develop ecosystem conservation, protection and restoration programs;
- control activities damaging high seas ecosystems;
- reduce or eliminate overfishing.

Agenda 21 provided more detail on agreed approaches to 'ensuring' sustainable development, and applying broad principles to management. For the purposes of this discussion, Chapters 15 and 17 are of interest. Chapter 15, dealing with the conservation of biological diversity, urged States to:

15.5 (b). Develop national strategies for the conservation of biological diversity and the sustainable use of biological resources;

(c). Integrate strategies for the conservation of biological diversity and the sustainable use of biological resources into national development strategies and/or plans;

(f). Produce regularly updated world reports on biodiversity based upon national assessments;

(g). Take action where necessary for the conservation of biological diversity through the in situ conservation of ecosystems and natural habitats, as well as primitive cultivars and their wild relatives, and the maintenance and recovery of viable populations of species in their natural surroundings, and implement ex situ measures, preferably in the source country. In situ measures should include the reinforcement of terrestrial, marine and aquatic protected area systems and embrace, inter alia, vulnerable freshwater and other wetlands and coastal ecosystems, such as estuaries, coral reefs and mangroves;

(h). Promote the rehabilitation and restoration of damaged ecosystems and the recovery of threatened and endangered species;

(j). Promote environmentally sound and sustainable development in areas adjacent to protected areas with a view to furthering protection of these areas;

(l). Promote, where appropriate, the establishment and strengthening of national inventory, regulation or management and control systems related to biological resources, at the appropriate level;

(m). Take measures to encourage a greater understanding and appreciation of the value of biological diversity, as manifested both in its component parts and in the ecosystem services provided;

15.6 (b). Develop methodologies with a view to undertaking systematic sampling and evaluation on a national basis of the components of biological diversity identified by means of country studies; and

(c). Initiate or further develop methodologies and begin or continue work on surveys at the appropriate level on the status of ecosystems and establish baseline information on biological and genetic resources, including those in terrestrial, aquatic, coastal and marine ecosystems.

At the State level, these agreed strategies provide obligations to:

- develop inventories and assessments of all nationally important ecosystems;
- develop integrated national biodiversity conservation strategies, including regular reports on the effectiveness of conservation programs and the conservation status of species and ecosystems;

- include in such strategies the development of protected area networks, together with protected area buffer zones; and
- promote the restoration and rehabilitation of damaged ecosystems;

Expanding these requirements in relation to the marine environment, the Rio Conference established obligations at the national level to map, conserve, and restore (where necessary) marine ecosystems. Obligations were also established to develop protected area networks within a strategic framework – incorporating, where possible, buffer zones.

Chapter 17 of Agenda 21 dealt with the marine environment. It provided considerable detail regarding pollution prevention, which we will not discuss here. In its statement of objectives, it expanded on the need to apply a precautionary approach by including an adaptive framework:

17.5d. Apply preventive and precautionary approaches in project planning and implementation, including prior assessment and systematic observation of the impacts of major projects;

17.6d. Prior environmental impact assessment, systematic observation and follow-up of major projects, including the systematic incorporation of results in decision-making;

Importantly, section 17.5 e stresses the need to regard ecosystems as valuable economic assets:

17.5e. Promote the development and application of methods, such as national resource and environmental accounting, that reflect changes in value resulting from uses of coastal and marine areas, including pollution, marine erosion, loss of resources and habitat destruction;

Sections 17.45 ff drew attention to many chronic problems of the fishing industry globally: overfishing, illegal and unregulated fishing, fleet over-capacity, excessive bycatch, unreliable management databases, and widespread non-compliance with fishing laws and regulations. It expressed concern over expanding high seas fishing operations:

17.51. States should take effective action consistent with international law to monitor and control fishing activities by vessels flying their flags on the high seas to ensure compliance with applicable conservation and management rules, including full, detailed, accurate and timely reporting of catches and effort.

17.52. States should take effective action, consistent with international law, to deter reflagging of vessels by their nationals as a means of avoiding compliance with applicable conservation and management rules for fishing activities on the high seas.

Agenda 21 requires application of ecosystem-based management to fisheries. According to section 17.74: “States commit themselves to the conservation and sustainable use of marine living resources under national jurisdiction. To this end, it is necessary to:

...

17.74c. Maintain or restore populations of marine species at levels that can produce the maximum sustainable yield as qualified by relevant environmental and economic factors, taking into consideration relationships among species;

Agenda 21 requires the development of protected area networks, although with a somewhat oblique emphasis on the need to take a strategic approach:

17.85. States should identify marine ecosystems exhibiting high levels of biodiversity and productivity and other critical habitat areas and should provide necessary limitations on use in these areas, through, inter alia, designation of protected areas. Priority should be accorded, as appropriate, to:

- a. Coral reef ecosystems;
- b. Estuaries;
- c. Temperate and tropical wetlands, including mangroves;
- d. Seagrass beds;
- e. Other spawning and nursery areas.

In summary, Rio's Agenda 21 provides comprehensive guidance to State governments on many issues affecting the marine environment, including considerable detail on risks posed by pollution and climate change – which are not discussed here. In relation to the core issues under discussion in this chapter, to fully comply with the recommendations States would need to:

- develop networks of marine protected areas, although noting that the Agenda's strategic focus is limited to fragile, rare, critical, damaged, or economically important ecosystems, without emphasising the broader need to protect representative ecosystems for biodiversity or scientific benchmarking reasons (however see notes on the Stockholm Declaration and the World Charter for Nature above);
- apply precautionary and adaptive management to marine ecosystems generally, but to fisheries in particular;
- move away from single-species fishery management towards ecosystem-based management; and
- ensure that the activities of State nationals and State flagged vessels did not prejudice the conservation or good management of high seas marine ecosystems, and in particular ensure that such activities adhered to the requirements of global and regional requirements (the UNGA resolution 46/215 on pelagic drift-netting is specifically mentioned).

Although none of these requirements introduce new obligations, they do strongly reinforce existing obligations, given the stature of the Rio Conference, stemming in part from the wide participation of States in both the Conference and its preliminary deliberations.

5.8 Convention on Biological Diversity 1992

The Convention on Biological Diversity (CBD) is arguably the most important international 'hard law' instrument for the protection of biological diversity at the global level. With over 180 signatory States (Parties) it has wide international support. Its Secretariat, in Montreal, is directed by the Executive Secretary. Meetings of the Conference of the Parties (CoP) take place roughly every two years, and have the ability to direct the detailed policies, programs and finances of the Secretariat. The decisions taken by the CoP are binding on the Parties within the general limits of the Convention (Article 23). The CoP developed a Strategic Plan in 2002, and the Secretariat has published two influential 'Global Biodiversity Outlook' reports, the latest in 2006.

Article 1 of the Convention establishes three central objectives:

- the conservation of biological diversity;
- the sustainable use of its components, and
- the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

Certain aspects of the Convention's preamble are of particular note:

- the Convention recognises that biological diversity has intrinsic value in addition to anthropocentric values;
- the Convention endorses the precautionary principle as well as the related need to anticipate threats (ie: prior environmental assessment); and
- *in situ* conservation is acknowledged as "the fundamental requirement" of biodiversity conservation programs.

The Convention, through its preamble and Article 8, establishes an approach to *in-situ* conservation which has subsequently been adopted globally as the prime mechanism for biodiversity conservation. According to the CBD (read in conjunction with the CoP's Strategic Plan and its decisions on protected areas) the conservation of biodiversity, including aquatic biodiversity, requires:

- the protection of representative examples of all major ecosystem types (especially those vulnerable to degradation)
- coupled with the sympathetic management of ecosystems outside those protected areas.

These twin policy planks form the primary basis of biodiversity conservation programs in all State Parties globally. The two fundamental concepts are reflected, for example, in Principle 8 of the Australian Government's '*National strategy for the conservation of Australia's biological diversity*' 1996³⁸. Precaution, and the use of an ecosystem-based approach, are key to the sympathetic management of utilised ecosystems. The ecosystem approach has been the subject of specific decisions (V/6 and VI/12). While use of the precautionary approach is often referred to in CoP decisions, no guidelines have yet been provided on its use in specific sectors through the vehicle of a formal CoP decision. In the marine context, however, this seems to be of little consequence, as decisions do endorse the FAO Code of Conduct (see decision VII/5) which includes ancillary guidelines on precaution.

The CBD requires that Parties report on progress made in implementing commitments made under the Convention. Three reporting cycles have been undertaken between 1992 and 2004, and Party progress reports are available through the Secretariat's website: www.biodiv.org.

The CBD established (Article 25) an advisory body named the *Subsidiary Body on Scientific, Technical and Technological Advice* (SBSTTA). The SBSTTA conducts formal meetings, and its recommendations are made available through the CBD website in a similar format to CoP decisions. Advice from the SBSTTA is considered in some depth by meetings of the CoP, and the CoP in turn refers matters to the SBSTTA for investigation and review. To complement the work of the SBSTTA, the CoP, from time to time, establishes specific-purpose working and advisory committees on an *ad hoc* basis.

Article 3 of the CBD lists a single central principle, of critical importance to issues of high seas biodiversity:

States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, *and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.*[my emphasis]

The Jakarta Mandate:

The CoP at its second meeting (Jakarta, 1995) decided to create a programme of work on marine and coastal biological diversity, with five components:

- integrated marine and coastal management;
- sustainable use of biodiversity;
- marine and coastal protected areas;
- mariculture; and
- management of threats posed by alien species.

The Ministerial Statement at the close of the meeting, underlining widely-shared concerns, referred to the "Jakarta mandate on marine and coastal biological diversity." The subsequent programme, adopted in 1998 and revised in 2004, has become known simply as "the Jakarta Mandate".

The Mandate rests on the objectives of the CBD, in particular coupled with decisions on protected areas (see VII/5 and VIII/22 and VIII/24) and the ecosystem-based approach. In addition to the five core components of the Mandate program defined in 1995, recently issues of the genetic resources of the deep sea bed, as well as high seas biodiversity have been the focus of ad hoc reports and featured in decisions. At the 2006 CoP, decision VIII/21 (on deep seabed genetic resources) stresses the need for precaution, and requests further investigation of management options. Decision VIII/24 (on the programme of work on protected areas) urges Parties to take a precautionary approach to the protection of high seas biodiversity, calls for Parties to take action to curtail destructive activities under their jurisdiction as requested by UN General Assembly resolution 59/25, and requests the investigation of options for high seas MPAs.

Decision VII/5 (2004) reviewed and expanded the programme of work on marine and coastal biodiversity. The decision was informed by an important paper published by the Executive Secretary and authored by the *Ad Hoc Technical Expert Group on Marine and Coastal Protected Areas* (AHTEG 2003) titled “Technical advice on the establishment and management of a national system of marine and coastal protected areas”.

Amongst many important recommendations, the AHTEG emphasised: “A strategic planning approach, embracing sustainable use and ecosystem-based management, to enable the implementation of an ecologically viable framework for marine and coastal protected area development, should be adopted at the national and regional levels”.

In particular, the AHTEG listed three core elements of such a framework:

- a representative network of highly protected areas where extractive uses are prevented, and other significant human pressures are removed (or at least minimised) to enable the integrity, structure, functioning, and exchange processes of and between ecosystems to be maintained or recovered;
- an ancillary network of areas that support the biodiversity objectives of the highly protected network, where specific perceived threats are managed in a sustainable manner for the purposes of biodiversity conservation and sustainable use; and
- sustainable management practices over the wider coastal and marine environment.

These elements, combined with recommendations made elsewhere (see above) on the need for precaution and ecosystem-based management, essentially defined a strategic approach to the development of national marine and coastal protected area networks.

Programme implementation targets:

At the sixth meeting³⁹ of the CBD CoP, in decision VI/26 (UNEP 2002) the Parties adopted the *Strategic Plan for the Convention on Biological Diversity*. In its mission statement, Parties committed themselves to more effective and coherent implementation of the objectives of the Convention, “to achieve by 2010 a significant reduction of the current rate of biodiversity loss at global, regional and national levels as a contribution to poverty alleviation and to the benefit of all life on earth”.

This target was subsequently endorsed by the Johannesburg *World Summit on Sustainable Development* (WSSD⁴⁰) (United Nations 2002a:33). The Summit’s ‘key outcomes’ statement committed participating nations to: “achieve by 2010 a significant reduction in the current rate of loss of biological diversity” – notably omitting the final section of the CBD statement which, importantly, contains an explicit validation of the ‘intrinsic value’ concept.

The WSSD outcomes statement also contained a commitment with regard to ‘oceans and fisheries’ which included the development of MPA networks:

Develop and facilitate the use of diverse approaches and tools, including the ecosystem approach, the elimination of destructive fishing practices, and the establishment of marine protected areas consistent with international law and based on scientific information, including representative networks by 2012 (United Nations 2002b:3, my emphasis).

Although most nations are committed to the establishment of representative protected area networks, no global statistics on representation of marine ecosystems with protected area networks are available, largely as the collection of this information, in the marine realm, has only recently been addressed by nations themselves.

At the seventh meeting of the CBD CoP, in Decision VII/30 Annex II (UNEP 2004) the Parties adopted a target: “at least 10% of each of the world’s ecological regions effectively conserved”. Through Decision VII/5:18-19, the parties also agreed to establish (by 2012) and maintain a network of marine and coastal protected areas that are representative, effectively managed, ecologically based, consistent with international law, based on scientific information, and including a range of levels of protection – thus providing a slight expansion of the 2002 WSSD commitment, but, like the WSSD, omitting the earlier reference to intrinsic values.

Notably the 10% target does not mention protected areas, or provide a target timeframe. It can be argued (and often is) that, read in conjunction with the above WSSD commitments, a specific target for the development of MPA networks covering at least 10% of ecoregions by 2012 is implied. In decision VII/5 Annex I (UNEP 2004) the Parties requested that: “the Subsidiary Body on Scientific Technical and Technological Advice (SBSTTA) at its tenth or eleventh meeting *further refine the proposal for the integration of outcome-oriented targets into the programme of work on marine and coastal biodiversity...*”.

This recommendation provided the SBSTTA with the opportunity to expand the implicit meaning and time-frames of the target, especially given the 2003 recommendations of the World Parks Congress⁴¹; however in its tenth meeting (2005) it did not do so. In its ‘application of the VII/30 targets to the CBD programme of works on marine and coastal biodiversity’ it chose to simply repeat the original general target within the marine context: “At least 10% of each of the world’s marine and coastal ecological regions effectively conserved” (UNEP 2005:44).

Leaving the original CoP target expressed in these general terms, without specific measurable goals (relating, for example, to the establishment of no-take area networks - or more generally protected area networks - within defined timeframes) means that *the target cannot be effectively monitored and reported* – the different meanings which can be attributed to the phrase “effectively conserved” are simply too broad, and the timeframe too vague.

In summary:

Parties to the CBD have a range of responsibilities conferred on them by the CBD itself as well as by decisions of the CoP meetings. Within the constraints of the present discussion, the most important obligations are:

- to widely apply the precautionary approach and the ecosystem approach, guided by advice provided by CBD decisions and the precautionary guidelines of the FAO Code of Conduct;
- to take action which, collectively, will significantly reduce the global loss of biodiversity by 2010;
- to establish strategic networks of marine and coastal protected areas by 2012 within the framework of decisions VII/5 and VIII/24, informed by the recommendations of the AHTEG 2003;
- to immediately halt activities destructive of high seas biodiversity within the limits of national jurisdiction (Article 3); and
- to act, within the limits of national jurisdiction, to ensure that at least 10% of each of the world’s marine and coastal ecological regions are effectively conserved.

5.9 FAO Compliance Agreement 1993

The *Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas* (Rome, November 1993) is targeted specifically at suppressing illegal, unregulated and unreported fishing.

Article III summarises the central purpose of the Agreement: “each Party shall take such measures as may be necessary to ensure that fishing vessels entitled to fly its flag do not engage in any activity that undermines the effectiveness of international conservation and management measures”.

Subject to certain exemptions, based primarily on vessel length, the Agreement creates a ‘white’ list of authorised fishing vessels, accessible to all Parties through the FAO. It requires Parties to keep watch on the activities of its vessels (Article III especially clause 3) and withdraw authorisation for serious breaches of authorisation conditions (Article III especially clause 8).

The Agreement deals with change of ownership, prior records of breaching international requirements, and history of reflagging. It also discusses the responsibilities of Port States (Article V).

Article VI (clauses 8-10) creates a ‘grey’ list based on Party information “regarding any activities of fishing vessels flying its flag that undermine the effectiveness of international conservation and management measures...”.

In summary, under the Agreement, Parties have a responsibility to:

- place authorisation conditions on flagged fishing vessels so as to require compliance with international conservation and management measures;
- take measures to deter improper re-flagging;
- undertake compliance surveillance and enforcement programs;
- make available through the FAO basic information on authorised vessels (required information does not include location, as the agreement pre-dated widespread use of satellite location systems); and
- report non-compliance.

The Agreement has nothing to say on the precautionary or ecosystem approaches, or on the creation of protected area networks.

The Agreement is the only binding component of the FAO Code of Conduct, which is otherwise voluntary – including associated International Plans of Action.

5.10 FAO Code of Conduct for Responsible Fisheries 1995

The FAO began preparation of the Code of Conduct in the early 1990s, responding to international concern at large-scale overfishing, illegal fishing and the use of destructive fishing practices. Such concern was expressed, for example, through the UNGA Resolution 46/215 on drift-netting (1991) and the Cancun Declaration on Responsible Fishing (Mexico, 1992).

This Code sets out principles and international standards of behaviour for responsible practices with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for supporting ecosystems and biodiversity. It covers the capture, processing and trade of fish and fishery products, fishing operations, aquaculture, fisheries research and the integration of fisheries into coastal area management. The Code recognises the nutritional, economic, social, environmental and cultural importance of fisheries and the interests of all those concerned with the fishery sector. The Code takes into account the biological characteristics of the resources and their environment and the interests of consumers and other users. The Code is voluntary: States and all those

involved in fisheries are encouraged to apply the Code and give effect to it. The Compliance Agreement (see above) is an integral component of the Code, and is its only binding component.

The Code needs to be understood in the context of the wider FAO programme associated with the Code. The principle elements of the wider context are:

- the Compliance Agreement 1993;
- the Rome Declaration on Implementation 1999;
- the FAO's ongoing implementation programme, including biannual reports;
- International Plans of Action;
- Technical Guidelines;
- the Strategy for Improving Information on the Status and Trends of Capture Fisheries;
- annual Reviews of the State of World Marine Fishery Resources; and
- ongoing technical and policy meetings and workshops organised by the FAO.

The Code of Conduct for Responsible Fisheries

The Code is available in Arabic, Chinese, English, French, Spanish and Vietnamese, as well as in other languages in translations which have not been endorsed by the FAO. The Code itself was formally adopted by the 28th session of the FAO Conference in 1995. The core of the Code consists of 12 Articles.

Article 2 sets out the ten objectives of the code. Of these 10, six are of particular interest to the present discussion:

- a) establish principles, in accordance with the relevant rules of international law, for responsible fishing and fisheries activities, taking into account all their relevant biological, technological, economic, social, environmental and commercial aspects;
- b) establish principles and criteria for the elaboration and implementation of national policies for responsible conservation of fisheries resources and fisheries management and development;
- c) serve as an instrument of reference to help States to establish or to improve the legal and institutional framework required for the exercise of responsible fisheries and in the formulation and implementation of appropriate measures;
- d) provide guidance which may be used where appropriate in the formulation and implementation of international agreements and other legal instruments, both binding and voluntary;
- g) promote protection of living aquatic resources and their environments and coastal areas; and
- j) provide standards of conduct for all persons involved in the fisheries sector.

Objectives a), b), c) and d) are targeted at providing a model for the development of legal and institutional management frameworks at global, regional and national levels. Objective g) includes an ecological perspective, which, like the Law of the Sea, goes further than merely protecting sustainable development. Objective j) places the code itself as a benchmark in direct relevance to fishers' and managers' daily business.

The 19 paragraphs of Article 6 list important 'general principles'. Of special relevance to the present discussion are the following:

- 6.1 States and users of living aquatic resources should conserve aquatic ecosystems. The right to fish carries with it the obligation to do so in a responsible manner so as to ensure effective conservation and management of the living aquatic resources.

- 6.2 [...] Management measures should not only ensure the conservation of target species but also of species belonging to the same ecosystem or associated with or dependent upon the target species.
- 6.3 States should prevent over fishing and excess fishing capacity ... States should take measures to rehabilitate populations as far as possible and when appropriate.
- 6.4 Conservation and management decisions for fisheries should be based on the best scientific evidence available, also taking into account traditional knowledge ...
- 6.5 States and subregional and regional fisheries management organizations should apply a precautionary approach widely to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment, taking account of the best scientific evidence available. The absence of adequate scientific information should not be used as a reason for postponing or failing to take measures to conserve target species, associated or dependent species and non-target species and their environment.
- 6.6 Selective and environmentally safe fishing gear and practices should be further developed and applied ... States and users of aquatic ecosystems should minimize waste, catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species.
- 6.8 All critical fisheries habitats in marine and fresh water ecosystems, such as wetlands, mangroves, reefs, lagoons, nursery and spawning areas, should be protected and rehabilitated as far as possible and where necessary. Particular effort should be made to protect such habitats from destruction, degradation, pollution and other significant impacts resulting from human activities that threaten the health and viability of the fishery resources.
- 6.11 States authorizing fishing and fishing support vessels to fly their flags should exercise effective control over those vessels so as to ensure the proper application of this Code...

In summary, these principles require compliant Parties to:

- protect marine ecosystems beyond the protection of fisheries;
- apply the precautionary and ecosystem approaches to fishery management;
- utilise the best scientific information and traditional knowledge;
- protect (and rehabilitate where necessary) critical fisheries habitats; and
- ensure compliance surveillance and enforcement, including over high seas fishing vessels.

Article 7 ('fisheries management') expands the general principles of Article 6 in the context of State fishery management. In particular, it requires a State to:

- develop an appropriate legal and institutional framework to enable effective management, including implementation of the Code;
- ensure that such a framework is transparent, accountable and understood;
- consult with all relevant stakeholders, taking into account the ecological scale of the fishery;
- authorise fishing operations in accordance with a fishery management plan;
- ensure that such a plan provides for the protection of aquatic biodiversity and the recovery of depleted populations;
- ensure endangered species receive special protection;
- ensure that pollution, waste, bycatch, ecosystem effects and habitat destruction are minimised;
- reduce fishing overcapacity; and

- ensure adequate compliance surveillance and enforcement.

Article 7 (section 7.5) deals with the precautionary approach. Two paragraphs are of particular note:

- 7.5.3 States and subregional or regional fisheries management organizations and arrangements should, on the basis of the best scientific evidence available, *inter alia*, determine:
- a) stock specific target reference points, and, at the same time, the action to be taken if they are exceeded; and
 - b) stock specific limit reference points and, at the same time, the action to be taken if they are exceeded; when a limit reference point is approached, measures should be taken to ensure that it will not be exceeded.
- 7.5.4 In the case of new or exploratory fisheries, States should adopt as soon as possible cautious conservation and management measures, including, *inter alia*, catch limits and effort limits. Such measures should remain in force until there are sufficient data to allow assessment of the impact of the fisheries on the long-term sustainability of the stocks, whereupon conservation and management measures based on that assessment should be implemented. The latter measures should, if appropriate, allow for the gradual development of the fisheries.

The programme supporting the Code of Conduct:

The FAO currently has 180 Member States. In March 1999, the FAO organised a Ministerial Meeting on the Implementation of the Code of Conduct. At the close of the meeting the 126 Members attending endorsed *The Rome Declaration on the Implementation of the Code of Conduct for Responsible Fisheries*. Australia endorsed the Rome Declaration.

In this Declaration, Member States undertook to support both the Compliance Agreement 1993 and the Fish Stock Agreement 1995. The Declaration "Calls upon all users of fisheries resources to apply the Code of Conduct for Responsible Fisheries".

Four detailed *International Plans of Action* have been prepared to support implementation of the Code by States. These are:

- IPoA – Sharks
- IPoA – Seabirds
- IPoA – Fishing capacity, and
- IPoA – Illegal, unregulated and unreported fishing.

Ten Technical Guidelines have been prepared to support implementation of the Code by States. Of these ten, the most important from to this discussion are:

Technical Guideline 1 – *Fishing operations*;

Technical Guideline 1 supplement 1 – *Vessel monitoring systems*;

Technical Guideline 2 – *Precautionary approach to capture fisheries and species introductions*;

Technical Guideline 3 – *Integration of fisheries into coastal area management*;

Technical Guideline 4 – *Fisheries management*;

Technical Guideline 4 supplement 1 – *Conservation and management of sharks*;

Technical Guideline 4 supplement 2 – *The ecosystem approach to fisheries*;

Technical Guideline 8 – *Indicators for sustainable development of marine capture fisheries*.

Implementation reports have been prepared biannually, with a recent recommendation for a four-year reporting cycle.

The 2005 report, *Progress in the implementation of the Code of Conduct for Responsible Fisheries and related International Plans of Action*, indicates that, a decade after the inception of the Code, implementation globally is far from complete.

Response to the survey was incomplete. Of 180 FAO Member States, 49 replied by the analysis deadline. Some of the survey results appear particularly disappointing:

- 13 Member States reported having no national programs working towards conformity with the Code in legal and policy domains;
- 10 Member States do not have any fisheries management plans in place;
- About half of responding Member States have developed stock specific target reference points for use in fisheries management. In most cases however, stock specific target reference points were either being approached or exceeded, indicating that a majority of fisheries managed by making use of stock specific target reference points were either nearing full exploitation or were being overexploited;
- Only two Member States explicitly reported the use of mechanisms based on actual precautionary principles, such as the setting of lower precautionary harvesting limits in data deficient management contexts. The report notes “Both the ecosystem approach and the implementation of the precautionary approach remain weak.”
- Only 25 Member States reported that a legal framework for the integrated management of fisheries resources and coastal areas was in place;
- Only 25 Member States reported monitoring bycatch and discards on a regular basis. The report notes: “[This] must be seen as a very serious information gap. Bycatch and discard data are of paramount importance to evaluate impacts of given fisheries on stocks and ecosystems.”
- Only 5 Members reported developing a national plan supporting the *IPoA Sharks*, and 7 Member States reported developing a national plan supporting the *IPoA Seabirds*.

On the encouraging side, most responding Members reported that they had commenced use of vessel monitoring systems or were planning to do so.

Seventeen of the 32 Regional Fisheries Bodies (RFBs) responded to the FAO survey. Again, some responses indicated little activity in comprehensive application of the Code:

- With respect to Article 7 of the Code, four RFBs (APFIC, NPAFC, SPC and WECAFC) stated that they had no or only limited mandate for fisheries management;
- Eight RFBs indicated that reference points they set have been approached or exceeded;
- Nearly half of RFBs indicated that the precautionary approach had not been applied to the management of fisheries resources. Of those RFBs reporting application of the precautionary approach, only two (CCAMLR and NASCO) were able to name policy approaches actually embodying precautionary elements;
- Regarding Article 8, nearly half of the RFBs (and about 30 percent of Regional Fisheries Management Organizations - RFMOs) indicated that they had not yet taken steps to ensure only fishing operations in accordance with the fisheries management measures adopted were conducted within their areas of competence – ie: no compliance enforcement activity.
- While most RFBs and RFMOs have taken steps to implement the IPoA IUU in their areas of competence, implementation of the remaining IPoAs (Sharks, Seabirds and Fishing Capacity) was poor. Only six RFBs, for example, reported implementing elements of the IPoA on Fishing Capacity.
- Thirty percent of RFBs appear to have made no effort to implement the *Strategy for Improving Information on Status and Trends in Capture Fisheries*.

In summary, the FAO Code of Conduct and its supporting programme contains the most progressive and detailed framework for responsible fisheries in existence globally. The Code includes the three core elements under central discussion in this chapter: the precautionary and ecosystem approaches, and the development of protected areas. Ancillary documents to the Code provide detailed advice on the application of the precautionary and ecosystem

approaches to fishery management. Protected areas are not similarly dealt with in depth – perhaps acknowledging the role of the CBD and the Jakarta Declaration.

However, in spite of the crisis facing world fisheries, and a long track record of fishery management failures, application of the Code has been slow and disappointing. Only one State (the USA) has developed a policy document focussing on implementation of the Code within its jurisdiction, in spite of the specific support for the Code expressed by 124 States through the Rome Declaration in 1999. The fishing industries of Canada and Australia have developed fishing industry codes which are perhaps of some value, although they are a pale shadow of the original FAO Code.

The FAO Implementation Report 2005, together with the poor response to the survey underpinning that report, suggest that even the most basic elements of the code, such as the restriction of entry into fisheries according to an agreed strategic plan, and the enforcement of conditions attached to fishing authorisations, are not being implemented by many of the nations which supported the Code through the Rome Declaration.

Further, the more sophisticated elements of the Code, such as the application of the ecosystem and precautionary approaches, and the strategic protection of critical habitats, appear in practice to be almost completely ignored by perhaps the majority of FAO Member States – a decade after development of the Code in 1995. Even Regional Fishery Bodies and Regional Fishery Management Organisations appear, for the most part, to pay little more than lip-service to these important elements.

5.11 UN Fish Stocks Agreement 1995

The Agreement for the implementation of the provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the conservation and management of straddling fish stocks and highly migratory fish stocks 1995. In force generally: 11 Dec 2001; in force for Australia 11 Dec 2001.

The Agreement implements provisions of the UNCLOS relating to straddling and highly migratory fish stocks. The Agreement provides mechanisms for international cooperation in the management of straddling and highly migratory species. In particular, the Agreement encourages and empowers the establishment of subregional and regional fisheries management organisations. Although not considered an integral component of the FAO Code of Conduct, it repeats and reinforces key aspects of the Code.

The Department of Agriculture, Fisheries and Forestry - Australia (DAFF) and the Australian Fisheries Management Authority (AFMA) oversee the implementation of the Agreement in Australia. The Agreement entered into force for Australia and generally on 11 December 2001 and is legally binding.

The preamble of the Agreement tracks its inheritance to the 1992 Rio de Janeiro Conference:

Seeking to address in particular the problems identified in chapter 17, programme area C, of Agenda 21 adopted by the United Nations Conference on Environment and Development, namely, that the management of high seas fisheries is inadequate in many areas and that some resources are overutilized; noting that there are problems of unregulated fishing, over-capitalization, excessive fleet size, vessel reflagging to escape controls, insufficiently selective gear, unreliable databases and lack of sufficient cooperation between States...

According to the provisions of the Vienna Convention on Treaties 1986, a State cannot, in general, be forced to adhere to the provisions of international agreements which it does not support. However, by the date of the UNFSA, abundant evidence was available demonstrating the damage that a small number of, for example, whaling nations could do to global populations of marine animals by over-harvesting.

The UNFSA is particularly important as it expands certain general provisions of the Law of the Sea as they relate to straddling and migratory fish stocks, and these expanded rights and obligations *are not restricted to ratifying parties* (referred to in the Agreement as “States Parties”) but bind all States and other parties engaged in high seas fishing (Article 1 clause 3, and Articles 33, 34 and 35).

Articles 5, 6 and 7 establish the principles and core obligations of the Agreement. Under these Articles, all States involved in fishing of straddling and migratory fish must:

- apply the precautionary approach (further guided by Article 6 and Annex II), including an obligation to assess the impacts of fishing (Art. 5(c,d));
- adopt the ecosystem approach (Art. 5(e));
- minimise pollution, waste, discards, bycatch and ghost fishing (Art. 5(f));
- “protect biodiversity in the marine environment” (Art. 5(g));
- eliminate over-fishing (Art. 5(h)); and
- conduct necessary surveillance and enforcement (Art. 5(j,k,l)).

These are non-discretionary and powerful obligations, and would, if adhered to, do much to alleviate the crisis facing the global marine environment. They echo several of the core voluntary provisions of the FAO Code of Conduct. As discussed above, these provisions appear to be widely ignored, even by States expressing strong support for them (including Australia – see Chapter 12).

Article 6 clause 6, elaborating the application of the precautionary approach to the management of straddling and migratory fish stocks, again echoes the provisions of the FAO Code of Conduct:

For new or exploratory fisheries, States shall adopt as soon as possible cautious conservation and management measures, including, *inter alia*, catch limits and effort limits. Such measures shall remain in force until there are sufficient data to allow assessment of the impact of the fisheries on the long-term sustainability of the stocks, whereupon conservation and management measures based on that assessment shall be implemented. The latter measures shall, if appropriate, allow for the gradual development of the fisheries.

Much of the remainder of the Agreement is devoted to establishing governance frameworks, based largely on regional fishery management organisations, to apply the principles and requirements of Articles 5, 6 and 7. The Agreement is structured into the following Parts:

1. General provisions;
2. Conservation and management of straddling and migratory fish stocks;
3. Mechanisms for international cooperation concerning straggling and migratory fish stocks;
4. Non-members and non-participants;
5. Duties of the Flag State;
6. Compliance and enforcement;
7. Requirements of developing States;
8. Peaceful settlement of disputes;
9. Non-parties to the Agreement;
10. Good faith and abuse of rights;
11. Responsibility and liability;
12. Review
13. Final provisions.

Parts 4 and 9 are of particular interest, as they apply binding provisions to parties who do not support the Agreement. Such parties are not only encouraged, but required to cooperate with regional fishery management organisations. Article 17 clause 3 states, in effect: “no cooperation means no access to fish stocks”. Such organisations are required to develop transparent, accountable and enforceable management regimes, aimed at optimising harvesting levels within the context of long-term protection of the marine ecosystems which

ultimately sustain such harvesting. As indicated in the above discussion concerning implementation of the FAO Code of Conduct, these frameworks are, in most cases, not in place in any comprehensive sense.

Article 33 clause 2 states: "States Parties *shall* take measures consistent with this Agreement and international law to deter the activities of vessels flying the flag of non-parties which undermine the effective implementation of this Agreement" [my emphasis]. These are potentially powerful provisions.

As at 15 June 2006 the Agreement had 58 signatories. Among States which have not signed the Agreement are Chile, Mexico, Peru, Thailand and Vietnam – some of the world's larger high seas fishery nations.

Article 36 provides for a review of the Agreement after four years of operation. The United Nations Fish Stocks Agreement (UNFSA) Review Conference was held in New York from 22 to 26 May 2006. The Review Conference's mandate was: (i) to assess the adequacy of the Agreement's provisions for securing the conservation and management of straddling and highly migratory fish stocks and; (ii) if necessary, to propose means of strengthening implementation. The momentum generated by the Review Conference saw 14 non-State Parties to the UNFSA indicate an intention to accede to the UNFSA.

The website for the review conference is:

http://www.un.org/Depts/los/convention_agreements/review_conf_fish_stocks.htm. An unofficial summary was published immediately after the conference conclusion by the International Institute for Sustainable Development (IISD). While this summary (Beintema et al. 2006) notes that progress made at the conference was incremental rather than radical, some important forward steps were made:

[... there are strong calls in the [final] text for: reducing global fishing capacity; eliminating subsidies; enforcing flag State controls on support vessels as well as fishing vessels; developing a comprehensive global register of fishing vessels that incorporates information on beneficial ownership; a legally binding agreement on port State controls; and stricter rules on transshipments.

While such progress demonstrates increasing international will to genuinely improve fisheries management, the lack of any timebound commitments in the Conference Report is considered by some a missed opportunity [several attempts to incorporate deadlines into draft commitments did not achieve consensus].

While delegates seemed to be resolute in supporting the full application of the ecosystem approach to fisheries management, observers noted the lack of any concrete measures to achieve this in the Conference Report. For example, no concrete measures are outlined for protecting vulnerable marine ecosystems from destructive fishing practices, notwithstanding the discussions on this matter at ICSP-5⁴² and the interventions on interim measures against bottom-trawling by Palau, Brazil and NGOs.

While the recommendation to address derelict fishing gear and discards is welcome, more glaring is the absence of any progress on designing measures to reduce bycatch. In addition, the development of biodiversity conservation tools, including marine protected areas, is called for only on a case-by-case basis. These weaknesses reflect the scant attention devoted to broader issues of biodiversity conservation at the meeting, and the paucity of references to relevant developments in other multilateral oceans and environmental forums. They indicate that the fisheries sector is still some way from achieving a genuine and multi-sectoral understanding of ecosystem-based management.

The extension of the Fish Stocks Agreement to discrete high seas stocks (rather than its existing restriction to straddling and highly migratory stocks) was discussed, but failed to achieve consensus. This extension is, however, accepted by many States as a matter of

principle, symbolised by the wide support for the FAO Code of Conduct through the Rome Declaration 1999. The FAO Code of Conduct, if fully implemented, would in fact achieve the same result as it mirrors most of the important areas of the Fish Stocks Agreement, and applies widely to all fisheries. Importantly, the full implementation of the Code would achieve important protection for high seas deepwater stocks (see discussion in Gianni 2004).

5.12 Johannesburg Declaration 2002 (UN World Summit on Sustainable Development)

One of the most widely quoted international statements calling for the acceleration of marine protected area programs around the world is that from the World Summit on Sustainable Development (WSSD Johannesburg 2002). The marine section of the WSSD Key Outcomes Statement provides basic benchmarks for the development of marine protected areas as well as other key issues:

Encourage the application by 2010 of the ecosystem approach for the sustainable development of the oceans.

On an urgent basis and where possible by 2015, maintain or restore depleted fish stocks to levels that can produce the maximum sustainable yield.

Put into effect the FAO international plans of action by the agreed dates:

- for the management of fishing capacity by 2005; and
- to prevent, deter and eliminate illegal, unreported and unregulated fishing by 2004.

Develop and facilitate the use of diverse approaches and tools, including the ecosystem approach, the elimination of destructive fishing practices, the establishment of marine protected areas consistent with international law and based on scientific information, including representative networks by 2012.

Establish by 2004 a regular process under the United Nations for global reporting and assessment of the state of the marine environment.

Eliminate subsidies that contribute to illegal, unreported and unregulated fishing and to over-capacity.

The Johannesburg Outcomes Statement also contains a commitment: “Achieve by 2010 a significant reduction in the current rate of loss of biological diversity.”

Neither the Declaration nor the Outcomes Statement deal with application of the precautionary approach, although the more detailed WSSD Report mentions the need to apply precaution several times, referencing the precautionary principle as defined by the Rio Declaration.

5.13 Chapter summary:

The above examination of key international agreements underlines the importance of the three central concepts emphasised in this chapter: the precautionary and ecosystem approaches, and the development of strategic networks of marine protected areas. All three are widely supported by international instruments. By contrast the use of adaptive management is promoted in only one of the ten instruments – the Rio Conference’s *Agenda 21*. The former three concepts, although critical to good management of the marine realm, have not so far been comprehensively or enthusiastically applied by the international community – in spite of repeated high-level commitments through United Nations programmes.

In addition to these three key concepts, other important themes relating to the conservation of marine ecosystems are discussed and promoted in international agreements. Table 5.1 below presents a chronological summary.

Table 5.1:

Chronological summary of key management concepts contained in international instruments:

Management concept	First year	Chapter reference.
The protection or conservation of the marine environment generally	1972	5.3, 5.5, 5.6, 5.8, 5.10, 5.11
Establishment of networks of marine protected areas, incorporating representative examples of all major ecosystems (later...by 2012)	1972	5.3, 5.5, 5.7, 5.8, 5.12
Application of the ecosystem approach to the management of marine resources	1980	5.4, 5.5, 5.7, 5.8, 5.10, 5.11, 5.12
Prior impact assessment of the impacts of harvesting activities, including impacts on related or dependent species and the supporting ecosystem	1980	5.4, 5.5, 5.6, 5.7
Use of best available science	1980	5.4, 5.8, 5.10
Special protection of rare, vulnerable, fragile or endangered marine species, communities and habitats	1982	5.5, 5.6, 5.10
The establishment of maps and inventories of marine habitats, including assessments of the conservation status of habitats, communities and ecosystems	1982	5.5, 5.7
Application of the precautionary principle or the precautionary approach to the management of marine resources	1982	5.4, 5.5, 5.7, 5.8, 5.10, 5.11
The protection of critical marine habitats, such as coral reef, estuaries, wetlands, seagrass, and spawning or nursery areas	1992	5.7, 5.10
The regulation of flagged vessels on the high seas in compliance with international obligations, including reporting obligations	1992	5.7, 5.8, 5.10, 5.11
The phase-out of destructive fishing practices by 2012	2002	5.12

The planet's nation-states have in some cases acted relatively quickly to implement parts of these agreements, especially where economic benefits to particular nations are in question. The establishment of 200 km Exclusive Economic Zones (under UNCLOS) is a good example. Some nations, such as Australia, have 'established' EEZs around their Antarctic 'territories' even though the validity of the territories themselves is not universally recognised - clearly an enthusiastic implementation of international law.

In other instances nations have been remarkably slow to implement important commitments. For example, commitments to protect representative examples of all major ecosystems date from 1972, yet Australia only moved to implement this commitment in relation to the marine environment in the early 1990s. The Great Barrier Reef Marine Park Authority, often cited as a world leader in marine conservation, only commenced its Representative Area Program in 2002 - thirty years after the initial commitment. As an aside, the situation regarding

freshwater environments is even more extreme, with New Zealand so far the only nation to establish a systematic program to implement its commitment to protect representative freshwater ecosystems.

Endnotes:

²⁵ The Food and Agriculture Organization of the United Nations (FAO) has been particularly influential through its Compliance Agreement 1993 and its Code of Conduct for Responsible Fisheries 1995, along with associated International Plans of Action (IPOAs), and various guidelines – particularly those regarding application of the precautionary principle.

²⁶ Regional fishery management organisations (RFMOs): the FAO identifies 17 RFMOs that directly establish management measures; 21 advisory bodies that provide scientific and management advice; and a further six scientific bodies that provide scientific and information advice. Of these, Australia has a direct interest in the: Asia-Pacific Fishery Commission (APFIC); Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR); Commission for the Conservation of Southern Bluefin Tuna (CCSBT); Forum Fisheries Agency (FFA); Indian Ocean Tuna Commission (IOTC); International Whaling Commission (IWC); Network of Aquaculture Centres in Asia-Pacific (NACA), Secretariat of the Pacific Community (SPC), Southwest Indian Ocean Fisheries Commission (SWIOFC) and Western and Central Pacific Fisheries Commission (WCPFC). Australia also has an interest in the South Pacific Regional Fisheries Management Organisation (SPRFMO) negotiations that are currently (January 2006) progressing.

²⁷ The United Nations General Assembly currently (January 2006) has 191 member states of which 149 are parties to UNCLOS; 57 are parties to the UN Fish Stocks Agreement; and 122 are parties to the Agreement for the Implementation of Part XI of UNCLOS, as administered by the International Seabed Authority (ISA).

²⁸ Ghost fishing refers to the continued effects of lost and abandoned fishing gear.

²⁹ Other important international bodies include Commissions under: the Convention on Migratory Species (CMS); the Convention on International Trade in Endangered Species (CITES); the International Convention on the Regulation of Whaling 1946; the Organisation for Economic Cooperation and Development (OECD); the World Trade Organisation (WTO); and the International Maritime Organization (IMO) – the latter being particularly influential with regard to the control of pollution from shipping.

The International Whaling Commission (IWC) has established whale sanctuaries for the Indian Ocean (1979) and Southern Ocean (1994). The contribution of such sanctuaries to whales conservation, when compared to catch limit outputs of the IWC's Revised Management Procedure (RMP) remains contentious – with those favouring sanctuaries noting that an application of the RMP (with its ecological focus) alone would fail to address the need (consistent with MPA development) to take account of management and political considerations necessary for effective implementation (Jonathon Barrington, pers. comm. 4/5/06). The CMS has also established regional whale conservation arrangements, e.g. Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS); Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS). A Memorandum of Understanding for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region is in preparation (May 2006). The IMO has developed Guidelines for the identification and Designation of Particularly Sensitive Sea Areas (PSSAs) and established such areas, e.g. Great Barrier Reef (1990) and Baltic Sea (2005). PSSAs are designated due to their significance and vulnerability to damage by international shipping activity, particularly pollution. Ecological criteria (e.g. uniqueness or rarity, fragility, representativeness and biogeographic importance); socio-cultural and economic criteria (e.g. socio-economic dependency; human dependency and cultural heritage); and scientific and educational criteria are used to assess the significance of proposed areas. Vulnerability criteria also apply, e.g. vessel traffic characteristics and natural factors.

³⁰ Aqorau (2003) reviews additional instruments, perhaps most importantly the *Washington Declaration on Protection of the Marine Environment from Land-based Activities 1995*. Cochrane & Doulman (2005) from the FAO provide one of many important recent reviews of international instruments affecting marine activities.

³¹ By 'strategic' I mean the development of national networks of MPAs within systematic and science-driven frameworks to achieve specific national goals, such as the protection of biodiversity, the establishment of management benchmarks, the maintenance of essential ecological processes and life support systems, and to help ensure the sustainable utilisation of species and ecosystems (Kelleher 1999). Margules and Pressey (2000) describe a general approach to systematic MPA development. Smith et al. (2005) in a Canadian context describe a systematic approach as: "an approach which sets out and achieves clear objectives for region-wide protected area network planning will provide the most efficient, effective and transparent planning method and offers benefits – for both industry and conservation – over the site-by-site approach". The CBD's Jakarta Mandate requires the strategic development of protected area networks (see discussion above).

³² The designation of marine protected areas can be traced back over a century: see the World Database of Protected Areas: www.unep-wcmc.org which lists the first MPA in 1888. The database also states that protected areas for fish were established in India as early as the year 250 BC.

³³ See Iles (1980) discussion of the need for ecosystem concepts in fishery management.

³⁴ According to the FAO website: "... the CCAMLR Convention Area is delimited to the north by the Antarctic Convergence (or Polar Front) which acts as an effective biological barrier- the Convention Area is therefore substantially a closed ecosystem." (www.fao.org/fishery/rfb/ccamlr/; accessed 19/3/09).

³⁵ Vienna Convention limitations on the applicability of international instruments to non-Parties are increasingly being circumvented, such as through trade-related measures, applied in a manner consistent with article XX(g) of the General Agreement on Trade and Tariffs (GATT) or the denial of services under the General Agreement on Trade and Services (GATS) under the WTO framework. *Jonathon Barrington, pers. comm. 4/5/06.*

³⁶ The ISA has prime carriage over establishing frameworks to ensure the effective protection of the marine environment of the Area, the protection and conservation of the natural resources of the Area, and the prevention of damage to the flora and fauna from harmful effects that may arise from activities in the Area. It has developed environmental impact assessment procedures, and guidelines for the establishment of environmental baselines against which to assess the likely effects on the marine environment of activities in the Area (with an initial emphasis on deep-sea polymetallic nodule mining).

³⁷ Agenda 21 is the hortatory action plan adopted at the close of the UN conference.

³⁸ Principle 8 of Australia's national biodiversity strategy states: "Central to the conservation of Australia's biological diversity is the establishment of a comprehensive, representative and adequate system of ecologically viable protected areas, integrated with sympathetic management of all other areas, including agricultural and resource production systems."

³⁹ The sixth CoP CBD meeting was held in April 2002.

⁴⁰ WSSD: August-September 2002.

⁴¹ The World Parks Congress 2003 (WPC) recommended the establishment of national networks of marine no-take areas (NTAs) covering 20-30% of habitats by 2012.

⁴² Fifth informal consultation of the State parties to the Fish Stocks Agreement, held immediately prior to the conference.

6. Uncertainty in fisheries management: sources and consequences

“Worse, some scientists involved in our discussions were worried about the very notion of publicly admitting uncertainty, and felt that it was important to maintain at least the appearance of consensus within the scientific community”

Carl Walters (1986:343).

6.1 Introduction:

A well-known fishery scientist, John Gulland, once said that “fishery management is an endless argument about how many fish there are in the sea, until all doubt has been removed – but so have all the fish.”⁴³ Although facetious, this comment does highlight the importance of uncertainty – and the quote unfortunately contains a certain amount of truth.

Fishery scientists provide advice to fishery managers. Fishery managers (within a governance framework created by national statute, international law, common law, and culture) provide and enforce society’s controls over fishers. Controls include both restrictions and incentives, and operate within the culture of various groups, as well as the prevailing national and international legal and economic framework.

The most basic scientific advice concerns the size of species stocks, and the effects on those stocks of harvesting pressures. In addition, assessments need to be made of the continuing ability of the ocean’s wider ecosystems to support individual populations.

Uncertainty in fisheries management stems mainly from seven sources:

1. imperfect understanding of the *oceanographic drivers* of ecosystem function and species behaviour, reproduction and growth within ecosystems;
2. imperfect understanding of *species-specific biology*, including growth rates and drivers, and movement patterns driven in part by feeding and reproduction;
3. imperfect understanding of the *behaviour of species within ecosystems*;
4. stemming from the above and from the practical limitations involved in expressing biological processes in mathematical form – imperfect predictive *models* of species biology and ecosystem function (incorporating the effects of fishing on ecosystems – including bycatch, habitat damage, and the impact of discarding);
5. errors created by inaccurate or insufficient *sampling for stock and other empirical data*, which seeks to support understanding of the size, movement, growth, mortality and genetic diversity of stocks of fishery target and bycatch species, and to provide oceanographic and ecosystem-related information;
6. systematic but poorly-appreciated *bias in scientific advice and managerial decisions* resulting from the cultures in which these groups operate; and
7. imperfect prediction of *fisher behaviour*, including movement, fishing effectiveness, and ecosystem damage (primarily from gear damage, bycatch and discards).

A significant part of fishery science attempts to understand uncertainty, and to minimise it (or estimate its bounds) where possible. Where uncertainty cannot be eliminated (and this is always the case in capture fisheries) its implications for management decisions need to be understood and taken into account. Powerful tools exist for the management of uncertainty.

Likelihoods, or probabilities, can be attached to some uncertainty elements. Where this is the case these uncertainties may be termed “risks” – and this terminology is used in this chapter (although not throughout the thesis, where a more relaxed meaning of “risk” is used in line with common language). The term “uncertainty” within the chapter refers to lack of certainty where the probable bounds of the uncertainty are not quantifiable (at least with reasonable accuracy).

The purpose of this chapter is to provide a brief general discussion of the sources and consequences of uncertainty in fisheries management. This discussion in turn lays the foundations for the following three chapters containing a detailed discussion of uncertainty management techniques, and their subsequent application in case studies.

6.2 Ocean ecosystems in a nutshell:

Almost all ocean ecosystems depend (directly or indirectly) on the energy of sunlight, which enables phytoplankton, algae and other plants to synthesize carbohydrates, using dissolved carbon dioxide and nutrients. Carbohydrates provide the energy source for resulting food chains, supporting a wide range of grazers, detritivores and predators. Photosynthesis (both marine and terrestrial) also produces oxygen, which enables the metabolic processes on which the grazers and predators (indeed all aerobic organisms) depend.

The energy of sunlight also drives the oceanographic processes which, broadly, move organisms, nutrients, and dissolved oxygen around the planet through winds and ocean currents. The primary driver for these processes is the energy differential (manifested as temperature) between the equator and the poles. This energy differential, through creating changes in density in air and water, drives the weather systems of both the atmosphere and the ocean. Ocean 'weather' can be every bit as variable as atmospheric weather – noting however that the time-scales on which changes are felt are orders of magnitude slower, particularly with increasing depth. Life in the deep oceans depends on dissolved oxygen 'pumped' from polar regions by the ocean's thermohaline circulation. The major oceanic currents, at different depths, form 'conveyor belts' capable of moving water masses around the planet – connected, importantly, by the Southern Ocean. With these water masses travel organisms, nutrients and oxygen.

Oceanic surface waters, distant from continental erosion, are usually depleted in nutrients, the result of a continual 'drain' of nutrients to deeper water through detritus fall. Although the drain is slow, and nutrients are recycled within the uppermost few hundred metres, the lack of nutrients is often (usually) sufficient to restrict the growth of phytoplankton, and thus to restrict the abundance of organisms up the food chain. Where strong, deep, nutrient-rich currents are pushed to the surface by continental shelves (for example on the west coast of South America, and the west coast of South Africa) the resulting increase in surface nutrients can support high densities of marine organisms. This productivity may in turn change dramatically with changing ocean climate – for example the abundance of Peruvian anchovetta is strongly influenced by the La Nina / El Nino cycle (Pontecorvo 2001).

Even the deep oceans, seemingly isolated from the obvious variability of the ocean's surface layers, can manifest striking changes in organism abundance over periods as short as a decade (Koslow 2007). The ocean is also a large place – covering about 70% of the planet's surface, with a volume several times the volume of the land which rises above sea-level. By the close of the twentieth century, few reliable time-series of even basic data such as temperature, salinity and nutrient levels in the deep ocean had been collected, in spite of the importance of deep and intermediate currents in controlling ocean climate and productivity. While data collection has been expanded over the last decade, accurate ocean forecasting programs are only now being developed.

Today, while the major physical features of ocean climate and weather are understood, variations within timescales of months to years still remain, to a considerable extent, unknown and unpredictable⁴⁴.

6.3 Harvesting renewable resources:

Although it was long recognised that fishing pressures could deplete or extinguish freshwater populations, at the close of the nineteenth century it was widely believed that fishing would have little, if any, impact on marine populations. However by the 1930s many instances of marine overfishing had been observed, and fisheries managers looked to basic concepts of fish biology to guide harvesting controls.

The biological basis for all sustainable harvesting is reproductive surplus (sometimes called surplus production). Normally, the maximum reproductive rate of individual females in a population is higher (sometimes much higher) than that which would be necessary simply to ensure the long-term survival of the species. Natural populations in favourable environments generally have the capacity to expand in size up until a point where environmental factors limit further growth – through for example competition for food or space. At this point the size and biomass of the population will remain stable if steady state conditions prevail – the population has reached the ‘carrying capacity’ of the environment under the prevailing conditions. In reality, steady-state conditions seldom prevail – and the reasons for this are at least partly understood (more below).

The concept of ‘maximum sustainable yield’ (MSY) rests on the idea of finding a level of harvesting which will maximise the reproductive surplus. As harvesting starts to reduce the population level, and thus reduce pressures, for example, relating to competition for food and space, individual growth rates will increase, mortality will be reduced, and recruitment to the adult population will increase. The surplus may be expressed as the population size balanced for births minus deaths, times an average individual growth rate, within a given period. Most fish do not grow continuously over their adult lifespan, with the result that the capacity for physical (somatic) growth is generally most pronounced in juveniles and young adults – another factor influenced by the removal of the larger, older fish from a ‘virgin’ population. Fishing activities, under this understanding, aim to harvest the reproductive surplus at a rate which produces a maximum yield for the fish stock, or population – while not reducing the population itself below a level which insures its long-term viability (Hilborn et al. 1995).

An important element in the theory underpinning the use of MSY relates to ‘compensatory mortality’ – or loss of ‘surplus’ juveniles prior to their recruitment into the adult population. Many fish, particularly pelagic species, have reproductive strategies where females produce large numbers of eggs. Most of the resulting offspring die, either from predation or environmental factors, before reaching reproductive status as adults. Thus for many fish populations under favourable conditions, net recruitment is sometimes more or less independent of parental egg production over a considerable range of parental abundance (provided viable subpopulations remain to maintain the population’s spatial distribution). This effect initially gave fishery scientists confidence that the spawning biomass of populations could be substantially reduced without markedly reducing the rate of recruitment⁴⁵. However confidence grew to overconfidence – for example contributing to the demise of the northern cod (Walters & Maguire 1996).

The pursuit of MSY, generally expressed in the form portrayed in Figure 6.1, assumed increasing prominence in fisheries management from the 1930s to the 1950s. For populations with rapid growth rates and powerful reproductive strategies (short-lived pelagic species, for example) the theory seemed at first to work reasonably well. Under basic assumptions of logistic growth, information on growth rates obtainable from the weight-at-age distributions of catches as fishing progressed, combined with assumptions on natural and fishing mortality, could be used to estimate the approximate current location of the fishery on the catch/effort curve. Logistic models of fish population growth (while admittedly simplistic) show that maximum growth is located when the virgin population has been reduced to half its original level⁴⁶. However key assumptions within the theory are not reliable in practice⁴⁷ (more below). By the late 1950s the limitations of the MSY approach were apparent, resulting in moves towards an ecosystem-based approach (Beverton & Holt 1957) at least amongst fishery scientists if not fishery managers. Unfortunately the absence of straightforward and palatable alternative methods for establishing catch limits has seen the MSY concept continue in use long past its use-by date. Another factor which probably contributed to delays in abandoning MSY was that managers could actually understand the theory – while the more complex modelling methods remained obscure, and untrusted. In many countries the pursuit of MSY was institutionalised in government policy, and sometimes legislation.

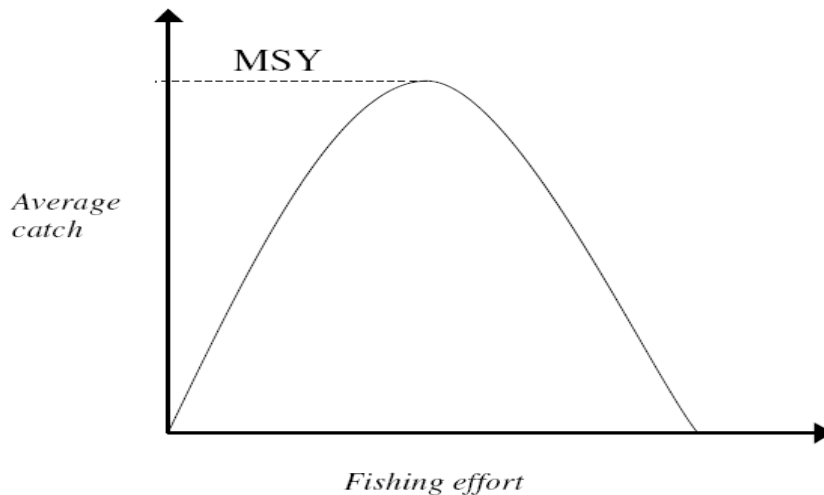


Figure 6.1. The catch / effort curve.

From Bonfil (2002)

An important difficulty in estimating the MSY of a given population relates in part to obtaining accurate information on catch and effort. Much of the immediate action within a fishery is beyond the direct observation of fishery scientists.

Given the inaccuracies in basic data, and the limitations of deductive, observational and experimental methods, “if we wish to learn how intensively a population can be exploited, we can find its limits only by exceeding them... This is perhaps the central problem with MSY: you cannot determine it without exceeding it.” (Hilborn et al. 1995:54).

In summary, sustainable harvesting of a renewable resource rests on harvesting the population’s reproductive surplus. This surplus does not exist in a natural population under steady-state conditions, and the population must be ‘fished down’ to release the surplus. Fishing down to find the point of MSY inevitably results in over-exploitation of the population. As soon as the fish-down commences, existing relationships within the ecosystem (predator, prey, competitor, vector) are disrupted – usually with unforeseen consequences.

Over-exploitation of populations has historically resulted in the depletion of many stocks by an order of magnitude or more (MEA 2006), and the extinction of some subpopulations (Sadovy & Cheung 2003, Casey & Myers 1998, Tegner et al. 1996). Yet, until recent decades, the effects of these changes on the ocean’s ecosystems has been all-but ignored by fishery managers.

6.4 Sources of uncertainty – oceanographic drivers:

Coastal, island and estuarine marine ecosystems are manifestly complex, with highly variable seafloor topography and biology-mediated habitats, such as coral reefs and seagrass meadows. However even the seemingly simple ecosystems of the open ocean are complex.

Coastal marine ecosystems, and especially estuaries, are often strongly influenced by continental runoff – bringing freshwater, sediments, and nutrients to the marine environment, varying seasonally or spasmodically. Runoff from highly populated areas, or intensively farmed areas, will contain micro-organisms and toxins, such as heavy metals or endocrine disruptors.

Several key determinants of biological function vary with depth, diurnal and seasonal cycles, and ocean dynamics: sunlight, temperature, dissolved oxygen, and nutrient levels. Radiant energy falling on the ocean varies with latitude, season and cloudiness, and the clarity of the water effects the degree to which sunlight penetrates below the ocean surface, thus influencing the photosynthetic abilities of phytoplankton. The open ocean is far more complex, physically, chemically and biologically, than it seems.

The ocean has its own climate and weather, just as the atmosphere does. While the key features of the atmosphere vary over hours and days, and more slowly over years, the larger features of ocean climate vary over weeks and months, and more slowly over years and decades.

Currents change in speed and direction, and create eddies at different spatial and temporal scales. The larger eddies, ocean gyres, are often semi-permanent features of the open ocean, varying however in exact location and strength. Gyres may create upwellings or downwellings, also a feature of major fronts created where large water bodies, driven by the major ocean currents, meet. These features may deplete or enhance nutrient levels, with consequent implications for phytoplankton and micro-organisms which form the base of ocean food chains.

The seemingly featureless open ocean also responds to seafloor topography. Seamounts in the path of ocean currents create downstream eddies, which can also move nutrients vertically, creating patches of enhanced productivity. These areas act as attractors to the larger inhabitants of the ocean – a fact long recognised by fishers (Koslow 2007).

The physical and chemical properties of the open ocean are variable in space and time, demonstrating both systematic and stochastic patterns. Ocean ecosystems respond to these variable drivers. Massive phytoplankton blooms come and move and disappear. Schools of ocean grazers and predators track these blooms, aggregating and dispersing over different spatial and temporal scales. Some, like jellyfish, move largely with the ocean's currents, while more mobile creatures display massive latitudinal and vertical movements. What has been dubbed the world's largest migration – the vertical movement of marine organisms between the epipelagic and mesopelagic zones – occurs on a daily cycle (Koslow 2007). All these movements are primarily focused on feeding, avoiding predators, or reproduction – activities which are central drivers of the behaviour of most marine organisms.

Both the open ocean and shallower seas (the continental shelves and coastal bays and estuaries) are complex even in terms of their simple physical and chemical parameters, a complexity which is magnified through biological processes. This complexity, poorly measured and understood, introduces much uncertainty into scientific predictions – and thus to management decisions.

6.5 Sources of uncertainty – species biology:

The theories underpinning fisheries management over most of the twentieth century depend on assumptions which seldom hold reliably in practice:

- (a) fish populations may often exist in *unfavourable* environments, with subsequent impacts on growth, recruitment and mortality; these three factors vary spatially and temporally;
- (b) even in relatively favourable environments, the logistic growth function does not hold, particularly with larger, slow-maturing fish;
- (c) fish populations are seldom in steady-state within their supporting ecosystems;
- (d) spawning stock and recruitment levels may be positively correlated within the range of fishery-induced population reductions, and
- (e) measurements taken from sampling commercial catches may not accurately reflect the state of the population at large.

The breakdown of core assumptions underpinning methods used to set single species harvest targets results in considerable uncertainty. Estimates of growth rates and mortalities (natural and fishing) are thus subject to considerable error, which is often difficult or impossible to quantify. Consequently estimates of current spawning biomass, virgin biomass, and 'safe yield' also contain substantial error margins, which are often not fully acknowledged by fishery scientists themselves, and consequently not properly taken into account (or even ignored entirely) by fishery managers.

A single species within a large marine ecosystem (and perhaps within the jurisdiction of a fishing nation) may contain considerable genetic diversity. This diversity is often (usually) spatially distributed. The population may be made up of relatively isolated local populations, or (perhaps likely in purely pelagic stocks) a single dispersed population. However, for coastal species (and species with coastal life-stages) it seems likely that the stock will be made up of distinct sub-populations which together comprise a larger metapopulation⁴⁸ (Kritzer & Sale 2006). Even for purely pelagic species, adherence of sub-populations to ocean topography or oceanographic features could produce a metapopulation structure.

The retention of genetic diversity is important to enable the metapopulation to adapt to changing environmental conditions, or to disease, for example (Conover & Munch 2002; Allendorf et al. 2008). If a fishery, without knowledge of this diversity, reduces the abundance of a species by an order of magnitude, it is entirely possible that subpopulations will be extinguished, and important genetic diversity lost (Crowder & Figueira 2006). Genetic diversity may not be obvious through variation in morphology, so unless an effort is made to measure and account for this diversity, considerable uncertainty will surround the likely effects of fishing in this regard.

Metapopulations of sedentary species are particularly vulnerable to overfishing. Fishing down local subpopulations to a point where Allee effects⁴⁹ inhibit recruitment is likely to result in the collapse and possible extinction of these subpopulations (Morgan & Shepherd 2006). This is may well be a factor in globally widespread abalone fishery collapse.

Where a stock has a metapopulation structure, the genetic impact of population turnover hinges on whether colonists are small groups of related individuals or large groups drawn from a larger geographically mixed pool. According to Hellberg (2006):

Although this may seem predictable based on larval dispersal capability, one of the few marine studies to address this issue directly found genetic results that contradicted ecological predictions. Genetic studies of settling larvae collected at different times have revealed an even more vexing problem: variation among temporal samples of larvae often exceeds that seen among geographic samples of adults. Competing explanations for this pattern (selection and sweepstakes reproductive success) predict wildly different effective population sizes, which in turn have consequences for the interpretation of all other population genetic data.

Fishing itself may alter the genetic makeup of a metapopulation. If fishing preferentially removes larger fish (likely to have higher growth rates) or fish which mature late, the genetic makeup of the metapopulation may shift towards smaller, early maturing fish. Such shifts are likely to adversely affect potential population growth rates, and decrease population resilience (Hutchings 2005). Again, unless a concerted effort is made to examine and account for this effect, considerable uncertainty will surround the long-term evolutionary effects of fishing on a particular stock.

In many species, large older females are far more fecund than newly recruited females. This is partly because egg production is greatly enhanced in such individuals. There is also evidence of learned behaviour which improves the reproductive success of these animals (Birkeland & Dayton 2005). A fishery may preferentially remove large breeding animals from the population, and if spawning stock is greatly reduced, this may have a significant effect on the productivity of the population and its ability to recover from overfishing. Unless this issue is examined and managed, considerable uncertainty is likely to surround its impacts.

Differing species biology, as well as population spatial and genetic structure, provide great scope for uncertainty – of which many aspects cannot be resolved with currently available data. For highly structured stocks, such as many species of benthic invertebrates, there is no likelihood that such uncertainties will ever be addressed due to practical limitations in gathering data.

6.6 Sources of uncertainty – ecosystem function:

An ecosystem is defined by its physical environment, living inhabitants, energy and material pathways, and trophic structure⁵⁰. Even the apparently simple ecosystems of the open ocean are in fact highly complex, as discussed above.

Fisheries management geared to single species stock assessments has often been used to regulate mixed species fisheries – by assuming that regulating catches for a dominant or abundant species will also conserve other target or bycatch species. This assumption is supported by optimism rather than evidence. This is especially true of tropical near-shore fisheries (Johannes 1998), which have suffered catastrophic declines in many areas of the Pacific and Caribbean (Sadovy 2005). Emphasizing irreducible uncertainties, Johannes (1998:243) states that “managing most marine finfisheries to achieve optimum yields is an unattainable dream.” Holding a similar view, and again emphasizing irreducible uncertainties, Walters (2001:279) states:

[We] cannot provide accurate assessments for most fish stocks, and probably never will [be able to]. Instead of treating the seas as open to fishing with small exceptions (marine refugia) we will only safely limit harvest rates if we reverse this view and treat the seas as closed to fishing with small exceptions (limited fishing areas and times).

Aquatic ecosystems are also, as a rule, dynamic – they are always changing, to a lesser or greater extent. Again, as mentioned above, even the ecosystems of the plateaus of the deep sea floor (the abyssal plain) demonstrate remarkable change over comparatively short time scales. And these ecosystems have probably the most physically stable environments of any ecosystems on the planet. It is always dark, water temperature and chemical properties vary negligibly over the course of a year, the seafloor is made up of a monotonous expanse of flat sediment, and the living organisms of this environment are sustained for the most part only by a thin rain of detritus. Yet these silent, simple, apparently stable environments can demonstrate large changes in the abundance of different organisms, and are also places of great biodiversity (Koslow 2007).

It is not surprising, then, that where the oceanic drivers of ecosystem form and function vary on a monthly or yearly basis, highly dynamic ecosystems exist. Many of the ocean’s smaller inhabitants are adapted to a changing environments, partly through extremely powerful reproductive strategies, and partly by considerable tolerance for changing physical conditions. While the larger inhabitants lack some of these qualities, they are often highly mobile, capable of travelling hundreds, sometimes thousands of kilometres over the course of a year or two.

Ecosystem change also occurs over different timescales, some so slow that they confound our ability to measure and understand them. Only the recent advent of remote sensing and robotic technologies has opened a window to their observation (Tourre et al. 2007). Many changes are cyclic – the most obvious being diurnal, tidal and seasonal cycles. Some of the slower cycles, such as the La Nina / El Nino (the El Nino Southern Oscillation, or ENSO) cycle, vary in length and intensity due to factors not yet fully understood. Interdecadal ocean dynamics clearly influence pelagic production, although the details are not well understood (Bakun 2001).

Other changes are uni-directional in nature – the most obvious being those driven by the global increase in atmospheric (and oceanic) carbon dioxide. Increasing ocean temperatures and acidities are on the verge of creating profound and disturbing changes to marine ecosystems – and the inertia of the systems which are creating these changes means that even if drastic action were to be taken immediately to reduce carbon dioxide emissions, a great deal of damage, for example through coral bleaching, is now unavoidable. Much uncertainty surrounds forecasts of likely impacts over the next century (Veron 2008, Koslow 2007).

Some impacts, potentially the most disturbing, may be abrupt. Climate change is forecast to undermine the ocean’s thermohaline circulation. The most pessimistic theories suggest both

dramatic regional climatic shifts, and the creation of anaerobic conditions over large areas of the deep sea floor are possible, particularly if a positive feedback warming effect undermines the stability of oceanic methane hydrate reservoirs (Koslow 2007).

Keystone species⁵¹ may mediate important ecosystem change. One of the best-known examples relates to the role of sea otters in the tall kelp forests of the northeast Pacific seaboard. When otters were removed by hunters, their prey, sea urchins, increased in abundance to such an extent that kelp forests were entirely removed (ie: eaten) from large areas where their presence had been apparently stable and enduring. Following cessation of hunting pressures, otter populations recovered in some areas, as did the kelp forests, habitat to a variety of rockfish whose abundance had in turn been influenced by the destruction of the kelp forests. Figure 6.2 portrays a relationship between state, fishing and nutrient level.

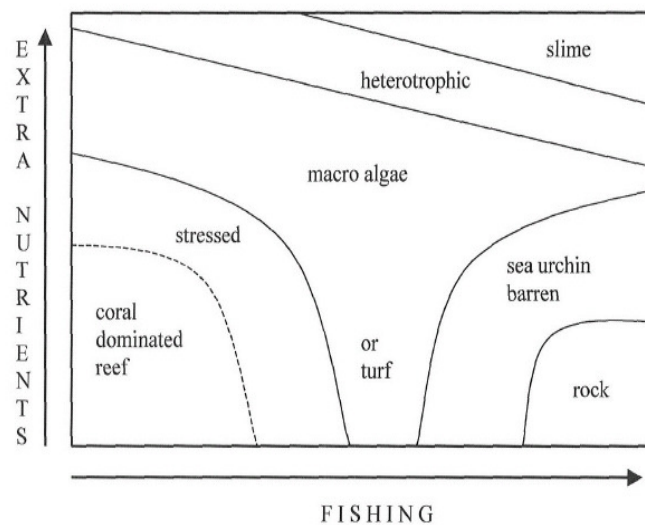


Figure 6.2 Effects of eutrophication and fishing, and observed shifts between states in coral reefs (from Folke et al. 2004:564)

A particular physical environment influences, but does not entirely determine the resulting ecosystem. The sea otter example illustrates another important feature of marine ecosystems – they can exist in alternative stable states. In this example, the two ‘stable states’ were very different: (a) a kelp forest, providing substantial protective habitat and breeding opportunities for rockfish (amongst others) as well as for the otters themselves, and (b) an urchin barren, with a seafloor characterised by large areas of bare rock, dotted with (hungry) sea urchins. Urchin barrens have been observed, or course in many places where otters have never existed – the dynamic balance of different ecosystems changes with the theatre and the players.

An important point with regard to changes in alternative stable states – sometimes called regime shifts – is that both states may be resilient. Here ‘resilience’ means an ability to return to a characteristic state following disturbance. The demise of the kelp forest, while reducing the urchin’s food supply, also removed habitat important to the urchins’ predators – thus providing a stable environment. When the kelp forest existed, it too was resilient, for example, to storm damage which reduced kelp abundance in exposed localities. The continuation of kelp in neighbouring locations provided sufficient habitat for urchin predators, this preventing a surge in urchin numbers.

Damage to coral reefs by algae overgrowth is another example of a change in stable state. Here overfishing can remove grazers which formerly held algae growth to very low levels, thus protecting the formation and health of the structural corals which in turn provided habitat to grazers as well as a variety of other animals. However, once overgrown, the new ecosystem is resilient, as coral polyp larvae cannot take hold amongst dense algae cover.

Figure 6.3 portrays, stylistically, change between alternative stable states.

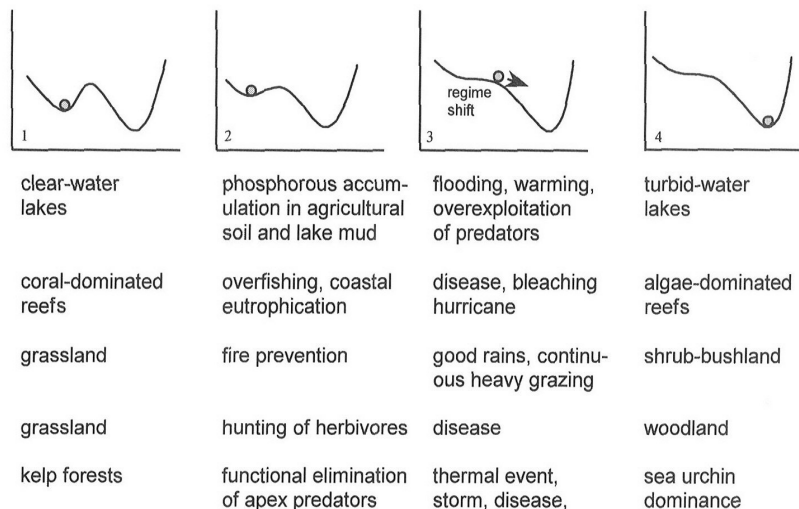


Figure 6.3 Alternative states in a diversity of ecosystems (1,4) and the causes (2) and triggers (3) behind loss of resilience and regime shifts. From Folke et al. 2004. The vertical axes are state-defining variables, while the horizontal axes are forcing variables.

In summary, fishing pressures must alter ecosystem structure and function – animals are removed from an environment in ‘dynamic equilibrium’. Each prey removed will affect a predator, and each predator removed will effect its prey. The same applies to competitors. The removal of ‘system engineers’ may reduce (or even eliminate) habitat vital to other organisms. These alterations will affect the flows of materials and energy which characterise the ecosystem. The removal of keystone species, or species playing major roles in the lifecycles of other organisms (biogenic habitat such as seagrass, sponge gardens, or coral, for example) can push an ecosystem from one stable state to another, and once a shift has occurred, return to the original state may be difficult or even impossible within the timescale of a human life. These are substantial dangers, and dangers for which there is already a considerable history (Jackson et al. 2001).

The complexity of marine ecosystems makes understanding and modelling ecosystem effects difficult and expensive – it seems likely that considerable uncertainties with regard to the effects of fishing on wider ecosystems will always remain, and these uncertainties (often substantial or critical) must be taken into account.

This will be greatly complicated where administrative boundaries are out-of-step with the scale of a particular ecosystem (Crowder et al. 2006). This factor is of greatest concern for shared or straddling stocks, and of least concern for restricted benthic communities.

6.7 Sources of uncertainty – model inaccuracies:

In its simplest form, a model is just an understanding of the way something behaves in response to certain driving or controlling factors. If one variable is affected by another variable, a mathematical formula or algorithm may be constructed as a tool for prediction.

The laws of physics, for example, can be used to predict the speed of a falling marble at a given time after it has been dropped, using fairly simple mathematics – and the resultant predictions will be extremely accurate. The formula used is deterministic; however algorithms can also incorporate probabilities and trigger points – useful in attempts to model biological or ecosystem patterns and processes.

While the laws of physics have been used to navigate a space probe through the rings of the planet Saturn, the weather systems of the atmosphere, and the ocean, are extremely complex even compared to the problems encountered in that amazing feat. Within that complexity (and the amplified ecosystem complexity which results) lies both stochastic and chaotic behaviour which currently prevents (and may always prevent) accurate long-term

predictive modelling of the behaviour of marine ecosystems. Admitting this constraint, models are nevertheless important (essential in fact) tools for the exploration of uncertainties, and for deepening our understanding of ecosystem behaviour. This issue is discussed again in Chapter 9.

As already mentioned, modellers are often forced to use simplifying assumptions because the real situation is either unseen or excessively complex (or both). Sometimes simple models appear to work surprisingly well, at least over short periods of time. However the defects in model structural assumptions are sometimes only revealed when a population collapses under fishing pressure. Examples of 'dangerous' assumptions include:

- the assumption that fishing mortality could be accurately estimated by commercial catch data appears to have been a key flaw in models used prior to the collapse of the northern cod (Shelton & Lilly 2000).
- Heithaus et al. (2008) warn that most ecosystem models assume that prey do not alter their behaviour as predator densities change – an assumption which can lead to significant errors.
- Cheung et al. (2005:98) draw attention to the obvious difficulties in modelling multi-species fisheries in data-poor situations using conventional techniques, noting “the intrinsic rate of increase r , a key population parameter for conventional assessment, is particularly difficult to estimate reliably.”
- Walters et al. (2005:561) draw attention to cryptic predation effects: “An abundant predator may have large predation impacts on a low-biomass prey, without that prey making up a recognizable proportion of its diet. Such cryptic predation impacts may be the most common reason for model “failure” to represent important species interactions.”

Problems in other commonly used assumptions have already been discussed above. In summary, the construction of models involves the use of simplifying assumptions. In many cases these assumptions have the status of “a good guess”, and are only put to the test indirectly, when model predictions are compared with real time-series data.

6.8 Sources of uncertainty – inaccuracies from sensitivity to initial conditions:

Mathematically, *chaos* means an aperiodic deterministic behaviour which is very sensitive to its initial conditions, ie: infinitesimal perturbations of initial conditions for a chaotic dynamical system lead to large variations of the orbit in the phase space - the probable outcomes. Chaotic systems are systems which are deterministic (governed by known physical laws) but exhibit unpredictable behaviour within certain bounds. The belief that deterministic systems are always predictable given enough information, widely held before the development of chaos theory in the 1970s, is not correct. A characteristic of chaotic systems is that description of behaviour always involves nonlinear equations⁵². Linear systems are never chaotic⁵³, although complex linear systems can exhibit stochastic variation (Hsieh et al. 2005).

To appreciate some of the limitations involved in modelling complex nonlinear systems, it is useful to consider the early work of Edward Lorenz, an American meteorologist and mathematician. In 1961 Lorenz built a simple, 12-variable, nonlinear mathematical model of the way air moves within the atmosphere, solved using a computer. By accident, he observed that minute variations in the initial values of variables in his model could result in grossly divergent predicted weather patterns.

The 'accident' (as recounted by Gleick 1987) involved a re-run in which he had to key-in a variable which previously had the value 0.506127. In re-entering the variable's value, Lorenz keyed in 0.506, the attenuated value contained in the printout of the first run. Intuitively, he assumed that such a slight change would make no difference to the end result. To his surprise, the result was in fact hugely different. This sensitive dependence on initial conditions

became popularly known as the 'butterfly effect'⁵⁴, and is the direct result of the nonlinearity and complexity of the mechanisms under study.

At a stage when weather predictions (based on simple models and meagre computers) even a day in advance were often incorrect, Lorenz predicted that the complex nonlinearity of the fundamental processes of the atmosphere would limit accurate weather predictions to about one week in advance, assuming the future development of complex models and powerful computers. If he was right, and perhaps he was, there is a lesson here for the prediction of the ecological outcomes of marine fishing. As mentioned earlier, the ocean has its own complex weather and climate – these are the partial drivers of ocean ecosystems. Biological interactions within the ecosystems add another layer of complexity, and chaos, to modelling endeavours. The timescales of ocean weather are much slower, by perhaps two orders of magnitude, than the atmosphere. It could be that ocean ecosystems will remain forever unpredictable (at least in terms of accuracies needed to support harvest forecasts) outside a timebound of somewhere between 100 and 1000 days.

An approach taken in climate modelling is to use the average predictions of several different models, each with its own strengths and weaknesses. So far, the work reported through the International Panel on Climate Change (IPCC) is impressive, at least on timescales of a year or two.

A similar approach is currently in use in single stock fisheries modelling (Smith et al. 1999), and is being extended to modelling the ecological effects of fishing as ecosystem models expand in variety and accuracy (Pikitch et al. 2002, Butterworth & Punt 2001). Complex models can better represent biological processes, but are strongly dependent on high quality input data. Simple models sometimes work surprisingly well over short time periods using basic data – sometimes all that is available. Bayesian models can take prior information into account. One general approach to using multiple models is to consider the strengths and weaknesses of each approach, and to consider the model outcomes in the light of possible errors in the accuracy of input variables and assumptions – including the prediction of 'worst case' scenarios. Management objectives and acceptable risks can be clearly stated at the outset, and within alternative management strategies a search can be conducted for a set of decisions which will be robust to the stated objectives within the bounds of *all* model outcomes, including worst case predictions, and outcomes bounded by limits to certainty (Hill et al. 2007). In some cases⁵⁵ decisions might be taken to use active adaptive rather than robust strategies; however in these cases all parties should understand the risks involved.

6.9 Sources of uncertainty – empirical data:

The obvious difficulty with obtaining information from the ocean is that we don't live there. Even if we did, over most of the ocean you can't see very far. It is hard to obtain accurate information on organism abundance and movement. Advances over the last two decades (and particularly the last decade) in remote sensing combined with robotics have opened a new window of information on the physical and chemical properties of the ocean surface, and this has been very useful in gaining an understanding of the oceanographic drivers of ecosystems. Habitat mapping is now technically feasible, and programs are underway particularly in coastal areas. Tagging studies are yielding important information on the movement of highly mobile species. However, for much information on biological aspects, we need to rely on the plants and animals we can extract (sample) from the sea.

Even for simple single species models, scientists need information on abundance, movements, growth and mortality, as well as total catch and fishing effort. A proportion of the commercial catch can be measured, and information obtained on length – and (with some extra effort) weight and age, and thus growth rates. Some species are more difficult to age than others – for example those without bony structures such as otoliths. Notorious mistakes have been made, and paid for through stock collapse – the incorrect initial aging of orange roughy is a well known example (Koslow 2007:205).

Many pelagic fish stocks are highly mobile, and exhibit variable aggregating behaviour. Estimates must be made on how representative information from sampling the commercial catch is in calculating key model parameters for the stock as a whole. The smaller or more

biased the sample, the more uncertainty there is in allocating parameter values. Without direct observation, estimating mortality from bycatch or discards introduces further sources of error, which again must be estimated.

Information on fishing effort is often masked or distorted by changes in fisher behaviour which may remain invisible to scientists and managers – at least for a period of time. Changes in harvesting technology ('technological creep') introduce obvious additional distortion when collecting effort data. Fish behaviour can contribute to these uncertainties; for example high densities in aggregations can help maintain CPUE levels even when overall stocks are declining (Rose & Kulka 1999).

Some of these problems may be reduced by collecting supplementary data from standardised scientific surveys. This data can be used to 'correct' data collected from the industry. However such surveys are expensive, and sometimes the first target of agency budget cuts. Where industry is co-funding such surveys, arguments may be expected that the surveys are unnecessary in the light of 'accurate' industry data. Even under adequate funding, the sampling adequacy of the surveys will be limited.

Ecosystem models using trophic structure need information on diet – who eats what, when and how much. Stomach sampling provides information on what has been eaten recently, particularly if bony parts remain and can be identified. Bias comes not only from the selection of the examined stomachs, but the digestibility of the food. Over the last decade, DNA-based diet analysis has offered new insights, and revealed substantial errors in earlier (and still widely used) techniques (Casper et al. 2007).

Obtaining catch and effort data from recreational fishers is still more difficult. Compared with the commercial industry, recreational fishers are often highly dispersed, and their behaviour may be spasmodic over time. Nevertheless, information can be collected from limited observational studies, catch surveys, licence statistics (if they exist) and questionnaires. If fishers perceive the possibility of further government restrictions on their activities (and this is not uncommon even if there is no basis for the idea) an incentive exists to understate both catch and effort information. The skill and training of those conducting both questionnaire surveys and observational studies will be important in minimising inaccuracies in data. Even in the best of circumstances, information from these sources must be based on limited data of questionable reliability.

Ecosystem models, particularly those which attempt to investigate medium or long-term phenomena, depend heavily on good time-series data. In an examination of regime shifts in one of the most well-documented regions – the North Pacific – Overland et al. (2006:582) comment: "Because of the inability to distinguish between underlying processes based on data, it is necessary to entertain multiple models and to consider how each model would impact resource management." Such a view underlines comments made above about the use of multiple models and the search for robust or adaptive management strategies.

An additional point, important in practice, concerns the 'age' and thus the currency of empirical data. The greater the time lags, and the more volatile the stocks – the greater the uncertainty. As Grafton et al. (2006:4) point out: "catches in one fishing season are often assessed the following season, for application of management controls in the subsequent season."

A further important issue concerning the use of empirical data is that, due to the size, inaccessibility and inherent variability of ocean ecosystems, it is usually expensive to obtain samples sufficiently large to provide results of high statistical power. This led to a situation over most of the twentieth century (perhaps less common today) where scientific advice was commonly based on insufficient evidence and poor statistical inference. Saetersdal (1980 – discussed in Peterman 1990) showed that:

Scientists' focus on rejections of null hypotheses contributed to the collapse of several North Atlantic and North Sea pelagic fish stocks, because large decreases in abundance occurred before strong actions were recommended by scientists to control fishing (Peterman 1990:8).

Peterman's review, a decade after Saetersdal's paper, found that little had changed. His examination of some scores of scientific papers found that only 2% reported the probability of making a Type II error – a critical measure of statistical power⁵⁶. Peterman (1990:13) concluded: "Most power analyses that have been done in fisheries management show that population changes can be masked by low-power stock assessment methods." In echoing Saetersdal's findings, he recommended much greater rigor in designing and reporting survey results – suggesting that poorly conceived and funded surveys were worse than useless.

6.10 Sources of uncertainty – scientific and managerial bias:

As discussed above, the scientific basis for harvesting a renewable resource is reproductive surplus. A virgin stock (an unfished population) has no reproductive surplus – the surplus is 'released' by fishing the stock down to a level where the density-dependent limitations of the environment are reduced or removed. The process of fishing down the stock could be conducted slowly and carefully, at a rate of little more than the maximum growth rate of the stock. While such an approach would appear prudent, in reality it is seldom (or never) attempted. First, the maximum growth rate of the fished-down stock is not known in advance (although of course a guess could be based on historical evidence from fishing similar stocks) and secondly the obvious question from the fishers is: "why wait?".

In their classic essay on sustainable exploitation, Hilborn et al. (1995:49) describe this as "one of the most pernicious problems in harvest management".

Non-sustainable yields are available during the fish-down period – the initial development of harvesting a natural population that has a substantial accumulation of older animals and unproductive local subpopulations. Hilborn et al. describe the problem:

The ... problem occurs in exploiting long-lived fishes, where the yields obtainable from an unfished stock may exceed the sustainable yield by several orders of magnitude. For instance, a simple theory of fish exploitation based upon the logistic growth law implies that the optimum stock size for producing sustainable yield is at 50% of the unfished stock size. Thus the process of "fishing down" the stock will involve harvesting, on a one-time basis, 50% of the unfished stock. If the annual mortality rate of adult fish is 20% per year, this means that yield while fishing down will be 16 times the annual sustainable yield.

The large yields available during the early stages of ... fishery development often lead to expectations of larger yields than are sustainable. The exploiting industries almost inevitably develop infrastructure to harvest and process the nonsustainable yield, and once that yield is gone they usually create great economic and political pressure to delay the "fall down." Any such delay is then likely to drive the stock to well below its most productive level, resulting in an even more severe fall down when the inevitable decline does come (Hilborn et al. 1995:49).

Hilborn's observations were widely understood in the late 1980s when Australia's orange roughy fishery commenced, yet did not, apparently, influence its management. The story of this fishery is the story of the scenario described above (see Chapter 12 below).

In an earlier paper the same three authors (Ludwig et al. 1993) had also discussed the issue of financing the expansion of harvesting capacity, and the resulting implications for management. When high yields are available from fishing down stocks, or from fluctuations in abundance (Peruvian anchovetta are an example already given above) fishers will borrow to invest in expanded harvesting capacity (bigger or more boats etc). Banks and other financial institutions, while supporting the expansion in good times, will be unsympathetic to their fisher clients as harvests fall – loans must still be repaid, one way or another. Fishery managers with clients facing bankruptcy will not be inclined to err on the side of biological caution in the face of uncertainty. It is more likely that erring will shift in the opposite direction – managers will be inclined to ignore scientific advice which indicates a need to impose

harvesting restrictions. This effect appears in the literature under the name “Ludwig’s ratchet” (Hennessey & Healey 2000).

Pitcher (Pitcher & Haggan 2003, Pitcher 2001) added two more ‘ratchets’ which help push fish stocks towards collapse – *Odum’s ratchet* (where stock resilience is depleted as subpopulations and their genetic values are extinguished) and *Pauly’s ratchet* where each generation (of fishers and fishery managers) assumes the depleted oceans they grew up with are the benchmark for the natural state of affairs (Pauly 1995). The latter of these two ratchets is particularly relevant to the current discussion, as it provides the backdrop for managers to make cumulative incremental concessions to appease the short term interests of fishers (Odum 1982).

An interesting question is: “what would fisheries management look like if it was staffed and headed by economists rather than fishery biologists and modellers?” Hannesson (2001:251) provides a glimpse into this hypothetical alternative when he argues: “rather than being profit-driven and trying to correct for the basic market failure that stems from free access to fish, management has aimed at serving political goals by catering to special interests in the fishing industry at the expense of economic efficiency.” History appears to support Hannesson’s proposition; we return to this point in a later chapter.

Agency databases containing catch statistics could be made available through the internet to allow access by the global scientific community. Widely endorsed principles of transparency and accountability strongly support such sharing of data. Easily accessible databases would allow scientists to study trends and develop models and other insights into the behaviour of marine ecosystems and markets. Facilitating independent scrutiny of basic data could counteract tendencies towards bias within fisheries management agencies, and could result in substantial improvements in stock assessment (Richards & Schnute 2001).

The above discussion has shown that a fishery, by its nature, when harvesting virgin stocks or highly fluctuating stocks, will place fishery managers under considerable pressure to allow harvests in excess of safe yields, even assessed under optimistic single stock scenarios. Taking other factors into account, such as ecosystem effects, genetic impacts and other long-term uncertainties, such ‘safe yields’ may themselves be wildly optimistic.

An important point should be made about the way in which overfishing is defined and measured. Overfishing is defined in this discussion as *a level of fishing which puts at risk values endorsed either by the fishery management agency, by the nation in whose waters fishing takes place, or within widely accepted international agreements*. A point of critical importance in this regard is that a level of fishing intensity which successfully meets traditional stock sustainability criteria (for example fishing a stock at maximum sustainable yield) may well be much higher than a level of fishing intensity which meets criteria designed to protect marine biodiversity (Jennings 2007). The wide endorsement of the *Convention on Biological Diversity 1992* implies that the latter level is the critical level by which overfishing should now be measured. However, for most of the twentieth century, overfishing was defined and measured against the MSY benchmark – a practice which still continues in violation of the logic created by wide international agreement to protect biodiversity values.

Is there evidence that the cultural pressures discussed above, and adherence to ideas which are now long-outdated, do in fact result in ‘errors of judgement’ on the part of either fishery scientists or fishery managers? Unfortunately, evidence is all too common. This issue is discussed below, in Chapter 12 in particular.

6.11 Sources of uncertainty – fisher behaviour:

By the nature of the industry, fishers tend to be independent and resourceful people. Their immediate concerns are catching fish and paying bills – or if they are poor, perhaps just feeding their families. Although in theory, fishers should be concerned about the future, and about the health of the fish stocks and habitats on which they ultimately depend, the available evidence suggests that overfishing has been the norm (Jackson et al. 2001, Pauly et al. 2002) and careful management the exception (Johannes 1984).

Historically, fishers have also operated in an environment where surveillance by government agencies has been difficult and expensive. Some fishing vessels carry agency observers, but most do not. While remote monitoring technologies, such as satellite-based vessel monitoring systems, and surveillance video are now technically and financially feasible, their use is not yet widespread. Although there are many examples of groups of fishers supporting government restrictions⁵⁷ (Grafton et al. 2005, Johannes 1998), these are again the exception rather than the rule. On the high seas, considerable illegal, unregulated and unreported fishing continues – in spite of great efforts on the part of some governments and organisations to curtail such activities (Sumaila et al. 2006).

Fishers have also benefited greatly from new technologies, some of which have originated from military or space industry innovations. The most important developments over the last half century have been navigational (eg: radar and satellite positioning systems, weather and ocean forecasting, search and rescue capabilities) and those related to catching and processing (sonar, plastic monofilaments, refrigeration, fish pumps, mobile telecommunication). In many cases the use of new techniques has enabled fishers to bypass effort controls imposed by government fishery management agencies (Bordalo-Machado 2006, Cooke & Beddington 1984).

The imposition of total allowable catch (TAC) controls often results in an unproductive 'race to fish' as fishers compete to take the highest value and lowest cost resources. Fishery controls such as individual transferable quotas (ITQs), designed in part to address the race to fish, have resulted in other undesirable activities, such as high-grading. In some fisheries, such as pelagic long-lining, and prawn fisheries, technologies have been developed to address serious bycatch problems. However the actual use of these technologies has been limited where there is either no surveillance to enforce government controls, or no economic incentive to use the technologies. Indeed, many such technologies impose financial costs on fishers.

The theory of the tragedy of the commons (Hardin 1968) explains a good deal of fisher behaviour. The tragedy of the commons occurs when many individuals use a common resource. Over time, collective use increases to the point where the commons starts to degrade. From an individual's viewpoint, the *benefits* he receives from excessive use accrue directly to him, while the *costs* of the degradation caused by his overuse are spread amongst all users of the commons. Under these conditions there is an economic incentive, in the short term, for the individual to keep increasing his use. By the time that his share of the costs of degradation outweigh the benefits he receives from increasing his incremental use (grazing one more sheep, or pulling one more net) the commons has become severely degraded.

The competitive use of a common resource, where the players seek only profit maximisation, is a major cause of overexploitation. Clark (1973) pointed out that there is a second major 'economic' mechanism promoting unsustainable use of renewable resources. The case discussed by Clark is one where competition is absent, and a resource has been appropriated to a harvester. Where a resource has a low rate of natural replenishment (Clark used the example of the blue whale) viewed through the eyes of a profit maximiser (whaling corporations) the present value of conserving future stocks depends critically on the discount rate⁵⁸. As the discount rate moves up, and the replenishment rate moves down, the renewable resource appears more like a non-renewable resource to the corporation's accountants. In other words, its present value exceeds its future value – a profit maximiser will choose the most profitable option: to mine the resource to extinction – even in the absence of competition. White sums up (Clark 1973:634):

The general economic analysis of a biological resource presented in this article suggests that overexploitation in the physical sense of reduced productivity may result from not one, but two social conditions: common-property competitive exploitation on the one hand, and private-property maximization of profits on the other. For populations that are economically valuable but possess low reproductive capacities, either condition may lead even to the extinction of the population. In view of the likelihood of private firms adopting high rates of

discount, the conservation of renewable resources would appear to require continual public surveillance and control of the physical yield and the condition of the stocks.

Even in Australia, where fisheries are often perceived to be well-managed, there is ample evidence not only of non-compliance, but of cultures of non-compliance. For example, Poiner et al. (1998:s2) in a study of prawn trawling in the Great Barrier Reef World Heritage Area reported: “there has been a high level of illegal trawling in the Green Zone and evidence that 40 to 50 boats regularly trawl the area. Misreporting of catch has taken place with catches from inside the Green Zone being credited to adjacent open areas.” Salini et al. (2007) reported a high level of illegal gillnetting across Australia’s northern coastline. An attempt to establish observer coverage of licensed gillnet operators in this area resulted in three observer resignations in a 12-month period – the result of threats and intimidation. Illegal fishing by commercial fishers also features prominently in Chapter 12 on orange roughy.

If economic theory holds, or if history may be used as a guide for predicting future behaviour, fishers cannot be relied upon to protect ocean ecosystems for future generations, or even for themselves. Fishery management agencies may require certain behaviours from fishers, but in many cases no practical enforcement or incentive measures are in place (even though they may be available). From the fishery manager’s viewpoint, much uncertainty surrounds fisher behaviour. Critical issues are catch, bycatch, discards, fishing location, and habitat damage.

6.12 Consequences of uncertainty:

The following words of Walters and Hilborn (1978:157) retain relevance three decades on, and provide a summary of the above discussion:

Uncertainty is a pervasive feature of ecological management problems. Rarely is it possible to predict even the short-term effects of major interventions. Given complete biological understanding, we would still be faced with the unpredictability of various environmental agents. Usually our perceptions are further clouded by statistical problems of measurement and aggregation.

Fisheries management must live with a high degree of irreducible uncertainty. Much of it has been ignored or underplayed in the past. This section explores the consequences of high levels of uncertainty for fisheries managers, fishers, and fish. The following three chapters examine powerful techniques for managing uncertainty, and much of the remainder of the thesis investigates the extent to which these techniques are in common use.

Taking a short-term perspective, it is often in the financial interests of fishers to harvest above sustainable levels – as discussed above. Overcapitalization of fishing capacity, partly the result of the race to fish, and partly due to government subsidies, amplifies this effect (Sumaila & Pauly 2007, Munro 1998, McNeely 1988).

The traditional single-species stock assessment techniques used by fishery scientists and managers over most of the twentieth century, and still in use today, encourage, even necessitate overfishing in attempts to find maximum ‘sustainable’ harvest levels. These techniques, although appealingly simple in principle, depend on a number of assumptions which are generally not reliable in practice. When such techniques are applied to fish populations in environments which exhibit high levels of natural variability, and this variability is reflected in the abundance of many organisms within the supporting ecosystem, overfishing is highly likely to (and does) result. Fishery collapse (defined as annual yield reduced to below 10% of the maximum recorded yield⁵⁹ for at least five consecutive years) may – and often does – follow (Worm et al. 2006).

Although scientific and economic explanations for this result were published many years ago, and the technical, financial and social drivers of excessive exploitation are well understood, overfishing under government regulation remains commonplace in today’s oceans (Grafton et al. 2006, Pauly et al. 2005).

Fishery managers work in an uncertain environment, where (as history has attested) mistakes are likely. Where mistakes in setting harvest targets may be expected, prudence and precaution are warranted – and yet seldom (almost never) applied in practice (see case study chapters below). In a discussion of the implications of 'living with uncertainty' now more than two decades old, Hilborn (1987:1) recommended "holding some resources in reserve to cope with the unexpected" – a simple strategy which, as the above discussion indicates, runs directly counter to the tendencies experienced in practice. Hilborn also stressed the need for managers to detect unexpected changes, and respond, quickly. In practice the management environment allows quick expansion of harvests, but quick reductions in harvest levels face huge difficulties (Ludwig et al. 1993).

In the same paper Hilborn discusses the problems caused by uncertainty in combination with a lack of institutional memory within fishery management agencies. In a striking Australian example (ASFB 1990) fishery agencies were asked for their rationale behind establishing minimum legal lengths. Some agencies replied that "no one could remember" and that the agency had no documentation! Yet the established legal lengths continued to be used, year after year. Hilborn (1987) listed several immediate causes for poor institutional memory, as well as useful remedies. Two causes are particularly intractable. The first is the tendency to 'bury' mistakes rather than consciously and methodically learn from them. The second is 'goal displacement' – where a legitimate goal, such as maximizing net economic returns in an uncertain environment (Grafton et al. 2006), is displaced by a short-term goal to increase industry employment (Finlayson 1994). In some ways the goals are similar, however the second subverts the first, ignoring the lessons of the past (Hilborn et al. 1993).

An important point concerning mistakes in fisheries management is that, from the viewpoint of senior managers, there is an incentive to bury them if they carry a flavour of managerial incompetence. Management agencies are always constituted as government bodies – often characterised by intellectual conservatism and lack of willingness to innovate. Within such agencies, the salaries of senior executives are not tied either to the short-term profitability of the industry (which could place long-term values at risk), or to the long-term capital value of the resource. Managers have no strong incentive to ensure stable or increasing capital resources over a long timeframe – a situation diametrically opposed to the corporate world, or to national economic governance (noting that bankers, like fishery managers, do not appear to learn from the mistake of the past, and seem bound to repeat them). Without incentives for good management (or penalties for bad management) fishery managers ignored the development of corporate management science over the last four decades of the twentieth century (Lane & Stephenson 1999) – arguably at great cost both to fishers and to the ecological resource.

Many fishery scientists and managers believe that continued management failures are not related to failures in science, or indeed to lack of scientific knowledge – and that the fundamental cause of fishery collapse is poor governance, characterised by a failure of fishery managers and decision-makers to accept scientific advice (Grafton et al. 2006:5, Tiltz & Rowling 2001) coupled with lack of will to pursue genuine sustainable harvesting (Swan & Greboval 2003, Beverton 1998). Indeed, while the work of some fishery management organizations is inspirational, the operation of many others gives an impression of managers in league with "greedy and ruthless exploiters of dwindling natural resources" – an impression which is partially correct (Beverton 1998:230).

Fishery management which is weak, cowardly or corrupt will not resist the pressures created by management techniques still in common use, overcapitalisation, or the force of vested fisher interests – which are now commonly incorporated into decision-making structures advising or within fishery management agencies themselves.

The same story unfolds around the world, decade after decade. Few writers have described this story as well and as simply as Rosenberg (2003:102)⁶⁰:

The problem is one of governance and politics, and the following scenario is typical. A fishery operating within national or international jurisdiction undergoes continual change in gear technology, capitalization, and profitability. A variety of

conditions can lead to a call for management action. Perhaps there are resource declines, loss of productivity and profitability, increasing pressure from new entrants to the fishery, or simply a recognition that government has a responsibility to manage the marine resources it holds in the public trust. Subsequent scientific analyses warn that current rates and catches are not sustainable, and/or predict problems if exploitation rates continue to increase.

Managers discuss possible options, but take little action and call for more research. This continues until the problems become severe. A management regime is finally implemented, but includes many political compromises.

Most, if not all, of these come from political pressure by the fishing industry, and thus actually ease restrictions. Next, industry lobbyists challenge the science as inaccurate or insufficient, resulting in the further easing of restrictions. Meanwhile, population declines continue, and often accelerate. Managers increase controls slowly because of increasing political resistance to both the management actions and the scientific data, resulting in more compromises to address industry objections.

Ultimately, a major resource decline occurs, with severe economic and social dislocation and a considerable loss of public resources. A recovery plan is negotiated and implemented, with most of the same sort of arguments over each management action as described above, while fishing continues.

A key feature of this cycle is that fishing is continually allowed to exceed the levels that any reasonable interpretation of the scientific studies would call for. This happens because managers quickly take every opportunity to ease restrictions, while addressing the need for increased restrictions only slowly.

The 'irreducible uncertainties' inherent in fishery science provide the oil which lubricates the wheels of weak, incompetent or compromised fishery management – again noting the story of the Australian orange roughy fishery (Chapter 12).

Scientists, employed or contracted to fishery management agencies, are not immune from the effects of cultures geared to the interests of fishers. Uncertainties offer scientists opportunities to provide biased advice, encouraged by such cultures. In a study evaluating the science behind the management advice for North Sea cod, Reeves & Pastoors (2007:671) found:

that, generally, catch forecasts have been positively biased and that the bias has been driven by three main factors: (i) substantial overestimates of terminal stock size since the late 1990s, (ii) overestimates of incoming recruitment, and (iii) overestimates of growth. Information for other North Sea stocks (haddock, plaice, and sole) suggests that bias is a problem generally, not one unique to cod.

In an examination of the collapse of the Atlantic northern cod fishery, Finlayson (1994) found that the culture within the Canadian fishery management agency was partly responsible for a series of overoptimistic stock forecasts, a finding supported by Walters & Maguire (1996). Also discussing northern cod, Hutchings et al. (1997:1198) found: "The present framework linking fisheries science with fisheries management has permitted, intentionally or unintentionally, a suppression of scientific uncertainty and a failure to document legitimate differences in scientific opinion." In a paper published about the same time Pauly (1996) argued that the provision of biased scientific advice was widespread within fishery management agencies.

In the light of Reeves & Pastoors' work, biased scientific advice appears to remain a major problem today, amplifying the longstanding and continuing tendency of fishery managers to water-down scientific advice when setting harvest targets (Grafton et al. 2006).

'Resilience thinking' is an approach to resource management which provides a very different perspective on the role of uncertainty, and the resulting implications for management (Walker & Salt 2006). Walker and Salt challenge a fundamental assumption still commonly

used in fisheries management: that an 'optimum' harvesting level can be found amongst the huge uncertainties surrounding predictions of ecosystem behaviour. They argue (see the extended extract below in Attachment One) that pursuing the goal of optimum harvest levels, however defined, undermines, over time, the resilience of the ecosystems on which we rely – not just for the production of edible fish. Without resilience, ecosystems are highly likely to collapse, and/or shift to possibly undesirable alternative states. Walker and Salt call for a new approach to management – an approach where maintaining and enhancing ecosystem resilience becomes a primary objective of management. This call for a new approach to fisheries management echoes long-standing calls from such authors as Pitcher & Pauly (2001).

Over the last 25 years, three core approaches to the management of uncertainty in natural resource management have been developed: (a) the precautionary approach, (b) the ecosystem approach, and (c) active adaptive management. These three approaches have been discussed, trialled, refined, and adopted as goals in international law – but seldom comprehensively or enthusiastically applied to fishery management.

In the following three chapters I argue that the thorough and thoughtful application of these three approaches is essential in managing under uncertainty. These three chapters, after providing background on the different approaches, examine fisheries management literature in an attempt to distil simple 'benchmarks' by which a particular fisheries program may be judged as to the degree with which a particular benchmark is incorporated in practical fisheries management.

Further, these approaches need to be applied within a management framework which takes compliance seriously, and includes effective stakeholder consultation. In this context a key to effective communication – including fishers, conservationists, consumers and politicians, is the open and transparent analysis of the likely effects of different operational procedures, and the assessment of the results against agreed management objectives. This later approach (already mentioned) is often termed a 'management procedure' or 'management strategy evaluation' approach (Smith et al. 2007, Butterworth 2007).

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Chapter Six, Attachment One:

6.13 Resilience thinking:

Extract from Walker & Salt 2006:chapter 1:

Optimizing for particular products has characterised the early development of natural resource management. ... An optimization approach aims to get a system into some particular "optimal state," and then hold it there. That state, it is believed, will deliver maximum sustained benefit. It is sometimes recognized that the optimal state may vary under different conditions, and the approach is then to find the optimal path for the state of the system. This approach is sometimes referred to as a maximum sustainable yield or optimal sustainable yield paradigm.

To achieve this outcome, management builds models that generally assume (among other unrecognized assumptions) that changes will be incremental and linear (cause-and-effect changes). These models mostly ignore the implications of what might be happening at higher scales and frequently fail to take full account of changes at lower scales.

"Efficiency" is a cornerstone of economics, and the very basis of environmental economics. In theory, an economy is efficient if it includes all the things that people want and value. An efficient economy, in this sense, is therefore a good thing and efficiency has become to be regarded as a laudable goal in policy and management. The paradox is that while optimization is supposedly about efficiency, because it is applied to a narrow range of values and a particular set of interests, the result is major inefficiencies in the way we generate values for societies. Being efficient, in a narrow sense, leads to elimination of redundancies-

keeping only those things that are directly and immediately beneficial. [T]his kind of efficiency leads to drastic losses in resilience.

Optimization ...reduces time horizons to a couple of decades - the limit of the time horizon for most commercial investments. Values that do not have property rights or are publicly owned are not marketed, do not generate wealth, and gain little support, even if they involve critical ecosystem services. Often not enough people understand the criticality of the life support systems - the ozone layer and climate regulation are examples.

Though efficiency, per se, is not the problem, when it is applied to only a narrow range of values and a particular set of interests it sets the system on a trajectory that, due to its complex nature, leads inevitably to unwanted outcomes. The history of ecology, economics, and sociology is full of examples showing that the systems around us, the systems we are a part of, are much more complex than our assumptions allow for.

What it all adds up to is that there is no sustainable "optimal" state of an ecosystem, a social system, or the world. It is an illusion, a product of the way we look at and model the world. It is unattainable; in fact (as we shall see) it is counterproductive, and yet it is a widely pursued goal (my italics).

It is little wonder, then, that problems arise. And when they do, rather than question the validity of the model being applied, the response has been to attempt to exert even greater control over the system. In most cases this exacerbates the problem or leaves us with a solution that comes with too high a cost to be sustained.

The ruling paradigm - that we can optimize components of a system in isolation of the rest of the system - is proving inadequate to deal with the dynamic complexity of the real world. Sustainable solutions to our growing resource problems need to look beyond a business as usual approach. Why? Because the more you optimize elements of a complex system of humans and nature for some specific goal, the more you diminish that system's resilience. A drive for an efficient optimal state outcome has the effect of making the total system more vulnerable to shocks and disturbances.

The bottom line for sustainability is that any proposal for sustainable development that does not explicitly acknowledge a system's resilience is simply not going to keep delivering the goods (or services). The key to sustainability lies in enhancing the resilience of social-ecological systems, not in optimizing isolated components of the system.

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It is a sad but understandable fact that most scientists base their research programs not on broad analyses of uncertainties, but instead on the investigative tools (nets etc) and analytical methods that they learned in university or find popular among colleagues. Carl Walters (1986).

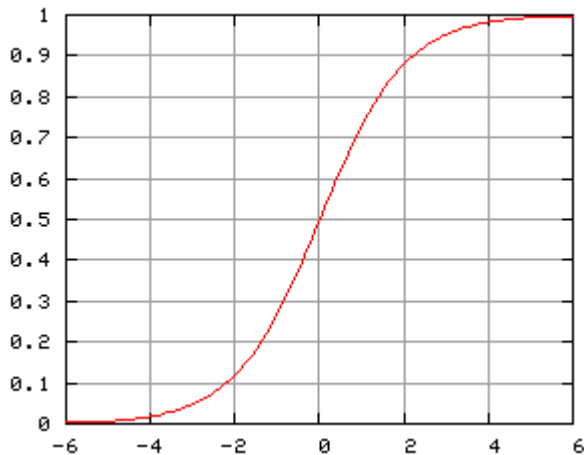
Endnotes:

⁴³ Gulland quoted by Rosenberg (2003). Rosenberg, A (2003) 'Managing to the margins: the over-exploitation of marine fisheries', *Frontiers in Ecology and the Environment*, vol. 1, pp. 102-6.

⁴⁴ Mark Baird (pers.comm. 4/6/08) makes an important point about system prediction: "Some things are predictable for long periods, other phenomena are not. Particularly, if a system approaches an equilibrium, and we can calculate that equilibrium, then we can predict the future state. So specification of initial conditions will never be sufficient for predicting a weather system in 30 days, but a broad range of initial conditions specified in 5000 BC would produce the approximate global mean temperature of today."

⁴⁵ Initial confidence in the generality of **compensatory mortality** waned with increasing knowledge of fishing effects. According to Hilborn et al. (1995:48): "In one major fisheries textbook of the 1980s, Gulland (1983) summarized the available data: 'more commonly the numbers of recruits is effectively independent of the adult stock size over most of the observed range of stock size.' Later Myers et al (1994) reviewed the data for 72 fish stocks and showed that for almost all stocks there was evidence that the reproductive surplus declined as adult population size was reduced."

⁴⁶ The **logistic curve** can be represented by the sigmoid function (http://en.wikipedia.org/wiki/Logistic_function).



Endnote Figure 6.4: the Logistic Function:

For our discussion the vertical axis is population size, measured as number of individuals. The horizontal axis is time. Numerical axis values can be interpreted as indices. The population starts near zero size, growing exponentially until environmental limitations begin to exert an influence at population size 0.5. The population growth rate is given by the slope of the curve – highest at population 0.5. Under this example it is noteworthy that the population exhibits continuously high growth within the population range 0.2 to 0.8 – implying that high reproductive surplus will be yielded within this range.

⁴⁷ The issue of invalid assumptions has of course been long recognised, along with the unavoidability of making the assumptions in the first place. For example, in reviewing Beverton & Holt 1957, Rounsefell – discussing the use of assumptions in modelling population dynamics, makes the comment that "only rarely does one find all of these assumptions satisfied in any set of actual field data." Rounsefell also notes, concerning the assumption of a stable environment, that in practice "... such an environment is practically non-existent" (Rounsefell 1959:230).

⁴⁸ A **metapopulation** consists of a group of spatially separated populations of the same species which interact at some level. The term metapopulation was coined by Richard Levins in 1969 to describe a model of population dynamics of insect pests in agricultural fields, but the idea has been most broadly applied to species in naturally or artificially fragmented habitats. In Levins' own words, it consists of "a population of populations". <http://en.wikipedia.org/wiki/Metapopulation>. Recruitment within each local population depends on both local reproduction as well as transport or migration from other local populations within the wider metapopulation.

⁴⁹ The **Allee effect** is a phenomenon in biology characterized by a positive correlation between population density and the per capita growth rate. The Allee effect was first written on extensively by its namesake Warder Clyde Allee. The general idea is that for smaller populations, the reproduction and survival of individuals decrease. This effect usually saturates or disappears as populations get larger. The effect may be due to any number of causes. In some species, reproduction—finding a mate in particular—may be increasingly difficult as the population density decreases in large areas. The Allee effect either limits that

small population to a small area where they grow, or the population dies off. Other species may use strategies (such as schooling in fish) that are more effective for larger populations.

⁵⁰ Eugene Odum, one of the forefathers of the science of ecology, stated: "Any unit that includes all of the organisms (ie: the "community") in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity, and material cycles (ie: exchange of materials between living and nonliving parts) within the system is an **ecosystem**." (Odum 1971:8).

⁵¹ A **keystone species** is a species that has a disproportionate effect on its environment relative to its abundance (http://en.wikipedia.org/wiki/Keystone_species accessed 20 May 08).

⁵² Hsieh et al. (2005:336) in a comprehensive examination of both physical and biological information for the North Pacific large marine ecosystem, concluded: "Our measurements suggest that large-scale marine ecosystems are dynamically nonlinear, and as such have the capacity for dramatic change in response to stochastic fluctuations in basin-scale physical states."

⁵³ <http://en.wikipedia.org/wiki/Chaos>, accessed 20 May 2008.

⁵⁴ According to http://en.wikipedia.org/wiki/Butterfly_effect, (accessed 24 May 2008) the butterfly effect was first described by Jacques Hadamard in 1890.

⁵⁵ For example, where a clear opportunity has been identified (by modelling) which could yield information of value for future management decisions.

⁵⁶ Peterman 1990: Table 1:

Four possible outcomes for a statistical test of some null hypothesis, depending on the true state of nature. The probability of for each outcome is given in parentheses. Peterman 1990.

State of nature	Decision	
	Do not reject null hypothesis	Reject null hypothesis
Null hypothesis is actually true	Correct (1- α)	Type I error (α)
Null hypothesis is actually false	Type II error (β)	Correct (1- β) (=power)

Here α is the level of significance of the test for the null hypothesis being true (the probability that the null hypothesis is rejected when it is actually true), and β is the probability of failing to reject the null hypothesis when in fact it is false.

⁵⁷ Cited examples all apply where some kind of ownership 'rights' over fish resources have been recognized by government.

⁵⁸ White points out: "The question of the cause of high **discount rates** is a complex one; it is sufficient to remark that at any time the discount rate adopted by exploiters will be related to the marginal opportunity cost of capital in alternative investments. In a technologically expanding economy, this rate could be quite large" Clark (1973:632).

⁵⁹ After Worm et al. 2006.

⁶⁰ See also Walters 1986:25,32.

Part Two: case studies

7. The precautionary principle in fisheries: assessment benchmarks.

7.1 Introduction:

The precautionary principle should play (and occasionally does play) an important role in the management of fisheries against a background of uncertainty. Its significance to the management of renewable resources, and its adoption in Australian ocean management policy and programs, is discussed at some length in Appendix 2. The purpose of the present discussion is to (a) briefly introduce the principle, (b) to outline its adoption in both international and national policy frameworks, (c) discuss the development of guidelines on the application of the principle to fisheries management, and finally (d) to develop six benchmarks by which the adoption of the principle within management programs may be judged. The chapter contains a small amount of repetition, again designed to assist readers 'dipping into' the thesis.

7.2 The precautionary principle:

There are many definitions of the precautionary principle. A basic definition is:

Where the possibility exists of serious or irreversible harm, lack of scientific certainty should not preclude cautious action by decision-makers to prevent or mitigate such harm.

Precaution is caution in advance, or more correctly 'caution practised in the context of uncertainty'. All definitions of the precautionary principle have two key elements.

- an expression of a need by decision-makers to anticipate harm before it occurs. Within this element lies an implicit reversal of the burden of proof. Under the precautionary principle it is the responsibility of an activity proponent (eg: someone wishing to harvest fish) to establish that the proposed activity will not (or is very unlikely to) result in significant harm⁶¹.
- the establishment of an obligation, if the level of harm may be high, for action to prevent or minimise such harm even when the absence of scientific evidence makes it difficult to predict the likelihood of harm occurring, or to predict the level of harm should it occur. The need for precautionary control measures increases with both the level of possible harm *and* the degree of uncertainty.

A distinction exists between the precautionary **principle** and the precautionary **approach**. Principle 15 of the Rio Declaration⁶² states that: "*in order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.*" As Garcia (1995) pointed out, "the wording [of the approach], largely similar to that of the principle, is subtly different in that: (1) it recognizes that there may be differences in local capabilities to apply the approach, and (2) it calls for cost-effectiveness in applying the approach, e.g., taking economic and social costs into account." The 'approach' is generally considered a softening of the 'principle'.

7.3 Precaution in international law:

According to Cooney (2004) "the precautionary principle is widely recognised as emerging from the *Vorsorgeprinzip* (directly translated as "fore-caring" or "foresight" principle) of German domestic law, although it has earlier antecedents in Swedish law". The precautionary principle is in some ways an expansion of the English common law concept of 'duty of care' originating in the decisions of the judge Lord Esher in the late 1800s. According to Lord Esher: "Whenever one person is by circumstances placed in such a position with

regard to another that everyone of ordinary sense who did think, would at once recognise that if he did not use ordinary care and skill in his own conduct with regard to those circumstances, he would cause danger or injury to the person, or property of the other, a duty arises to use ordinary care and skill to avoid such danger” (Wikipedia 23/6/08). This statement clearly contains elements of foresight and responsibility, but does not refer to a lack of certainty, as the word “would” is used rather than “might”, or “could”. A second important difference is that the duty of care applies only to people and property, not to the environment.

The precautionary principle has been current in international agreements and statements, and various national strategies and policies, for over 25 years. For example, it appears in Article 11 of the *World Charter for Nature 1982*, a resolution of the General Assembly of the United Nations, endorsed many nations including Australia. The Charter places a non-binding obligation on both States and individual persons within those States to apply the Charter’s measures, including the precautionary principle (amongst other matters).

Convention for the Conservation of Antarctic Living Resources 1980

The *Convention for the Conservation of Antarctic Living Resources 1980* was written two years before the *World Charter*, and did not specifically encompass the precautionary principle – an omission continued by the UN *Convention on the Law of the Sea 1982*. However, amongst regional fishery management organisations, the *Commission on the Conservation of Antarctic Marine Living Resources* (CCAMLR) is often viewed as being among the most precautionary (Parkes 2000, Mace and Gabriel, 1999). While precaution is not explicitly specified in the convention⁶³, since at least the early 1990s it has been understood that in the case of uncertainty, CCAMLR Conservation Measures should be consistent with a precautionary approach (CCAMLR 1993), although in practice this is sometimes subject to dispute (TAP 2001). CCAMLR adopts an ecosystem-level approach to conservation and management, widely understood as necessitating, or at least being consistent with a precautionary approach.

The UN Fish Stocks Agreement 1995

The 1995 United Nations Fish Stocks Agreement (UNFSA)⁶⁴ coming three years after the influential collapse of the Canadian cod fishery, marks a significant shift of emphasis and approach in fisheries management, and remains today probably the most important of the many international fisheries agreements. The UNFSA establishes obligations for signatory States that affect both management within national waters of straddling or highly migratory stocks, and management of high seas stocks by international and regional fishing organizations. Within these constraints, the UNFSA provides a legal basis for the application of several of the most important provisions of the United Nations Food and Agriculture Organization (FAO) *Code of Conduct for Responsible Fisheries 1995* – see below).

Environmental considerations are strongly highlighted in the preambular language of the UNFSA, and given effect throughout the operative provisions. The UNFSA is the first global fisheries agreement requiring a precautionary approach to fisheries management – a precedent-setting and highly influential development. Article 6 requires that to preserve the marine environment as well as protect marine living resources, the precautionary approach should be applied to conservation, management and exploitation measures. It includes requirements that States apply a prescribed methodology for precautionary measures (set out in Annex II), implement improved techniques for dealing with risk and uncertainty, take into account both ecological and socio-economic uncertainties, and develop research and monitoring programs and plans aimed at conserving non-target and dependent species (Article 6(3)). Annex II sets out guidelines for precautionary measures based on the establishment of reference points, and actions to be taken when such points are approached and exceeded. Reference to Maximum Sustainable Yield (MSY) is retained in the Annex II guidelines, but as a limit reference point, constraining harvest, rather than as (the old-fashioned) target for management.

The FAO Code of Conduct for Responsible Fisheries 1995

The voluntary FAO Code of Conduct for Responsible Fisheries, also concluded in 1995, includes an exhortation to apply the precautionary approach widely in the conservation, management and utilization of living aquatic resources, directed at States, sub-regional and regional fisheries management organisations and arrangements (see Article 6.5 and 7.5). While the code of conduct is voluntary, it is widely supported (see Chapter 5 above) including by Australia. While most fishing nations have 'signed up' to the code, progress at implementation has been slow (FAO 2005b). The Code, together with the UNFSA, remain the two most influential of existing international fisheries agreements.

Technical guidance for implementation of the precautionary approach has been developed by the FAO (FAO 1996a,b). These guidelines represent probably the most detailed treatments of the operational meaning of precaution in a natural resource management or conservation arena, and offer valuable lessons for other sectors. The FAO guidance first characterizes the general concept of the precautionary approach, setting out that the precautionary approach requires, *inter alia*:

- avoidance of irreversible changes;
- prior identification of undesirable outcomes;
- initiation of corrective measures without delay;
- priority given to conserving the productive capacity of the resource;
- harvesting and processing capacity commensurate with estimated sustainable levels of the resource;
- that all fishing activities have prior management authorization and are subject to periodic review;
- legal and institutional frameworks for fishery management, with management plans implementing the above for each fishery; and
- appropriate placement of the burden of proof through meeting these requirements (para. 6(a)-(h)).

Detailed guidance is then developed for the implementation of the precautionary approach in relation to fisheries management, research, technology development/transfer, and species introductions, including, for example, management planning and design, monitoring, stock assessment methods, review and evaluation of new technologies, and cooperation and information systems on invasive species.

It is not clear that this broad and far-reaching understanding of the precautionary approach is widely reflected in legal and policy developments within nations supporting the Code, or more importantly within fisheries program implementation (Mooney-Seus & Rosenberg 2007, FAO 2005b).

Within the UN Fish Stocks Agreement, guidance on the precautionary approach focuses on target and limit biological reference points, rather than including the more "systemic" changes set out in the FAO guidance. It has been argued that this narrow understanding of the precautionary approach characterizes current efforts in this area, at the expense of the broader management implications (Mace & Gabriel 1999).

The FAO continues to actively develop the precautionary approach, developing guidance across a range of fisheries (eg, FAO 2001b, Caddy 1998, Caddy and Mahon 1995). The precautionary approach has also been endorsed by and incorporated into ongoing work under FAO auspices on developing guidance for the ecosystem approach to fisheries (FAO 2003).

7.4 Precaution in Australian oceans policy and fisheries law:

The Australian (Commonwealth) Government has direct control of many fisheries in Australia's 200 nm Exclusive Economic Zone (EEZ). Although the resource management responsibilities of the Commonwealth are limited by the Australian Constitution (which provides States with resource management responsibilities in areas under State jurisdiction)

Commonwealth controls over fisheries are extended by the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, which requires (amongst other matters) that all fisheries requiring export permits be managed in a sustainable and precautionary way. The precautionary principle is a central feature of the EPBC Act (Kriwoken et al. 2001) although the Act contains a curious anomaly in this respect – see the detailed discussion of the EPBC Act in Appendix 2 below).

The precautionary principle is also a central principle of Australia's *Oceans Policy* (Commonwealth of Australia 1998:19). In addition, the Policy lists another principle closely connected with precaution: "If the potential impact of an action is of concern, priority should be given to maintaining ecosystem health and integrity". The Ocean's Policy stresses the need to 'err on the safe side' – an approach all too often neglected in fisheries management (see Chapter 6 on uncertainty, and Chapter 12 dealing with orange roughy).

The Commonwealth 'blueprint' for Australia's marine protected area network, the *Strategic Plan of Action for the National Representative System of Marine Protected Areas* (ANZECC 1999:16) lists the precautionary principle amongst its guiding principles.

Within the Australian context, fisheries are managed either by:

- the Commonwealth (Australian) government where the fishery is primarily in offshore waters⁶⁵, or
- by the governments of the States and Territories⁶⁶ where the fishery is primarily within coastal waters, or
- jointly or cooperatively by the Commonwealth in conjunction with the States under the Australian Offshore Constitutional Settlement⁶⁷.

The Commonwealth's *Fisheries Administration Act 1991* establishes the Australian Fisheries Management Authority, and lists as an objective of the Authority (s.6(b)):

...ensuring that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development *and the exercise of the precautionary principle*, in particular the need to have regard to the impact of fishing activities on non-target species and the long term sustainability of the marine environment (emphasis added).

The Commonwealth's *Fisheries Management Act 1991* section 3 states:

The following objectives must be pursued by the Minister in the administration of this Act and by the Australian Fisheries Management Authority in the performance of its functions:

- a) implementing efficient and cost-effective fisheries management on behalf of the Commonwealth; and
- b) ensuring that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development *and the exercise of the precautionary principle*, in particular the need to have regard to the impact of fishing activities on non-target species and the long term sustainability of the marine environment... (emphasis added).

The precautionary principle and approach have also been incorporated into Australian State fisheries legislation, as follows:

- **Australian Capital Territory – Fisheries Act 2000** – incorporated by reference to the application of "the principles of ecologically sustainable development mentioned in the *Environment Protection Act 1997*". This latter Act lists and defines the precautionary principle⁶⁸, and includes an obligation to pursue "conservation of biological diversity and ecological integrity". It is also noteworthy that s.3 of the Fisheries Act 2000 (Objects of the Act) first lists "to conserve native fish species and their habitats".

- **New South Wales** – *Fisheries Management Act 1994* – s.3 (Objects of the Act) includes “to promote ecologically sustainable development, including the conservation of biodiversity.” The Act creates a “TAC Committee” which (s.30) “is to have regard to the precautionary principle” in making determinations. As NSW endorsed the *National Strategy for Ecologically Sustainable Development* (Commonwealth of Australia 1992) which embodies the precautionary principle, it appears implicit that precaution must be applied within activities sanctioned under the Fisheries Management Act;
- **Northern Territory** – *Fisheries Act 1988* – not specifically incorporated, although s.2A (Objects of the Act) includes “to manage the aquatic resources of the Territory in accordance with the principles of ecologically sustainable development...” As the NT endorsed the *National Strategy for Ecologically Sustainable Development* (Commonwealth of Australia 1992) which embodies the precautionary principle, it appears implicit that precaution must be applied within activities sanctioned under the Fisheries Act;
- **Queensland** – *Fisheries Act 1994* – s.3(5) “apply and balance the principles of ecologically sustainable development” which are interpreted as including the precautionary principle. It is also worth noting that the *Great Barrier Reef Marine Park Act 1975* (Commonwealth) requires the Great Barrier Reef Marine Park Authority to “be informed by the precautionary principle in the preparation of management plans” (s.39Z).
- **South Australia** – *Fisheries Management Act 2007* – explicitly incorporated. Section 7 (Objects of the Act) emphasizes “proper conservation” and the need to for actions to be “consistent with ecologically sustainable development” – defined as “taking into account” the precautionary principle. In addition South Australian endorsed the *National Strategy for Ecologically Sustainable Development* (Commonwealth of Australia 1992) which embodies the precautionary principle. It appears that precaution must be applied within activities sanctioned under the Fisheries Management Act;
- **Tasmania** – *Living Marine Resources Management Act 1995* – not incorporated; however s.310 of the Act references the “objectives of the resource management and planning system of Tasmania” which include: “to promote the sustainable development of natural and physical resources and the maintenance of ecological processes and genetic diversity”. As Tasmania endorsed the *National Strategy for Ecologically Sustainable Development* (Commonwealth of Australia 1992) which embodies the precautionary principle, it appears implicit that precaution must be applied within activities sanctioned under the Living Marine Resources Management Act;
- **Victoria** – *Fisheries Act 1995* – not incorporated, although s.3 (Objects of the Act) states that the Act should “provide for the management, development and use” of resources in an “ecologically sustainable manner”. S3(b) includes an objective “to protect and conserve fisheries resources, habitats and ecosystems including the maintenance of aquatic ecological processes and genetic diversity”. As Victoria endorsed the *National Strategy for Ecologically Sustainable Development* (Commonwealth of Australia 1992) which embodies the precautionary principle, it appears implicit that precaution must be applied within activities sanctioned under the Fisheries Act;
- **Western Australia** – *Fish Resources Management Act 1994* – not incorporated; although s.3 (Objects of the Act) lists as the first two objectives: “(a) to conserve fish and protect their environment, and (b) to ensure that the exploitation of fish resources is carried out in a sustainable manner.” As Western Australian endorsed the *National Strategy for Ecologically Sustainable Development* (Commonwealth of Australia 1992) which embodies the precautionary principle, it appears implicit that precaution must be applied within activities sanctioned under the Fish Resources Management Act.

In New Zealand, the *Fisheries Act 1996* specifically requires management to take account of responsibilities following New Zealand's ratification of the UNFSA. The UNFSA is in fact printed as an attachment to this Act, including Annex II dealing with precaution.

Section 8 (Purpose of the Act) requires "(a) maintaining the potential of fisheries resources to meet the reasonably foreseeable needs of future generations; and (b) avoiding, remedying, or mitigating any adverse effects of fishing on the aquatic environment."

Section 9 of the NZ Act lists three "Environmental Principles" which do not include the precautionary principle – in spite of the Act's reference later to the precautionary obligations of the UNFSA. The listed principles are more relevant to the ecosystem approach rather than the precautionary approach: "(a) associated or dependent species should be maintained above a level that ensures their long-term viability: (b) biological diversity of the aquatic environment should be maintained: (c) habitat of particular significance for fisheries management should be protected.

It might be expected that the Australian Fisheries Management Authority (AFMA), the government agency directly responsible for managing Commonwealth fisheries, or the responsible government department within which AFMA sits, would have developed protocols or guidelines for the application of precaution to the Australian situation. This has not occurred, with AFMA and State agencies apparently relying on existing guidance from FAO-sponsored sources. In practice, however, these guidelines seem to be widely ignored (see the case study chapters below).

Precaution in Australian case law:

Precaution is an accepted principle within Australian government resource management strategies, at all three levels: Commonwealth (the Australian Government), State and Territory, and local government⁶⁹. Much has been written about the precautionary principle and its use, although clear examples of its application are relatively rare in Australia (Preston 2006, Kriwoken et al. 2006, Kriwoken et al. 2001, Coffey 2001, Stein 1999).

Prior to 2006 a handful of Australian court cases provided little consistent precedent. These have, however, been overshadowed by *Telstra Corporation Limited v Hornsby Shire Council*. This case, heard in the NSW Land and Environment Court under Justice CJ Preston (24 April 2006) provides the most detailed consideration of the precautionary principle in Australian case law at this stage. Mohr (2006) has provided a short review of the rather detailed case findings.

The version of the principle discussed in the case was that of the NSW *Protection of the Environment Administration Act 1991*:

"If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reasoning for postponing measures to prevent environmental degradation. In the application of the principle... 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 consequence of various options".*

The most significant points of the decision are (after Mohr 2006):

- a) The principle and accompanying need to take precautionary measures is 'triggered' when two prior conditions exist: a threat of serious or irreversible damage, and scientific uncertainty as to the extent (likelihood and severity) of possible damage.
- b) Once both triggers are satisfied, "a proportionate precautionary measure may be taken to avert the anticipated threat of environmental damage, but it should be proportionate."

- c) The principle shifts the burden of proof. If the principle applies, the burden shifts: "a decision maker must assume the threat of serious or irreversible environmental damage is... a reality [and] the burden of showing this threat... is negligible reverts to the proponent..."
- d) The precautionary principle invokes preventative action: "the principle permits the taking of preventative measures without having to wait until the reality and seriousness of the threat become fully known".
- e) The precautionary measures appropriate will depend on the combined effect of "the degree of seriousness and irreversibility of the threat and the degree of uncertainty... the more significant and uncertain the threat, the greater...the precaution required". "...measures should be adopted... proportionate to the potential threats".
- f) The threat of serious or irreversible damage should invoke consideration of five factors: the scale of threat (local, regional etc); the perceived value of the threatened environment; whether the possible impacts are manageable; the level of public concern, and whether there is a rational or scientific basis for the concern.
- g) The consideration of the level of scientific uncertainty should involve factors which may include: what would constitute sufficient evidence; the level and kind of uncertainty; and the potential of further investigations to reduce uncertainty.
- h) "The principle should not be used to try to avoid all risks."

These findings provide useful guidance against which all Australian natural resource management programs might be judged. While couched in general terms, they remain pertinent to fisheries management, even though the Court Case had nothing to do with fisheries. One of the most important points is that caution, under the principle, should be applied on a sliding scale, determined by two elements⁷⁰. First, the greater the possible harm, the greater should be the caution applied, even if the possibility of that harm seems remote. Secondly, the greater the uncertainty, the greater should be the caution applied. In summary: the greater the possible harm, and the greater the uncertainty, then greater should be the caution.

Set against the highly uncertain background of the ocean, the history of global fisheries contains numerous examples of great harm (Jackson et al. 2001).

7.5 Precautionary guidelines for fisheries management:

An examination of the literature reveals that guidelines for precautionary fisheries management, and for ecosystem based management have evolved somewhat differently. In the case of the ecosystem approach, although the FAO published guidelines in 2003, many other authors have published their own papers providing guidance to a global audience. However, the FAO sponsored documents on precautionary fisheries management, published in 1995 and 1996, remain the seminal documents today. Where national or regional frameworks have been discussed, they are generally based on the earlier FAO documents (eg: Serchuk et al. 1999). The core documents are:

- 1) The *FAO Code of Conduct for Responsible Fisheries 1995*, especially Article 7.5;
- 2) The *UN Fish Stocks Agreement 1995* (known by its short title) Article 6 and Annex II;
- 3) The *Lysekil Statement 1995* (the summary statement and section 4 of the guidelines compiled by the FAO Technical Consultation on the Precautionary Approach to Capture Fisheries, held at Lysekil Sweden 6-13 June 1995;
- 4) The *FAO Guidelines on the precautionary approach to capture fisheries and species introductions 1996*. FAO Fisheries Technical Paper 350, based on the findings of the Lysekil Consultation; and
- 5) *Guidelines on the precautionary approach by Garcia* (1996) attached to FAO Technical Paper 350.

A review of these five documents reveals, not surprisingly, a considerable degree of coherence in the themes put forward as key components of precautionary fisheries

management. Not surprisingly, as all documents were developed at about the same time, under the influence (largely) of the same core group of fisheries scientists and managers. Looking back, it appears that these documents were ahead of their time⁷¹. Table 7.1 lists the 32 key themes against the reference documents.

Table 7.1: *themes identified as important components of precautionary fisheries management.*

Theme	Reference (see list above)
1 "Appropriate placement of the burden of proof", where uncertainty exists "priority should be given to conserving the productive capacity of the resource."	3
2 Assess the impact of fisheries on target and non-target species, and on habitat.	2, 3, 4, 5
3 Plan to protect non-target species and habitat.	2, 3, 4
4 Assess risks to target and non-target species; where risks are high attempt to reduce uncertainties through additional monitoring.	2
5 As uncertainty increases, management should be increasingly conservative.	3
6 avoid irreversible impacts on stocks or ecosystems.	5
7 Fishery management should preserve the evolutionary potential of aquatic species.	4
8 Use pre-agreed decision rules in conjunction with target and limit reference points relating to target species.	1, 2, 3, 4, 5
9 Use pre-agreed decision rules in conjunction with target and limit reference points relating to non-target species.	2, 4, 5
10 Use a third (threshold) reference point between the target and limit reference points, with decision rules.	5
11 Set provisional or default reference points even where information is poor or absent	2
12 Express reference points in statistical terms where possible	5
13 The fishing rate which generates maximum sustainable yield should be a minimum standard for limit reference points. Fishing mortality should not exceed that which corresponds to maximum sustainable yield, unless stocks are overfished, in which case rebuilding should take place.	2, 4, 5
14 Until stock specific research leads to the establishment of alternative operational target based on research and practical experiences, a precautionary approach would seek to: (a) maintain the spawning biomass at a prudent level (i.e., above 50% of its unexploited level), (b) keep the fishing mortality rate relatively low (i.e., below the natural mortality rate).	3, 4
15 Use best available science.	1, 2, 4, 5
16 Use best available science; evidence should be objective, verifiable and potentially replicable. Use independent peer review as quality assurance.	3
17 Use all available knowledge, including fisher knowledge	3
18 Collect accurate and complete data on retained catch, discarded catch and fishing effort.	3
19 Share fisheries information with stakeholders and other agencies.	2, 3

Table 7.1 (continued)

20	Monitoring programs should be designed and funded at a level which is likely to detect undesirable trends; where this is impractical management should be increasingly cautious.	Reference (see list above)
21	Use a cautious, gradual approach to new or exploratory fisheries.	1, 2, 4, 5
22	Ensure fishing does not aggravate the effects of deteriorating environmental conditions.	1, 2
23	Prepare a rapid response to unexpected effects of fishing, or natural catastrophes.	1, 2, 3
24	Avoid intensive fishing of immature fish.	3
25	All fishing activities should have prior authorization and be subject to periodic review.	3
26	Fishery management plans should operate within an established legal and institutional framework.	3, 5
27	Use active adaptive management to reduce uncertainties.	3, 4, 5
28	Management should establish clear, transparent operational targets, constraints and decision rules.	3, 4, 5
29	Consider all potential management alternatives and their consequences before finalising management plans.	4
30	Improve decision-making procedures, replacing consensus decision-making by voting procedures wherever possible	5
31	Strengthen monitoring, control and surveillance, thereby improving detection and enforcement capacity (including legal tools), raising penalties to deterrent levels, and exerting more effectively the responsibilities pertaining to the flag or the port States.	5
32	Improve public awareness, as well as consultation of non-fishery users, taking all interests into account when developing and managing fisheries, improving management transparency and reporting procedures.	5

7.6 Benchmarks for assessment of precautionary management:

It is useful to consider these themes against Justice Preston's analysis of the central elements of the precautionary principle. Reversal of the burden of proof is a critical element, coupled with a need for cautious action. Transferred to a fisheries context, where there is a long history of serious damage occurring in spite of the best intentions of fishery managers, *the precautionary principle dictates that fishing should not occur without evidence that the proposed types, levels, timing and locations of fishing activities will not result in serious harm.* Moreover, the degree of management caution should be proportional to both the magnitude of the possible harm, and the extent of uncertainty. Relevant uncertainties in wild fisheries usually range from high to extreme (refer to the discussion in Chapter 6).

Examining the themes of Table 7.1 in this context, it is apparent that four 'theme groups' emerge. Themes 1-7 deal with the burden of proof, and assessing the degree of uncertainty and the degree of possible harm. Themes 8-14 refer to operational aspects of applying caution – specifically the use of pre-agreed decision rules linked to reference points. Themes 15-20 relate to the collection, sharing and use of evidence. The remaining themes (21-32) refer to broad 'good governance' approaches, most of which have fairly obvious application in situations of uncertainty where history has shown serious damage occurring in the face of well-intentioned regulation. There is a clear implication within several of these themes that management strategies need both prior-implementation assessment, and post-

implementation evaluation. Such an approach is explicit within adaptive management, which is listed as theme 27.

Workable benchmarks for evaluating the extent to which fishery management agencies have adopted the precautionary approach need to be fairly explicit – vague generalities are not useful in this context. Benchmarks should be such as to rest on explicit elements in management policy, or preferably specific elements in program budgets or outcome reports. Six benchmarks have been proposed in Chapter 8 below for the assessment of agency adoption of ecologically based fisheries management, however here I propose nine benchmarks resting on the themes identified above.

A fisheries management program will be identified as incorporating the precautionary approach if:

- a) All legal fishing activities have prior management authorization, and are subject to periodic review.
- b) Management strategies and plans contain clear objectives, indicators and performance targets relating to the protection of: target stocks, populations of dependent and associated species, and habitat
- c) Fishery management plans use pre-agreed decision rules based partly on limit reference points equivalent to, or more conservative than, both target stock MSY and bycatch population MSY for the most vulnerable species of bycatch.
- d) Alternative management programs are assessed before program implementation, and management program effectiveness is subject to post-implementation evaluation.
- e) Undesirable outcomes which could result from excessive fishing pressures are identified, and monitoring programs are in place with sufficient power to rapidly detect these changes should they occur.
- f) Controls are in place to limit fishing capacity commensurate with the productive capacity of the resource.
- g) The risks to ecosystem health and integrity are assessed for each major fishery, and additional caution applied to management programs for high-risk fisheries.
- h) Independent peer review is used as quality assurance for major management policies, strategies and plans.
- i) Management procedures provide for rapid response in the light of unexpected declines in target stocks, bycatch populations, or habitat value. Such provisions provide for fisher compensation where necessary.

Some of these benchmarks will not be used in the agency evaluation program. Benchmark a) is similar to EBFM Benchmark 1) so will not be used. Benchmark d) overlaps with EBFM Benchmarks 1) and 2), so will not be used. Benchmark f) may prove difficult to evaluate in practice, so will not be used.

7.7 Benchmark summary:

My wider examination of the three core “approaches” has, on the basis of a literature review, identified the main elements of adaptive management, and the ecosystem and precautionary approaches, as they apply to fisheries (Chapters 7, 8 and 9). In relation to the precautionary principle, six benchmarks are identified, as follows:

Table 7.2 Benchmarks for the precautionary approach:

A1	Management strategies and plans contain clear objectives, indicators and performance targets relating to the protection of: target stocks, populations of dependent and associated species, and habitat.
A2	Fishery management plans use pre-agreed decision rules based partly on limit reference points equivalent to, or more conservative than, both target stock MSY and bycatch population MSY for the most vulnerable species of bycatch.
A3	Undesirable outcomes which could result from excessive fishing pressures are identified, and monitoring programs are in place with sufficient power to rapidly detect these changes should they occur.
A4	The risks to ecosystem health and integrity are assessed for each major fishery, and additional caution applied to management programs for high-risk fisheries
A5	Independent peer review is used as quality assurance for major management policies, strategies and plans.
A6	Management procedures provide for rapid response in the light of unexpected declines in target stocks, bycatch populations, or habitat value. Such provisions provide for fisher compensation where necessary.

Each benchmark will be scored as follows:

- 0 – no evidence of policy or implementation;
- 1 – policy in place; no significant implementation at this stage;
- 2 – policy in place; evidence of partial implementation;
- 3 – policy in place; evidence of substantial implementation.

Endnotes:

⁶¹ Cooney (2004) discusses early application of the principle in the recommendations of the ministerial conferences on North Sea pollution in the late 1970s, which explicitly acknowledged the need to reverse the onus of proof. See also the discussion in Dayton 1998.

⁶² United Nations Conference on the Environment and Development, Rio, 1992.

⁶³ Convention on the Conservation of Antarctic Marine Living Resources 1980.

⁶⁴ The full title is seldom used: *Agreement for the Implementation of Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks 1995*.

⁶⁵ Including the 200 nautical mile Exclusive Economic Zone, and, where declared, the extended 350 nm zone over Australian continental shelf.

⁶⁶ Australia has a three-tiered government structure – Commonwealth (Australian), State/Territory, and Local (Municipal).

⁶⁷ The purpose of the Offshore Constitutional Settlement (OCS) is to provide a single responsible jurisdiction for fisheries which overlap Commonwealth and State jurisdictions. About 140 OCS Agreements are in place.

⁶⁸ The Australian Capital Territory's *Environment Protection Act 1997* section 2(2a) defines the precautionary principle: "that if there is a threat of serious or irreversible environmental damage, a lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation."

⁶⁹ See, for example, the Australia's *National Strategy for Ecologically Sustainable Development 1992*, and the *InterGovernmental Agreement on the Environment 1992*. Kriwoken et al. (2001) discuss other national and state examples of endorsement of the principle.

⁷⁰ See, for example, Justice CJ Preston (2006) *Telstra Corporation Limited v Hornsby Shire Council*, New South Wales Land and Environment Court 133, 24 March 2006, para 161.

⁷¹ In FAO (2005b), implementation of the precautionary approach amongst regional fisheries management organisations was reviewed. While most of the responding organisations (about half of those approached in the survey) indicated they endorsed the precautionary approach, only two organizations were able to name precautionary strategies in current use.

8. Ecologically based fisheries management: assessment benchmarks.

8.1 Preface:

The place of ecologically based fisheries management (the 'ecosystem approach') within the development of fishery industry paradigms has been discussed in Chapters 1, 4 and 5. The purpose of the discussion in this chapter is to provide a brief overview of ecologically based fisheries management (EBFM)⁷², to identify the essential elements of the approach applicable to practical fishery management from a literature review, and to use these elements to formulate testable EBFM benchmarks by which a fisheries management program can be judged.

8.2 Fundamental concepts:

The ecosystem approach grew from the disciples of ecology and conservation biology, combined with a little management theory. The word *ecology* is derived from the Greek *oikos*, meaning 'house' or 'place to live', and *logos* 'knowledge'. Literally, ecology is the study of organisms 'at home'. A Webster's Dictionary definition is "*the study of the totality or pattern of relations between organisms and their environment*". The term (oekologie) was first used by the German biologist Ernst Haeckel in 1866; however the first significant textbook on the subject, and the first university course, was written by the Danish botanist Eugenius Warming in 1909 (Wikipedia 22/6/08). While Warming is often identified as the founder of ecology, the science owes much to important figures in the mid-twentieth century, such as Eugene Odum. Odum's major textbook 'Fundamentals of Ecology' is still in use today (Odum 1971). Odum defined an *ecosystem* as:

a unit that includes all of the organisms (ie: the "community") in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity, and material cycles (ie: exchange of materials between living and nonliving parts) within the system.

This definition of an ecosystem raises an immediate issue which is important in all attempts at ecosystem management: where does an ecosystem start and end? Even in situations which seem to provide distinct natural boundaries, such as a catchment, lake or estuary, there are clearly flows of organisms and materials which cross these boundaries. Within extended coastal waters, bioregions may be roughly defined as areas containing repeating patterns of similar ecosystems (Commonwealth of Australia 2005a). Ken Sherman has been instrumental in promoting the concept of 'large marine ecosystems' spatially defined by ocean basin topography, currents, upwellings and fronts (Sherman & Alexander 1986). Despite the shortcomings of the 'ecosystem' concept, it has proved of great use to scientists and managers, and provides the foundation for ecosystem based fisheries management.

8.3 Ecosystem based management:

Ecosystem based management, although in use in one form or another for the best part of a century, remains an evolving concept. Grumbine's seminal essay (Grumbine 1994) provides important historical perspective. The Ecological Society of America actively promoted important elements of the ecosystem approach from the early 1930s. People such as Aldo Leopold were influential in promoting and popularising the concept in the 1940s. "By the late 1980s an ecosystem approach to land management was being supported by many scientists, managers and others" (Grumbine 1994:28).

Importantly, the concept appeared for the first time in a major international agreement – and related to marine management – in 1980. The *Convention on the Conservation of Antarctic Marine Living Resources* (CCAMLR) Article II(3) defined three "principles of conservation", of which the second and third principles identify the need for harvesting management to (a) protect entire ecosystems, and (b) take a cautious approach to ecological risk, particularly with regard to irreversible effects. The boundaries of the Convention were – appropriately –

defined by the approximate location of the Antarctic Polar Front (otherwise known as the Antarctic Convergence, at about 50° south) which provides a rough natural boundary for the Antarctic large marine ecosystem.

Grumbine's 1994 paper is important for a number of reasons, not least of which is his thoughtful discussion of the social and governance implications of the ecosystem approach. He suggested a definition:

Ecosystem management integrates scientific knowledge of ecological relationships within a complex socio-political and values framework toward the general goal of protecting native ecosystem integrity over the long term (Grumbine 1994:31).

Grumbine identified five 'ecosystem management goals' which, he pointed out, "provide a striking contrast to the goals of traditional resource management" (Grumbine 1994:31). These are to:

- maintain viable populations of all native species in situ;
- represent, within protected areas, all native ecosystem types across their natural range of variation;
- maintain evolutionary and ecological processes;
- manage over periods of time long enough to maintain the evolutionary potential of species and ecosystems; and
- accommodate human use and occupancy with these constraints.

Grumbine's extensive literature survey included few marine examples of either advocacy or implementation of the ecosystem approach. His finding that the perspectives of the US Forest Service (on the subject of the ecosystem approach) were narrow and production-oriented may perhaps come as no surprise. A similar finding might be expected in comparing the perspectives of fisheries management agencies with those of academic ecologists – or indeed the public at large. Grumbine found: "... in the academic and popular literature there is general agreement that maintaining ecosystem integrity should take precedence over any other management goal" (1994:32). This concept has been echoed in policy formulation down the years. Pikitch et al. (2004:346) echo this idea with respect to fisheries when they advocate exploitation "without compromising the ecosystem." Australia's *Oceans Policy* (1998:19) states: "...priority should be given to maintaining ecosystem health and integrity". The reality of fisheries management, however, often runs directly counter to such clear statements of policy intent (see case study chapters, especially 11 and 12).

Grumbine explored the long-term implications of the ecosystem approach in the context of changing social values and institutions. He argued (1994:34) that the comprehensive application of the ecosystem approach will "not only help reduce our negative impact on the biosphere, but will also give us the opportunity to reinterpret our place on the planet as one species amongst many. Protecting ecological integrity becomes the ultimate test of whether people will learn to fit in with nature. Thus, ecosystem management gains importance far beyond finding new ways to manage parks and forests" – and, I would add, oceans. This observation of the ethical importance of the ecosystem approach should not be lost sight of, and, I believe, is as critical for ocean ecosystems as it is for those of terrestrial and freshwater environments. Ethical issues are addressed in more detail in Chapter 3 of this thesis.

8.4 Ecosystem based fisheries management:

Grumbine provided a historical overview and a status report of the concept of ecosystem based management as it had evolved to 1994. Since then (and especially since 2000) a number of publications have appeared dealing specifically with the application of the concept to fisheries management. Moreover, growing public awareness of the biodiversity crisis, and the likely negative impacts of climate change on what remains of the natural world, has prompted the endorsement of the ecosystem approach in important international and national policy statements. A brief summary follows (for details see Chapter 5 on international agreements).

At the international level, the *Convention on Biological Diversity 1992* (CBD), through the related Jakarta Mandate⁷³, explicitly promotes the application of the ecosystem approach to the marine environment. The *FAO Code of Conduct for Responsible Fisheries 1995*, although not mentioning the ecosystem approach by name, does require complying nations to adopt several key elements of the approach⁷⁴ (see Table 8.1 below – note that implementation of the Code's provisions is voluntary for endorsing nations). The Implementation Plan of the *World Summit on Sustainable Development 2002* requested endorsing nations to implement the ecosystem approach to fisheries management by 2010. Each year the *United Nations General Assembly* (UNGA) meets to consider pressing global issues. For the last several years, the twin UNGA resolutions dealing with fisheries, and with the Law of the Sea, have endorsed the ecosystem approach, and urged its rapid implementation. Australia has ratified the CBD, supports the FAO Code of Conduct, the WSSD Implementation Plan, and has supported all recent UNGA fisheries resolutions.

International endorsement of the ecosystem approach is reflected in core Australian national policy. The *National Strategy for the Conservation of Australia's Biological Diversity* (Commonwealth of Australia 1996) requires the implementation of the ecosystem approach, including within fisheries management. All Australian jurisdictions endorsed this Strategy. *Australia's Oceans Policy 1998* (Commonwealth of Australia 1998) did not receive the same wide jurisdictional endorsement; nevertheless it too requires the implementation of the ecosystem approach to oceans management. The concept of ecosystem management lies behind the regional planning approach promoted by the Oceans Policy, where the planning boundaries coincide, as far as practical, with the boundaries of identified (provisional) Australian marine bioregions.

There is no doubt that the Australian Government, at least on paper, is strongly committed to the application of the ecosystem approach within fisheries.

Within these documents, and within academic papers which seek to clarify, elaborate and define ecosystem based fisheries management, key themes emerge. Overall, these themes are not unlike the themes Grumbine identified in 1994 – as you might expect. They do, however, add detail important in defining the way the approach may be applied to the marine environment. These themes are listed in Table 8.1 below, tabulated with the references of my literature review. Note that reference codes in bold refer to documents which deal specifically with EBFM or EBM.

As with EBM, choosing a definition for EBFM from amongst the many available is a matter of personal preference. A simple statement of purpose is useful:

the overall objective of ecosystem based fishery management is to maintain and restore healthy ecosystems, and the fisheries they support (after Pikitch et al. 2004:346).

8.5 Literature review: what defines EBFM?

Major reviews of EBFM have been published over the last few years. The two theme sections in *Marine Ecology Progress Series* (Browman et al. 2004, 2005) contain the views of over 40 senior marine scientists. An important paper published in *Science* by Pikitch et al. (2004) contains the views of 17 senior marine scientists. Major organizations have published reviews, such as the FAO EBFM guidelines (Garcia et al. 2003), the review by the Secretariat to the Convention on Biological Diversity (CBD-ES 2000), as well as the review by the Ecosystem Approach Task Force (EATF 2003). The United Nations General Assembly has also considered the ecosystem approach in a number of its recent reviews (see especially UNGA 2006 A/61/105,156). The American Association for the Advancement of Science has published a major consensus statement (AAAS 2005). Several important papers on the subject have appeared in the scientific literature, as well as reviews sponsored by NGOs (eg: Cripps et al. 2001) and by governments (eg Ward & Hegerl 2003).

I believe I have included all major papers dealing with EBFM published since 2000, however my literature review is not comprehensive, as several minor papers (eg Vierros et al. 2006) have been omitted due to time constraints.

Broadly, the papers selected fall into two groups: (a) those focussed on EBM or EBFM, and (b) more general papers containing substantive discussion of EBFM. There are 18 references in the first category and 10 in the second. Most were published in the period 2000 to 2008.

The papers were searched for themes stated by the authors as characteristic of EBFM. Forty themes were found, as set out in Table 8.1. The associated references are listed in Table 8.2.

Of these themes, 18 deal with 'good governance', ten with 'ecological processes', six with ecosystem structure, four with evolutionary processes, and two with ocean zoning. If these themes characterise EBFM, a definition drawn from them might read:

Ecological based fisheries management is management based on a variety of modern good governance principles and approaches (including ocean zoning), aimed at rebuilding and maintaining the health of ecosystems and their dependent fisheries, principally through safeguarding ecological and evolutionary processes, and ecosystem structure.

A glance at the 'good governance' themes (D1-D18 in Table 8.1) shows that many of these themes are governance approaches which have evolved separately from ecosystem based management. Of the eighteen themes, ten are very broad, containing no reference to fisheries, oceans, or even ecosystems – they are simply drawn from modern governance approaches. In my view, the 'larger' of these themes, such as the precautionary and adaptive approaches, are in fact best discussed quite separately from EBFM, as they are complex and important approaches in their own right. While I do not agree with their inclusion in a characterization of EBFM, my view is clearly out of favour: the precautionary approach is one of the most commonly listed characteristics of EBFM, with adaptive management not far behind (Table 8.1).

Of the twenty-four themes which are strongly related to ecosystems (theme groups A, B and C, as well as D7, and D10-12 in Table 8.1) some are fairly general (eg: A9, protect from pollution). Such themes are probably of little use in developing EBFM benchmarks – all agencies or national governments apply pollution control in one form or another. However other themes are more specific. The themes of 'protect habitat' or 'report ecosystem indicators' seem potentially more useful in attempts to assess the extent to which a fishery agency is actually implementing EBFM.

The issue of developing indicators and reference points from explicit ecosystem objectives is discussed in a number of papers. Gislason et al. (2000:471) suggest that *ecosystem objectives* should include:

- maintenance of ecosystem diversity;
- maintenance of species diversity;
- maintenance of genetic variability within species;
- maintenance of directly impacted species;
- maintenance of ecologically dependent species;
- maintenance of trophic level balance.

Once objectives have been chosen, indicators and reference points can be selected for the six potential ecosystem objectives. Gislason et al. (2000:471) comment: "There is a need to reconstruct our image of historical conditions of marine ecosystems in a scientific manner, in order to define accurate reference points." They suggest:

Table 8.3

Examples of ecosystem objectives, indicators and reference points for ocean zones

Objective	Indicator	Reference point
Maintenance of:		
Ecosystem diversity	Areas of shelf disturbed by fishing.	% of each habitat type undisturbed.
Species diversity	Abundance of species at risk. Area of distribution.	Maximum annual bycatch. % of distribution area relative to period of moderate abundance.
Species genetic variability	Number of spawning populations. Selection differentials.	% reduction in spawning areas. Minimum selection differential.
Directly impacted species	Fishing mortality. Spawning stock biomass. Area of distribution.	$F_{0.1}$ Minimum stock biomass for safeguarding recruitment and forage. % of distribution area relative to period of moderate abundance.
Ecologically dependent spp.	Abundance of predator. Condition of predator. % of prey species in predator diet.	Minimum predator abundance. Minimum predator condition. Minimum % in predator diet.
Trophic level balance	Slope of size spectrum. Pauly's FIB index (Pauly et al. 2000). Aggregate annual removals for each trophic level.	Minimum slope. Minimum Fishery Is Balanced index. Maximum % removals.

Source: Gislason et al. (2000:471)

8.6 Selecting EBFM benchmarks:

The point of this section is to decide on benchmarks which can be used to assess the extent to which a fishery management agency is actually implementing an ecosystem based approach to management. Examining agency policy may not be helpful in this regard, as there may be a substantial time lag between accepting a policy and implementing it.

My proposal is to select six benchmark indicators so as to provide a graduated scale of agency EBFM implementation. Two indicators would target information only likely to be found in agencies with advanced EBFM programs. Two more would target information likely to be found in most agencies, even those just starting on an EBFM program track. The final two indicators would sit somewhere in the middle.

All benchmarks should rest on evidence of a tangible nature, such as elements in a program budget, or agency reports. This rules out the use of several themes listed in Table 8.1, such as A9 (too vague) or A10 (open to wide interpretation). My selection (based simply on judgement exercised within the above constraints) are:

Basic EBFM implementation:

Benchmark 1: D7: is there formal periodic assessment of the impacts of particular fisheries against agreed objectives, including ecosystem-based objectives?

Benchmark 2: D11: is there monitoring and reporting of agreed ecosystem indicators based on stated ecosystem objectives?

Alternative basic benchmarks might be developed from themes A3, A7, or A8 – all fairly basic approaches already widely implemented.

Intermediate EBFM implementation:

Benchmark 3: A5/6: has the agency a substantial program in mapping, protecting and monitoring critical and vulnerable habitats?

Benchmark 4: B2: are there effective programs in place to monitor and maintain old-growth age structure in specific fisheries?

Alternative intermediate benchmarks might be developed from themes B3 or B6.

Advanced EBFM implementation:

Benchmark 5: C1: has the agency a substantial program to account for evolutionary change caused by fishing?

Benchmark 6: C3: are there effective programs in place to maintain the spatial extent of all major sub-populations (both target and bycatch), and maintain and monitor population genetic diversity?

There appear to be few other opportunities to develop alternative advanced benchmarks from the themes listed in Table 8.1.

Benchmark summary:

The above discussion has, on the basis of a literature review, identified the main elements of the ecosystem approach, as it applies to fisheries. Six benchmarks are identified, as follows:

Table 8.4 Benchmarks for the ecosystem approach:

B1	There is formal periodic assessment of the impacts of particular fisheries against agreed objectives, including ecosystem-based objectives.
B2	There is monitoring and reporting of agreed ecosystem indicators based on stated ecosystem objectives.
B3	There is a substantial program in mapping, protecting and monitoring critical and vulnerable habitats, funded by the fishery agency or responsible government.
B4	There are effective programs in place to monitor and maintain old-growth age structure in specific fisheries.
B5	The agency has a substantial program to account for evolutionary change caused by fishing.
B6	There are effective programs in place to maintain the spatial extent of all major sub-populations (both target and bycatch) affected by specific fisheries, and maintain and monitor population genetic diversity.

Each benchmark will be scored as follows:

- 0 – no evidence of policy or implementation;
- 1 – policy in place; no significant implementation at this stage;
- 2 – policy in place; evidence of partial implementation;
- 3 – policy in place; evidence of substantial implementation.

Table 8.1 Themes in ecosystem based fisheries management

	Theme	Reference
A1	Ecological processes: identify, value, monitor and seek to maintain ecosystem services	19, 7, 3, 2, 10, 25, 29
A2	Ecological processes: maintain patterns of natural disturbance	16,
A3	Ecological processes: match management boundaries to the scale and location of the ecosystem, through collaborative mechanisms where necessary	14, 15, 16, 27, 28, 19, 8, 7, 6, 3, 2, 10, 1, 25, 29
A4	Ecological processes: map, monitor and protect all natural habitats where possible	16, 15, 26, 7, 4, 3, 2, 10, 1, 25
A5	Ecological processes: map, monitor and protect critical habitats ⁷⁵	20, 14, 15, 25, 29
A6	Ecological processes: map, monitor, and provided special protection for vulnerable habitats	17, 18, 15, 9, 22, 1, 25
A7	Ecological processes: protect biological diversity, including rare, vulnerable, cryptic, and unknown species	15, 14, 19, 21, 22, 13, 27, 7, 6, 2, 10,1
A8	Ecological processes: protect migratory / spawning pathways, including rivers and estuaries	16,
A9	Ecological processes: protect ecosystems from pollution, both land-based and marine	18, 15, 13, 7, 27, 10, 25
A10	Ecological processes: understand and promote resilience of desirable ecosystem states	19, 4, 10, 1, 25
B1	Ecosystem structure: ensure harvesting of target species does not undermine the viability or role of dependent or associated species in the ecosystem: identify and monitor impacts	6, 7, 14, 27, 4, 3, 2, 10, 1, 25, 29
B2	Ecosystem structure: maintain old-growth age structure in fish populations	4, 1, 25
B3	Ecosystem structure: maintain the role and proportion of natural trophic levels, and material flows	15, 9, 27, 7, 6, 4, 10, 1, 25
B4	Ecosystem structure: maintain the role of keystone species	15, 27
B5	Ecosystem structure: seek to restore degraded ecosystems	15, 10, 25
B6	Ecosystem structure: top-down control: special protection (and restoration) for large predators	18, 10
C1	Evolutionary processes: account for evolutionary change caused by fishing	4, 1, 25
C2	Evolutionary processes: avoid accidental or deliberate introduction of alien species	14,
C3	Evolutionary processes: maintain spatial extent of all sub-populations, and population genetic diversity	16, 6, 4, 3, 29
C4	Evolutionary processes: use long-term management horizons	16, 13, 19, 7, 10, 1, 25

Table 8.1 Themes in ecosystem based fisheries management, continued

	Theme	Reference
D1	Good governance: declare a formal 'duty of care' towards ocean health – including government, corporations, and individuals	13,
D2	Good governance: account for, and manage the cumulative impacts of incremental activities	15, 13, 10, 25
D3	Good governance: apply the precautionary approach	24, 9, 14, 26, 7, 27, 4, 2, 10, 1, 25
D4	Good governance: data-sharing: eg: vulnerable habitats, IUU fishing, straddling, migratory,	18, 14, 26, 1
D5	Good governance: enhance equitable benefit sharing	19, 5,
D6	Good governance: ensure appropriate stakeholder consultation and involvement	19, 5, 4, 3, 2, 16, 1, 25
D7	Good governance: formal assessment of the impacts of fisheries against benchmarks	24, 13, 25, 19, 7, 6, 1, 25
D8	Good governance: harvesting impacts: minimise bycatch, discards, habitat gear damage	14, 13, 7, 6, 5, 1, 25
D9	Good governance: management should be decentralised to the lowest appropriate level	19,
D10	Good governance: state management objectives and constraints clearly: include explicit ecosystem objectives	8, 7, 6, 2, 1, 25
D11	Good governance: monitor and report agreed ecosystem indicators based on stated objectives	13, 9, 19, 14, 7, 3, 2, 10, 1, 25
D12	Good governance: question basic assumptions especially with respect to ecosystem stability over time	4, 2,
D13	Good governance: take uncertainty into account, use active adaptive management	26, 19, 8, 7, 5, 4, 2, 29
D14	Good governance: use best available knowledge, including traditional and fisher knowledge	15, 13, 21, 26, 28, 19, 7, 2, 10, 25
D15	Good governance: use incentives wherever practical to complement restrictions	26, 19, 1, 25
D16	Good governance: use independent peer review routinely for important assessments	6,
D17	Good governance: use risk assessment to focus conservation measures	24, 2
D18	Good governance: reduce fishing overcapacity, ensure policy transparency, accountability, conflict resolution and adequate enforcement and compliance monitoring.	5, 4, 3, 2, 1, 25
E1	Ocean zoning: use protected areas: MPAs for biodiversity conservation	16, 12, 19, 15, 21, 13, 9, 23, 6, 2, 10, 1, 25
E2	Ocean zoning: use protected areas: MPAs for fisheries enhancement	12, 19, 14, 9, 23, 6, 2, 10, 1, 25

References marked in bold deal principally with defining and elaborating EBFM; remaining references contain substantial discussion of EBFM.

Codes marked in bold refer to aquatic (marine or freshwater) environments.

Table 8.2: References:

1	Browman, HI, Cury, P, Hilborn, R, Jennings, S, Lotze, HK, Mace, PM, Murawski, SA, Pauly, D, Sissenwine, MP, Stergiou, KI & Zellar, D (2004) 'Perspectives on ecosystem-based approaches to the management of marine resources', <i>Marine Ecological Progress Series</i> , vol. 274, pp. 269-303.
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3	EATF Ecosystem Approach Task Force (2003) <i>Strategic guidance for implementing an ecosystem-based approach to fisheries management</i> , NOAA, Silver Spring MD.
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10	AAAS American Association for the Advancement of Science (2005) <i>Scientific consensus statement on marine ecosystem-based management</i> , AAAS, viewed July 12 2007, < www.aaas.org/publications/ >.
11	Ward, TJ (2000) 'Indicators for assessing the sustainability of Australia's marine ecosystems', <i>Marine and Freshwater Research</i> , vol. 51, no. 5, pp. 435-46.
12	Ward, TJ & Hegerl, E (2003) <i>Marine protected areas in ecosystem-based management of fisheries</i> , Department of the Environment and Heritage, Canberra.
13	Commonwealth of Australia (1998) <i>Australia's oceans policy</i> , Department of the Environment and Heritage, Canberra.
14	FAO Food and Agriculture Organisation (1995) <i>Code of conduct for responsible fisheries</i> , Food and Agriculture Organisation of the United Nations, Rome.
15	UNGA United Nations General Assembly (2006) <i>Assembly paper A/61/156</i> , UNGA, New York.
16	Grumbine, RE (1994) 'What Is Ecosystem Management?' <i>Conservation Biology</i> , vol. 8, no. 1, pp. 27-38.
17	UNGA United Nations General Assembly (2006) <i>Assembly paper A/61/222</i> , UNGA, New York.
18	UNGA United Nations General Assembly (2006) <i>Assembly paper A/61/105</i> , UNGA, New York.

Table 8.2: References, continued:

19	CBD-ES Executive Secretary of the Convention on Biological Diversity (2000) <i>Conference of the Parties meeting 5, Nairobi, Decision 23</i> , CBD Secretariat UNEP/CBD/COP/5/23, Ottawa Canada (to be read in conjunction with the CBD 'Jakarta Mandate' 1995).
20	UNGA United Nations General Assembly (2008) <i>Assembly paper A/63/63</i> , UNGA, New York.
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29	Brodziak, J & Link, J (2002) 'Ecosystem-Based Fishery Management: what is it and how can we do it?' <i>Bulletin of Marine Science</i> , vol. 70, pp. 589-611.

Reference (codes) marked in bold deal principally with defining and elaborating EBFM; remaining references contain substantial discussion of EBFM.

Endnotes:

⁷² In this paper the term 'ecosystem approach' is synonymous with 'ecosystem based management', or 'ecosystem management'. The later term can be disputed on the grounds that humans do not understand ecosystems sufficiently well to be said to be able to 'manage' them (see Chapter 6 on uncertainties in fishery management).

⁷³ Decision II/8 of the CBD Conference of the Parties (CoP) (Jakarta 1995) states in part: "... the ecosystem approach should be the primary framework of action to be taken under the Convention [on Biological Diversity]."

⁷⁴ See, for example, Articles 6.1, 6.2 and 6.8 of the FAO Code.

⁷⁵ Critical habitats include, generally, spawning sites, corals, mangroves, estuaries, breeding rivers, seamounts, seagrass, mudflats, wetlands, hydrothermal vents, cold seeps.

9. Active adaptive management in fisheries: assessment benchmarks

9.1 Introduction:

The place of adaptive management (the 'adaptive approach') within the development of fishery industry paradigms has been briefly discussed in Chapters 1, 4 & 5. The purpose of the present discussion is to provide a brief overview of the logic of adaptive management, to identify the essential elements of the approach as applied to practical fishery management, and to formulate testable benchmarks by which an agency program can be judged.

It is immediately necessary to distinguish between (a) passive adaptive management – sometimes called the 'monitor and modify approach', or 'learning by doing', and (b) active adaptive management. Active adaptive management is most applicable to the management of natural resources where small scale experimentation is either impractical or impossible. In this situation knowledge about the way the target ecosystem operates can be gained only by: (a) deduction from prior knowledge of the ecosystem's components, or (b) experience with similar ecosystems elsewhere, or (c) by using opportunities provided by optional management strategies in a conscious attempt to gain information critical to long-term management goals. This latter approach is active adaptive management. Within this thesis the term 'adaptive management' is used to encompass both active and passive adaptive management.

Active adaptive management in fisheries rests on a combination of three elements: the principle of quality assurance, coupled with mathematical modelling (particularly to investigate the effects of errors, uncertainties, and alternative management strategies), together with an intent to seek information from thoughtful management choices. Active adaptive management is management which consciously and thoughtfully seeks to learn from experience.

The principle of quality assurance, now familiar to many people through the International Standards Organisation ISO 9000 and ISO 14000 series of standards, postulates that agreed outcomes (quality) are achieved through a cyclic process which sets goals, monitors the achievement of these goals, and reviews both goals and operating procedures in the light of the results. Figure 9.1 portrays the process:

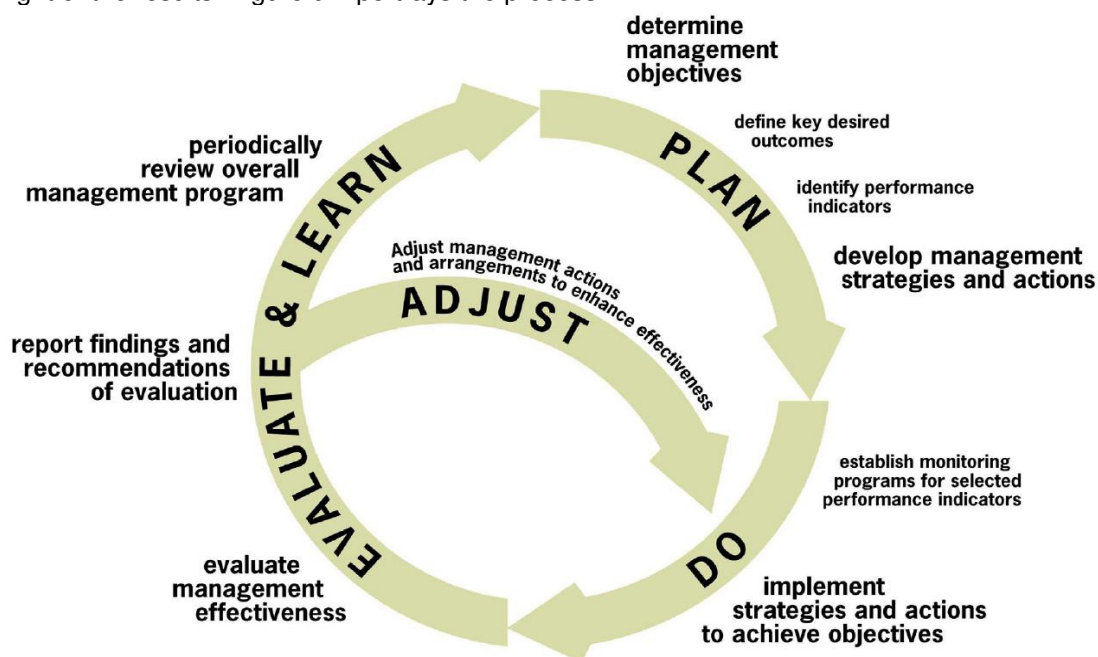


Figure 9.1: The QMS/EMS planning cycle. Source: Jones (2005)

The ISO 9000 (Quality Management System QMS) and ISO 14000 (Environmental Management System EMS) standards in practical use describe the system, organizational structure, procedures and resources that companies use to control processes and activities in order to produce a product or service of consistent quality. The EMS standard extends the essential logic of the QMS standard to a company's environmental performance, so as (in theory) to minimize the impact of the company's activities and products on the environment. The QMS standard incorporates the principle of continual improvement – which states that, as the cycle progresses over time, opportunities will arise (and should be taken) which will enable improvement in the 'quality' of the company's goods and services. A third important principle, underpinning the EMS standard, is that of 'producer responsibility' – a company should take responsibility for the environmental impacts of its products over their life cycle (often long after they have left the direct control of the company).

While the application of the quality assurance approach to, say, the manufacture of a small physical object (like a plastic drink container) is relatively straight-forward, this is not the case when applying the approach to the management of natural resources, such as forestry or fisheries. The extension of adaptive management to natural resources was pioneered by Crawford Holling, Carl Walters and Ray Hilborn in the 1970s.

To a large extent natural ecosystems are, and are likely to remain in the foreseeable future, highly unpredictable (Chapter 6). This is less the case with forestry, where small area trials can be conducted which will allow experimentation with key parameters, and the investigation of the effects of management options which may be widely applicable. However capture fisheries, in general, do not lend themselves to such experiments.

While the study of fish biology and ocean ecology has provided much insight into the possible ways in which large scale ecosystems might respond to fishing pressures, the very substantial uncertainties which remain preclude accurate predictions (Chapter 6). In this context adaptive management seeks to gather information which will be useful in informing future management decisions.

As computers became faster and more accessible in the later decades of the twentieth century, fisheries management turned increasingly to quantitative models in an attempt to predict the response of marine ecosystems to alternative harvesting policies. However, as Walters observed: ...“model building has not been particularly successful, and it keeps drawing attention to key uncertainties which are not being resolved through normal techniques of scientific investigation” (Walters 1986:vii). In opening his (now classic) book on the *'Adaptive management of renewable resources'* Walters sets out his view on the essential rationale for active adaptive management (Walters 1986:vii):

[A] basic issue becomes whether to use management policies which deliberately enhance the [management] experience. Such policies would represent a radical departure from traditional prescriptions about how to deal with uncertainty... My basic theme is that management should be viewed as an adaptive process: we learn about the potentials of natural populations to sustain harvesting mainly through experience with management itself, rather than through basic research or the development of general ecological theory.

My major conclusion is that actively adaptive, probing, deliberately experimental policies should indeed be a basic part of renewable resource management. The design of such policies involves three essential ingredients:

- mathematical modeling to pinpoint uncertainties and generate alternative hypotheses;
- statistical analysis to determine how uncertainties are likely to propagate over time in relation to policy choices; and
- formal optimization combined with game playing to seek better probing choices.

Walter expands these ingredients when he writes about four basic issues involved in the *application* of active adaptive management, which are (Walters 1986:8):

1. bounding of management problems in terms of explicit and hidden objectives, practical constraints on actions, and the breadth of factors considered in policy analysis;
2. representation of existing understanding of managed systems in terms of explicit models of dynamic behaviour, that spell out assumptions and predictions clearly enough so that errors can be detected and used as a basis for further learning;
3. representation of uncertainty and its propagation through time in relation to management actions, using statistical measures and imaginative identification of alternative hypotheses (models) that are consistent with experience but might point towards opportunities for improved productivity [here Walters appears to mean management performance]; and
4. design of balanced policies that provide for continuing resource production while simultaneously probing for better understanding and untested opportunity.

Walter also made important recommendations on the place of models within the general active adaptive approach. In particular, he recommended thinking carefully at the start of the exercise about what products the analysis should produce:

It has been taken for granted by too many analysts that the ultimate goal should be detailed and quantitative predictions about the future of the system. But in practice such predictions are seldom examined very carefully or taken seriously by the actors involved in decision making. [T]he key product should usually be a small set of strong (robust) qualitative arguments and conclusions that can be understood and debated by actors without quantitative skill. Each step in the analysis (and each proposal for data gathering) should be first examined in terms of its likely contribution to qualitative arguments (Walters 1986:36).

The application of active adaptive management to natural resource management should, according to Walters & Holling (1990:2063) involve the statement of an explicit hypothesis (or hypotheses). The authors also observe that the best policy "is to make a fairly dramatic and informative experimental disturbance; minor experiments are not favoured because they erode average performance without significantly improving learning rates (Walters & Holling 1990:2063).

The detection of small effects is extremely difficult in the highly variable ocean environment: Peterman (1990) has emphasised that managers must consider the size of detectable effects when evaluating alternate hypotheses. Peterman's discussion underlines the importance of the use of power analysis in statistical tests, in combination with the more commonly used likelihoods (Chapter 6).

Over the years active adaptive management techniques, under the definition used by its early founders, has been widely accepted as an important element in effective natural resource management – if frequent references to the need for the approach in scientific literature can be used as a measure of acceptance⁷⁶. Provision for adaptive management has, for example, been formally included in major north American forest plans (Stankey et al. 2005). However academic support has often been echoed by lip-service endorsement within management agencies, and even associated research institutions. The practical implementation, and indeed the assessment of the technique against more traditional approaches, has met with resistance. Writing a decade after publication of his seminal book on the subject, Walters (1997:1) wrote: "*Research and management stakeholders have shown deplorable self-interest, seeing adaptive policy development as a threat to existing research programs and management regimes, rather than as an opportunity for improvement*" (emphasis added). An application where adaptive management has been used with at least some success is the artificial flooding of the Grand Canyon (Walters et al. 2000).

9.2 Adaptive management in the OMP and MSE approaches:

The growing popularity of the Operational Management Procedure (OMP) approach, as well as the very similar Management Strategy Evaluation (MSE) approach over the last decade (Butterworth 2007, Smith et al. 2007, Butterworth & Punt 2001, Smith et al. 1999) rests substantially on the ability of these approaches to incorporate both adaptive and precautionary principles. The approaches, however, are defined more by their use of a suite of models, and the specific inclusion of fisher behaviour and fisher participation, than they are by precaution or adaption – these factors must be consciously included in the use of the MSE/OMP approaches in determining harvest requirements. Smith et al. 1999:971 describe the MSE approach:

Management strategy evaluation (MSE) involves assessing the consequences of a range of management strategies or options and presenting the results in a way that lays bare the trade-offs in performance across a range of management objectives. A key feature of the approach is that it does not seek to prescribe an optimal strategy or decision. Rather, it seeks to provide decision-makers with information on which to base management choices, given a set of (usually conflicting) objectives. The decision-makers are free to apply their own weightings and risk preferences to alternative objectives.

Smith et al. make a distinction between MSE and the similar OMP approach:

While virtually identical in methods and philosophy, [MSE] is slightly wider in scope, embracing evaluations that do not necessarily deal explicitly with feedback harvest strategies. Also, its purpose is not necessarily to develop an agreed management procedure, but to provide an objective basis for short- or long-term decision-making.

9.3 Adaptive management benchmarks:

If the proposed survey of agency management is to include an examination of the application of adaptive management, benchmarks for adaptive management must be formulated. The following benchmarks rest almost entirely on the work of Walters discussed above:

A management program will be deemed to incorporate passive adaptive management if:

- a) individual fisheries are subject to periodic public review against stated objectives, indicators and performance targets; and
- b) the performance of the management agency itself is subject to independent periodic review against stated objectives, indicators and performance targets.

A management program will be deemed to incorporate active adaptive management if:

- c) it uses mathematical modelling to pinpoint uncertainties and generate alternative hypotheses;
- d) the assumptions behind the models are clearly set out and evaluated;
- e) the reports incorporating the use of adaptive management set out the bounding of management problems in terms of explicit and hidden objectives, and practical constraints on actions;
- f) the use of adaptive management specifically explores key uncertainties and their propagation through time in relation to management actions, using statistical measures and imaginative identification of alternative hypotheses;
- g) there are changes in management controls, designed to test clearly stated hypotheses, which are sufficiently large to reasonably produce detectable effects; the size of these effects must be estimated in advance, and sufficiently powerful field surveys undertaken, and statistically examined to deduce the probabilities of both Type I and Type II errors (Peterman 1990).

- h) formal organizational requirements are established for evaluating and reporting the results of the experimental management strategies, both to managers and stakeholders.

Benchmark a) is similar to EBFM Benchmark B1) (see Chapter 8) so this benchmark will not be used in the proposed agency evaluation. Benchmark f) will not be used as it overlaps to some extent with Benchmarks d), e) and g). The remaining six benchmarks will be used.

9.4 Benchmark summary:

The above discussion has, on the basis of a literature review focusing mainly on the early seminal documents on active adaptive management, identified the main elements of adaptive management, as they apply to fisheries. Six benchmarks are identified, as follows:

Table 9.1 Benchmarks for active adaptive management:

C1	The performance of the fishery management agency itself is subject to independent periodic review against stated objectives, and quantifiable indicators and performance targets.
C2	The management program uses mathematical modelling to pinpoint uncertainties and generate alternative hypotheses.
C3	The assumptions behind the models are clearly set out and evaluated.
C4	Reports incorporating the use of adaptive management set out the bounding of management problems in terms of explicit and hidden objectives, and practical constraints on actions.
C5	There are changes in management controls, designed to test clearly stated hypotheses, which are sufficiently large to reasonably produce detectable effects; the size of these effects is estimated in advance, and sufficiently powerful field surveys undertaken, and statistically examined to deduce the probabilities of both Type I and Type II errors.
C6	Formal organizational requirements are established for evaluating and reporting the results of the experimental management strategies, both to managers and stakeholders.

Each benchmark will be scored as follows:

- 0 – no evidence of policy or implementation;
- 1 – policy in place; no significant implementation at this stage;
- 2 – policy in place; evidence of partial implementation;
- 3 – policy in place; evidence of substantial implementation.

Endnotes:

⁷⁶ Johnson (1999) found 65 papers that used ‘adaptive management’ in their title, abstract or keywords in the Cambridge Scientific Abstracts for the period 1997-98. That search, repeated for the period 2006-07, yielded 243 papers. It would appear that adaptive management has not lost its popularity within the subject matter of scientific journals. However a search for “evaluation of adaptive management” for the period 1978-2008 yielded only two publications – Parkinson (1990) and Walters et al. (2000).

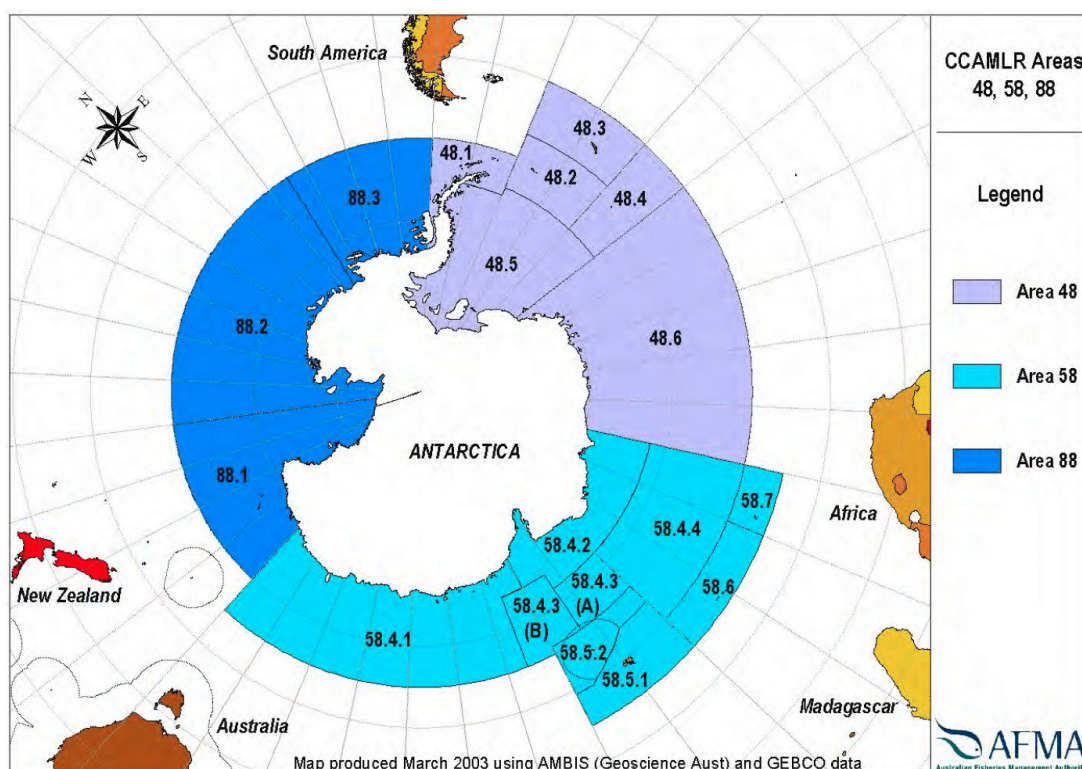
10. Benchmark appraisal: CCAMLR's krill fishery

The purpose of this appraisal is to compare CCAMLR's krill fishery management regime to benchmarks representing key aspects of three broad 'modern' management approaches: active adaptive management, and the precautionary and ecosystem approaches.

Chapter Five discussed the *Convention for the Conservation of Antarctic Marine Living Resources 1980*, which established the legal basis for the Commission. Readers should refer back to this discussion if in need of more detail. Again, a small amount of repetition is preserved here to provide this chapter with coherent flow.

10.1 Background:

Although the concept of ecosystem management has been under discussion for the best part of a century, in many ways the birthplace of the concept as applied to the marine environment lies with the creation of CCAMLR. The concept of ecosystem based management appeared for the first time in a major international agreement in 1980. The *Convention on the Conservation of Antarctic Marine Living Resources 1980* Article II(3) defined three "principles of conservation", of which the second and third principles identify the need for harvesting management to (a) protect entire ecosystems, and (b) take a cautious approach to ecological risk, particularly with regard to 'irreversible' effects. The boundaries of the Convention were – appropriately – defined by the approximate location of the Antarctic Polar Front (the Antarctic Convergence) which provides a rough natural boundary for the Antarctic large marine ecosystem. The administrative boundaries are shown on Map 10.1 below.



Map 10.1 CCAMLR statistical areas. Source: AFMA (2008d:2).

The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) has 24 member States (www.ccamlr.org) active in research and fishing activities, as well as 10 parties without voting rights. The 1980 Convention on the Conservation of Antarctic Marine

Living Resources (the Convention) makes an explicit reference to conservation as its primary objective. This objective (supported by directions under the Convention to apply the ecosystem approach) established⁷⁷ CCAMLR as the world's first regional ocean conservation organisation, as opposed to the more widespread sectorally-focused regional fishery management organisations (RFMOs). CCAMLR is widely held as the most effective regional fishery body globally. Even given its different objective, its performance can be compared with that of RFMOs. Article 2 of the Convention states:

The objective of this Convention is the conservation of Antarctic marine living resources. For the purposes of this Convention, the term 'conservation' includes rational use.

As a consequence of the Convention's objective, the whole of the Area of Competence of CCAMLR, vast as it is, meets the IUCN criteria for a class IV protected area, setting aside for a moment the issue of non-member State fishing.

The Antarctic and sub-Antarctic regions have had a history of unsustainable exploitation, notably of whales, seals, and marbled rockcod (*Notothernia rossii*). Whales are managed by International Whaling Commission (IWC) under the 1946 International Convention for the Regulation of Whaling, and seals are managed under the 1972 Convention for the Conservation of Antarctic Seals. Both of these management frameworks pre-date the Convention.

There are currently significant commercial fisheries in the CCAMLR area for krill, icefish and toothfish. Of these, the krill fishery is currently fished at levels well below estimated sustainable yields, although international interest in the fishery increased markedly in 2007 and 2008. Total krill catch is given in Figure 10.1 – current catch is below the total allowable catch, set in 2008 at over 6 million tonnes (CCAMLR Schedule of Conservation Measures 2008/09 page 143 - 6). Icefish fisheries are fully exploited. However, the estimated total catch of toothfish in CCAMLR waters is higher than the aggregate total allowable catch (TAC) established by CCAMLR.

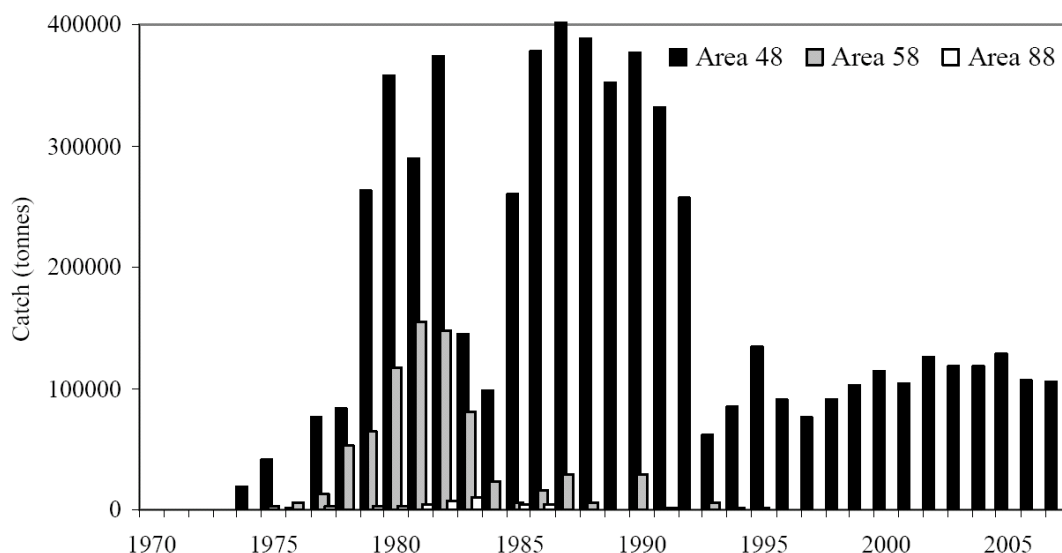


Figure 10.1 Krill catch 1970 - 2007. Source: CCAMLR Statistical Bulletin Vol.20.

There are high levels of compliance with CCAMLR conservation measures for toothfish fisheries by CCAMLR member States, but this is undermined by ongoing and probably unsustainable levels of illegal, unreported or unregulated (IUU) fishing. IUU fishing is predominately carried out by vessels operating under flags of convenience, technically non-member States – and, although accurate catch estimates are not available, IUU fishing is thought to account for an annual catch roughly equal to the legitimate harvest by permitted vessels operating under flags of CCAMLR member States.

According to Larkin (1996) the essential elements of ecosystem-based management (EBM) are:

- sustainable yield in managed fisheries;
- maintenance of ecosystem biodiversity; and
- protection from habitat degradation and pollution.

Assessed by Larkin's three criteria, CCAMLR has maintained the krill fishery at levels below which sustainability is threatened, and appears to have done its best to restrict toothfish and icefish harvests (limited by its budget and issues of international cooperation).

Insufficient data on ecosystem biodiversity are available from the Southern Ocean to evaluate Larkin's second criteria⁷⁸; however biodiversity impacts since CCAMLR's inception are likely to be limited to local damage to ecosystems where excessive exploitation of toothfish has occurred, and seabird bycatch from IUU toothfish and icefish fisheries, that, in combination with longline fisheries to the north of the CCAMLR area, is threatening the existence of some seabird populations and species.

With respect to the third criteria, the key identified risk for habitat destruction arises from bottom trawling. CCAMLR has issued only one exploratory permit for deep water trawling in the last year, and a prohibition applies to trawling in waters less than 550 m in depth. The potential damage to benthic environments so far may be relatively low, even given continued IUU fishing by non-member States, and deep-water trawling for marbled rockcod in some areas in the 1970s. However this issue merits further investigation.

Pollution impacts (putting aside global carbon dioxide issues) have had negligible local and no regional impacts of any significance. The main potential sources of pollution in the CCAMLR area are derived from Antarctic research bases, supply vessels, tourist vessels and fishing vessels. Except for IUU fishing vessels stringent pollution management measures have been implemented under the provisions of the Antarctic Treaty, MARPOL 73/78 and CCAMLR⁷⁹.

Ecosystem-based management approaches have received much attention since Larkin's paper was published in 1996, and his description of the main elements is now seen as simplistic. Pikitch *et al* (2004) provide a more comprehensive discussion in which they describe the main elements extending Larkin's view as:

- a) avoidance of activities with an unacceptable risk of causing irreversible ecosystem change;
- b) explicit use of precaution in setting harvest levels;
- c) harvesting plans should rest within larger ecosystem protection plans;
- d) adaptive approaches to monitoring, management and research, including explicit programs to monitor ecosystem health using ecosystem-based reference points;
- e) ocean zoning, including both temporary and permanent area closures to protect vulnerable habitats, critical habitats of commercial or endangered species, and ecological processes; and
- f) explicit and effective bycatch reduction programs within fisheries.

All of these elements are, or are being, addressed within the CCAMLR management framework.

In relation to point (a), CCAMLR has adopted an explicit policy that no activity will be permitted within the management framework which may have an effect which would not be reversible within 30 years (Constable *et al* 2000, also Article 3 of the Convention). Such a policy, for example, would appear to preclude deep-sea bottom trawling over vulnerable and fragile benthic habitat, where damaged habitat, particularly deep-sea corals, is known to recover extremely slowly.

In relation to point (b), although the Convention does not make a specific reference to the use of precaution, after early failures in controlling the marbled rockcod fishery⁸⁰ within

sustainable limits, CCAMLR adopted a precautionary approach to harvest management which, for example, uses predetermined decision rules relating to target and reference points (Constable 2006; Constable et al. 2000; Kock 2000). CCAMLR now sees precaution as an essential element of its ecosystem approach. FAO recently surveyed implementation of its Code of Conduct for Responsible Fisheries. Of the responding regional organisations, CCAMLR was one of only two organisations able to name a precautionary approach under implementation (FAO 2005b).

In relation to point (c), CCAMLR has developed single-species harvest models resting within simplified multi-species ecosystem models (Constable et al. 2000). CCAMLR has also adopted a philosophy of target reference points explicitly designed to allow for trophic interactions. For example, CCAMLR uses a target reference point for krill, toothfish and icefish of 75% of original biomass, on the argument that the traditional 50% reference point would not provide, in the absence of good information on the workings of the ecosystem, sufficient allowance for predators of the fished population (Constable 2006). This contrasts sharply with the equivalent target reference point currently in use in Australia and New Zealand of 30%.

In relation to point (d), CCAMLR has adopted specific requirements that member States seek permits for exploratory fisheries, and that the issue of such permits carries conditions requiring the collection of core data on catch and bycatch necessary for later ecosystem modelling studies⁸¹ (Constable et al. 2000, Constable 2006). At present, all CCAMLR finfish permits require observers⁸²; krill permits at present do not. CCAMLR has also established an ecosystem monitoring program (Agnew 1997, Constable 2002), which seeks to monitor the health of large ecosystems partly by measuring the health of accessible animal colonies, such as seals and penguins. The program also seeks information on ecosystem function and variability⁸³.

In relation to point (e), CCAMLR has (for more than 15 years) used closed areas or closed fishing seasons to protect habitat or species – under Article IX of the Convention (D. Miller, pers. comm. 4/10/2006). These are relatively small areas. CCAMLR is also developing management zoning based on “small scale management units” to take account of local and regional variation in ecosystem populations and processes (Constable 2006). These are essential to the effective application of fishery management harvest controls. CCAMLR has also adopted a long-term program, which aims to establish a comprehensive, adequate and representative network of marine protected areas (MPAs), partly to protect critical and vulnerable habitats. At this stage bioregionalisation of the CCAMLR area is being undertaken (CCAMLR 2006) to provide a scientific basis for the ultimate development of the MPA network. Given the ambitious nature of CCAMLR’s strategy, it will be several (perhaps many) years before substantial permanent MPAs are established (see further comment below).

In relation to point (f), CCAMLR’s member States have funded both research and operational programs aimed at reducing seabird bycatch (Robertson 2000) and conditions have been placed on member State fishing permits requiring longliners to take a variety of actions to reduce or eliminate seabird capture⁸⁴ (Constable 2006). Elasmobranchs (primarily skates and rays) are also of concern, and will be subject to ongoing study and controls. Both catch limits and ‘move on’ rules apply to all finfish permits in an effort to reduce bycatch (Constable 2006). Regrettably, major seabird bycatch continues north the Area of Competence for CCAMLR and by IUU fishing vessels operating within the CCAMLR area.

CCAMLR faces two major issues. While compliance monitoring and enforcement are requirements in all fisheries, not just EBM fisheries, IUU fishing by non-member States remains a scourge in the CCAMLR area. In this regard, CCAMLR needs a major change to international law⁸⁵ which would allow it sole accreditation rights over all fishing activities – so in the present circumstances better enforcement would solve only part of the problem. Secondly, CCAMLR’s marine protected area program is in a developmental phase and may take several years to progress to an implementation phase.

In summary, CCAMLR appears committed to the application of both the precautionary and ecosystem approaches (Kock 2000:8-9; Parkes 2000). While CCAMLR has not made an

explicit commitment to apply adaptive management, important elements of this management approach are in fact applied.

10.2 Benchmarks:

The benchmarks used below are derived Chapters 7, 8 and 9 above.

Each benchmark is scored as follows:

- 0 – no evidence of policy or implementation;
- 1 – policy in place or partially in place; no significant implementation at this stage;
- 2 – policy in place; evidence of partial implementation;
- 3 – policy in place; evidence of substantial implementation.

Table 10.1: The precautionary approach in the CCAMLR krill fishery:

	Benchmark	Assessment
A1	Management strategies and plans contain clear objectives, indicators and performance targets relating to the protection of: target stocks, populations of dependent and associated species, and habitat.	Score 2.5 Strategies, rather than plans, are particularly strong (Miller 2007:123). Specific targets, for example, relate to the reversibility of fishery-induced change, and the protection of predator/prey relationships. TACs are based on predetermined rules resting on spawning biomass and escapement levels allowing for predation (Miller & Agnew 2000:312). While each fishery has a ‘fishery plan’ (Miller 2007:135) the krill plan (Miller 2003) lacks both clarity as well as a planning structure (eg EMS).
A2	Fishery management plans use pre-agreed decision rules based partly on limit reference points equivalent to, or more conservative than, both target stock MSY and bycatch population MSY for the most vulnerable species of bycatch.	Score 2.5 Decision rules are in place which are considerably more conservative than using krill MSY as a limit reference point (Kock 2000:23) as the rules allow for the needs of krill predators. Midwater trawling for krill results in bycatch of larvae and juvenile fish (Kock 2000:27) but at this stage reference points for bycatch have not been set. However, in other CCAMLR fisheries, TACs for bycatch species are set, accompanied by decision rules which will halt targeted fishing if an area-based bycatch TAC is exceeded (Kock et al. 2007:2342).
A3	Undesirable outcomes which could result from excessive fishing pressures are identified, and monitoring programs are in place with sufficient power to rapidly detect these changes should they occur.	Score 2.5 A concern that krill fishing could lead to undesirable outcomes for krill predators led to the formation of CCAMLR (Kock 2000:7). An ongoing monitoring program was put in place in the 1990s to detect changes in prey populations, and to separate fishing induced changes from environmental changes (Kock 2000:9, 14). The power of both krill abundance monitoring, and predator response monitoring has been assessed (Reid et al. 2008) and leaves room for improvement.

Table 10.1 The precautionary approach (continued)

	Benchmark	Assessment
A4	The risks to ecosystem health and integrity are assessed for each major fishery, and additional caution applied to management programs for high-risk fisheries	Score 2.5 The risks for the krill, and other, fisheries are not formally assessed. However CCAMLR was created against a background of harvesting risk concern. CCAMLR's seabird bycatch abatement program is an example of precautionary measures applied to a high-risk fishery (toothfish longlining).
A5	Independent peer review is used as quality assurance for major management policies, strategies and plans.	Score 3 The krill fishery plan (Miller 2003) was subject to informal peer review. Further informal peer review of conservation measures is provided by CCAMLR's scientific committee structure (Miller 2007:126). Moreover the multi-party nature of CCAMLR management (Miller 2007:126) provides informal peer review over all major CCAMLR strategies (Kock 2000:11)
A6	Management procedures provide for rapid response in the light of unexpected declines in target stocks, bycatch populations, or habitat value. Such provisions provide for fisher compensation where necessary.	Score 2.5 Krill populations are monitored and modelled, using fishery-independent data. Annual spatial TACs are established. CCAMLR members provide prior information on fisher projected catches and operational areas. Catches are reported every 10 days. Once an area annual TAC has been reached that fishery is closed until re-opened the following year. A 'race to fish' has not resulted as fishing effort in the last several years is less than that necessary to harvest area-based TACs. Krill harvests have not reached the precautionary limit reference point (a target reference point is not used). However this may change as fishing effort increases (Miller & Agnew 2000, Miller 2007). No ongoing 'right to fish' is established by management procedures, and no compensation programs are envisaged if krill TACs do not meet intended harvests. Krill fishing is not expected to damage habitat; however in other fisheries an interim prohibition on bottom trawling (Miller 2007:127) is current in some areas.

Table 10.2: The ecosystem approach in the CCAMLR krill fishery:

	Benchmark	Assessment
B1	There is formal periodic assessment of the impacts of particular fisheries against agreed objectives, including ecosystem-based objectives.	Score 2 The krill fishery, and other fisheries, are subject to informal member review as part of the annual Commission meeting. Although krill harvesting is accelerating, present harvests are still well below agreed biomass reference points. However specific fisheries are not formally reviewed against fishery objectives or indicators.

Table 10.2 The ecosystem approach (continued)

	Benchmark	Assessment
B2	There is monitoring and reporting of agreed ecosystem indicators based on stated ecosystem objectives.	Score 2 CCAMLR's broad objectives are established by the 1980 Convention; ecosystem protection is the over-riding objective. Krill escapement to support predators is defined, as are the time-scales on which fishery effects are to be reversible (Kock 2000). The environmental monitoring program (CEMP) attempts to detect fishery-induced ecosystem changes. However, past the broad Commission objectives and reference points, no specific ecosystem indicators have been established.
B3	There is a substantial program in mapping, protecting and monitoring critical and vulnerable habitats, funded by the fishery agency or responsible government.	Score 2.5. A substantial program to map, assess and protect vulnerable and rare ecosystems, as well as to protect representative examples of ecosystems, was described in CCAMLR 2006 Working Paper 7. Progress on an interim bioregionalisation was reported by the Scientific Committee in 2007.
B4	There are effective programs in place to monitor and maintain old-growth age structure in specific fisheries.	Score 1. Krill, as short-lived animals, have no old-growth age structure of interest. Taking a wider view over other programs, while CCAMLR has no objectives related to maintaining natural age structures in harvested populations, monitoring of age structures is ongoing (eg: fish tagging in the Ross Sea will validate current aging procedures for Patagonian toothfish).
B5	The agency has a substantial program to account for evolutionary change caused by fishing.	Score 0 At the low harvesting levels of the existing krill fishery, evolutionary impacts would not be expected. Taking a wider view over other programs, CCAMLR has no objectives or programs in this area at present, although harvest rates (on toothfish for example) are at levels which may drive evolutionary changes.
B6	There are effective programs in place to maintain the spatial extent of all major sub-populations (both target and bycatch) affected by specific fisheries, and maintain and monitor population genetic diversity.	Score 2 While CCAMLR has no objectives or programs to monitor or maintain genetic diversity in harvested populations, krill harvesting is based on areas or regions. Management areas themselves are partially defined by the existence of land-based predator breeding colonies. Catch levels are set using precautionary rules (Kock 2000:23) which are theoretically applied to the most vulnerable populations on a spatial basis. Krill genetic diversity appears to lack significant spatial structure, indicating a single large Southern Ocean population rather than a metapopulation structure (D.Miller pers. comm. 14/08/08). Further investigation is needed on this matter, however.

Table 10.3: Active adaptive management in the CCAMLR krill fishery:

	Benchmark	Assessment
C1	The performance of the fishery management agency itself is subject to independent periodic review against stated objectives, and quantifiable indicators and performance targets.	Score 3. The 2007 CCAMLR meeting initiated an independent review of the Commission's operations. A nine-person panel was established after receiving nominations from members. The review report of the panel will be considered by the 2008 CCAMLR meeting, and made public early in 2009.
C2	The management program uses mathematical modelling to pinpoint uncertainties and generate alternative hypotheses.	Score 2.5 CCAMLR's "aim is not to attempt to develop a comprehensive ecosystem model of Antarctica, but rather to develop models that can cast light on particular scientific and management questions." (Kock 2000:23). CCAMLR current strategy is to set a krill catch limit using a single-species model, and then to investigate possible ecosystem impacts with alternative ecosystem models/parameters (CCAMLR 2007a). The approach has not been applied to finfish, but CCAMLR's intention is to do this.
C3	The assumptions behind the models are clearly set out and evaluated.	Score 2.5 Scientists working on the krill fishery have proposed and designed active adaptive modelling approaches (Constable & Nicol 2002). At least some key assumptions are evaluated or are being evaluated (CCAMLR 2008).
C4	Reports incorporating the use of adaptive management set out the bounding of management problems in terms of explicit and hidden objectives, and practical constraints on actions.	Score 2.5 While CCAMLR is clearly committed to such clarity (Constable 2005; Constable & Nicol 2002). Key explicit assumptions, and at least some 'hidden' assumptions are set out in scientific documentation, as well as practical constraints on actions. See for example the precautionary catch limits on krill for Areas 48(1,2,3) to provide for krill predators (CCAMLR 2007b). There are opportunities to apply this approach to finfish.
C5	There are changes in management controls, designed to test clearly stated hypotheses, which are sufficiently large to reasonably produce detectable effects; the size of these effects is estimated in advance, and sufficiently powerful field surveys undertaken, and statistically examined to deduce the probabilities of both Type I and Type II errors.	Score 2. While this approach is described and recommended by Reid et al. (2008), Constable (2005), and Constable & Nicol (2002), there have been difficulties in previous years applying the approach to the krill fishery, as the level of harvesting has been too low to produce an identifiable ecosystem effect (CCAMLR 2007c). This situation will change with increasing international interest in the Antarctic krill fishery.
C6	Formal organizational requirements are established for evaluating and reporting the results of the experimental management strategies, both to managers and stakeholders.	Score 3. CCAMLR has a highly developed general review and reporting program, centred around the annual reports of the Scientific Committee, the working groups, and the Commission. The annual meetings of the Commission, and the CCAMLR journal, provide important stakeholder and public review opportunities. Increasing exposure within peer-reviewed scientific literature should be expected.

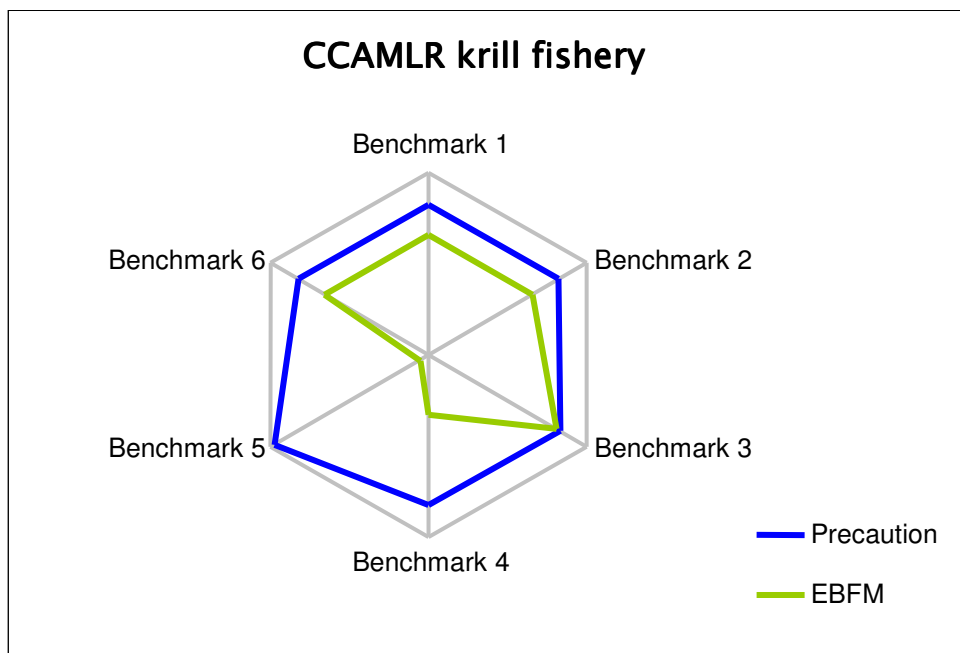


Figure 10.1: Kite diagram for CCAMLR precautionary and ecosystem approaches.

10.3 Management perceptions:

A professional scientist employed by CCAMLR, Dr Keith Reid, was interviewed on October 9, 2008 and Dr Karl-Herman Kock, a member of the scientific committee, interviewed on October 16, 2008. The interviews asked questions relating to the costs, benefits and impediments relating to the implementation of the three approaches. A view was expressed that the ecosystem and precautionary approaches are today, understood as essential ingredients in CCAMLR's role and identity. This being the case, it is hard to identify 'benefits' because there is no alternative management option – these approaches must be applied. There is no question of doing things differently. The point was also made that the precautionary approach is essentially a long-term strategy, and immediate benefits should not be expected.

Views expressed by Dr Reid and Dr Kock were similar. Interesting and important observations were made about the precautionary and ecosystem approaches, both in the CCAMLR context and generally:

- The precautionary and ecosystem approaches may be different in theory, but in practice they are interwoven. In some respects the precautionary approach can be seen as an element of the practical implementation of the ecosystem approach.
- Erring on the side of caution, and adopting 'safe' harvest levels rather than economically 'optimal' levels (ie: using different safety margins or likelihoods when choosing harvest levels) must reduce harvest targets – so leaving an added margin of species productivity within the natural food web of the ecosystem. "One of the reasons why CCAMLR is successful is that CCAMLR is always erring on the cautious side. When catch limits are calculated CCAMLR is going for the lower bound of the confidence limits and in most cases not for the mean. This helps a lot. Another reason is that models used in CCAMLR to calculate catch limits have the ecosystem built in and do not rely on a single species approach alone as the models in other RFMOs often do" Karl-Herman Kock⁸⁶.
- Application of the precautionary principle to ocean environments rests partly on careful consideration of the statistical power of monitoring programs designed to detect the ecological effects of harvesting – taking a precautionary approach will involve choosing increased probabilities of making Type I errors, while reducing

Type II errors. No guidelines for these probabilities exist, and each case will be different.

- The direct costs of both the precautionary and ecosystem approaches to fisheries are lower short term harvests – and thus in some cases profits. The direct benefits are greater stability of catches in the long term – which is likely to support future fishery profits.
- Although to some fishery scientists the ecosystem approach seems complex and daunting, it is important to start with simpler aspects which can be managed – predator/prey relationships being a good example. Although CCAMLR's krill fishery is 'lucky' in that key predators have land-based breeding colonies, making monitoring simpler, management options which allow for predator needs can be made in any fishery. Minimization of bycatch, and prevention of long-term damage to benthic habitats, are also basic elements of the ecosystem approach. Once a start has been made, a path of gradual incremental improvement can be followed to ultimately expand the scope of ecosystem based management within a particular fishery.

10.4 Summary and comment:

CCAMLR is an acknowledged leader amongst regional fishery management organisations, so it is not surprising that the Commission scored highly in regard to application of the precautionary and ecosystem approaches. Specific benchmarks with low scores relate to protecting genetic diversity of fish stocks, and managing the evolutionary effects of fishing. These are 'leading edge' EBFM issues, which few if any fishery organizations tackle well.

With respect to the krill fishery specifically, while genetic diversity within the Southern Ocean stock is high (Steve Nicol, pers. comm. 19/8/08) spatial variation between major areas of the Southern Ocean appears to be low, although this needs further investigation. At current low harvest levels the evolutionary effects of krill fishing might also be assumed to be low. It is easy to understand why these issues have not been accorded high priority by CCAMLR, as the organisation has been, and remains, beset by a major problem with illegal, unreported and unregulated (IUU) fishing. Other areas identified where there is room for improvement relate to the designation, monitoring and reporting of specific fishery and ecosystem indicators. With regard to the application of adaptive management, CCAMLR shares a broad commitment to the approach with many other natural resource management organisations. In several CCAMLR fisheries the financial stakes are low by international standards, and this fact, combined with the high reliance on best available science within the CCAMLR management structure, presents the organisation with opportunities to apply active adaptive management in ways which would be almost unthinkable to organisations dominated by short-term vested interests (eg the Commission of the European Union).

Mooney-Seus & Rosenberg (2007) examined the ways in which the ecosystem and precautionary approaches are being implemented within 13 regional fisheries management organisations. Their review focused on 15 specific components of fisheries management regimes, enabling them to build a "model" governance framework. Of the RFMOs reviewed, CCAMLR was the outstanding performer. Mooney-Seus & Rosenberg made an interesting observation concerning the use of science:

How well RFMOs adhere to scientific advice when defining management measures and how well they comply with those measures once implemented may provide a good indication of how effectively RFMOs will implement EBM and the precautionary approach. Only three RFMOs, CCAMLR, IATTC³⁷ and IPHC⁸⁸, and their respective Contracting Parties appear to consistently comply with both scientific advice and corresponding management measures.

--ooOoo--

Endnotes:

⁷⁷ This is my personal view and is not shared by many people associated with CCAMLR – who prefer to label the organisation simply as a progressive RFMO.

⁷⁸ Gislason et al. (2000) provide a framework to assess biodiversity impacts. They suggest that EBM should incorporate six ecosystem objectives. These are the maintenance of: (1) ecosystem diversity, (2) species diversity, (3) genetic variability within species, (4) directly impacted species, (5) ecologically dependent species, and (6) trophic level balance.

⁷⁹ For example prohibitions on dumping at high latitudes, and ice-strengthening requirements (in CCAMLR conservation measures and resolutions) (D. Miller, pers. comm. 4/10/2006).

⁸⁰ Rockcod fishing was a major problem before CCAMLR came into existence. Rockcod was the first species for which CCAMLR prohibited directed fishing.

⁸¹ Note that in some areas (e.g. crabs in Subarea 48.3 and Toothfish in Area 88 in general) CCAMLR has also instituted a research approach to fishing which spreads and minimises risk in respect to exploratory fisheries, as well as providing a systematic way of improving scientific knowledge (D. Miller, pers. comm. 4/10/2006).

⁸² CCAMLR finfish fisheries don't just require observers, they require observers appointed under the CCAMLR Observer Scheme which means they have carefully delineated and standardized functions and are not nationals of the flag of the vessel on which they serve (D. Miller, pers. comm. 4/10/2006).

⁸³ The CCAMLR Ecosystem Monitoring Programme (CEMP) does not only attempt to get some form of assessment of "ecosystem health", it is also trying to get information on key parameters (indicators) which could be used to improve knowledge of ecosystem functionality as well as attempting to discriminate between natural variability and human induced changes (especially from harvesting activities) (D. Miller, pers. comm. 4/10/2006).

⁸⁴ Seabird mitigation is one of CCAMLR's big successes. It has led to dramatic decreases in incidental seabird mortality in the legitimate longline fisheries and has offered a model to the world (e.g. the FAO Plan of Action relating to seabird incidental mortality has much to thank CCAMLR for in terms of philosophy and procedure) (D. Miller, pers. comm. 4/10/2006).

⁸⁵ In effect, CCAMLR, and other RFMOs around the world, need removal of the 'freedom of the high seas' to function effectively (see for example Constable 2006). While the need for this change has been widely recognised amongst legitimate fishing companies and marine managers, immediate amendment of the Law of the Sea are very unlikely due to the conservative nature of international politics.

⁸⁶ Pers. comm. (email from Karl-Hermann Kock) 27 Apr. 09.

⁸⁷ IATTC – Inter-American Tropical Tuna Commission.

⁸⁸ IPHC – International Pacific Halibut Commission.

11. Benchmark appraisal: Australia's northern prawn trawl fishery

The purpose of this appraisal is to compare the Northern Prawn Trawl Fishery management regime to benchmarks representing key aspects of three broad 'modern' management approaches: active adaptive management, and the precautionary and ecosystem approaches. This section also (a) provides brief background on the fishery, (b) discusses the fishery in regard to the issue of destructive fishing, and (c) discusses the Commonwealth re-accréditation of the fishery under the *Environmental Protection and Biodiversity Conservation Act 1999*, which took place in January 2009.

11.1 Background:

The Northern Prawn Trawl Fishery (NPTF) occupies an area of 771,000 square kilometres off Australia's northern coast. The fishery management area extends from low water mark to the outer edge of the Australian exclusive economic zone (EEZ) along approximately 6,000 kilometres of coastline between Cape York in Queensland and Cape Londonderry in Western Australia (Figure 11.1). Fishing is concentrated in a relatively small part of the total area. The total proportion of the fishing area that had been trawled by 2001 was 14% or 108,000 km² (AFMA 2002b:82). Areas of high intensity fishing activity in 2001 amounted to 24,720 km² or about 3% of the total area. For management purposes the area is divided into 6 minute x 6 minute grid blocks, and catch and bycatch reporting is referenced to this grid. Fishing was reported from 579 grid blocks (or about 70,000 km²) in 2007 (AFMA 2008a)⁸⁹. The total actively fished area was estimated in 2007 as about 220,000 km² or 29% of the total area (Larcombe & Begg 2008:27). Fishing effort decreased between 2001 – 2007.

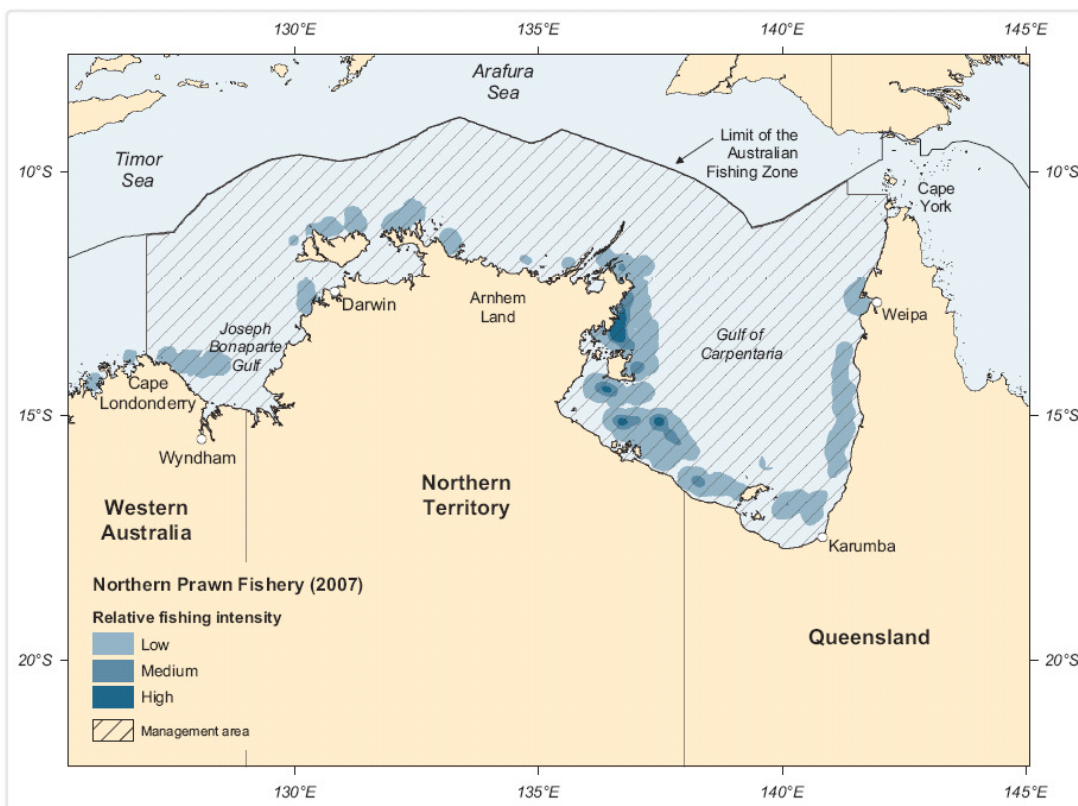


Figure 11.1. Location of the Northern Prawn Fishery 2007. Source: Larcombe & Begg (2008).

Although this area is impacted by a number of legal and illegal fisheries, Halpern et al. (2008) identified it as only moderately impacted compared to much of the remaining marine realm. The area still retains very important marine biodiversity values, in spite of substantial losses.

Under an Offshore Constitutional Settlement (OCS) agreement between the Commonwealth, Western Australia, the Northern Territory and Queensland, originally signed in 1988, prawn trawling in the area of the NPTF is the responsibility of the Commonwealth through the Australian Fisheries Management Authority (AFMA). Australia's prawn fisheries are sometimes cited as examples of well managed fisheries⁹⁰.

AFMA's enabling legislation, the Commonwealth *Fisheries Administration Act 1991*, and its directive legislation, the *Fisheries Management Act 1991*, require the fishery to be managed in accordance with a statutory management plan – in this case the *Northern Prawn Fishery Management Plan 1995*, as amended. AFMA's legislation also requires the application of the precautionary principle to fisheries management. *Australia's Oceans Policy* (Commonwealth of Australia 1998) mandates the application of the ecosystem approach to AFMA-managed fisheries, reinforcing national commitments made as early as 1982 (Chapter 5). By a ministerial direction issued in 2005, AFMA was required to apply specific components of the ecosystem approach to fisheries management (more below).

The fishery targets nine prawn species, as well as squid (*Loliginidae spp.*) and scampi (*Nephropidae spp.*). Several other species are taken as byproduct, including bugs (slipper lobsters - *Scyllaridae spp.*), scallops (*Pectinidae spp.*) and several fish species. The primary prawn target species fall into two genera (AFMA 2002b:16):

- White banana prawn *Penaeus merguensis*
- Red-legged banana prawn *Penaeus indicus*
- Grooved tiger prawn *Penaeus semisulcatus*
- Brown tiger prawn *Penaeus esculentus*
- Giant tiger prawn *Penaeus monodon*
- Red spot king prawn *Penaeus longistylus*
- Blue endeavour prawn *Metapenaeus endeavouri*
- Red endeavour prawn *Metapenaeus ensis*
- Western king prawn *Metapenaeus latisulcatus*, revised to *Peneaus latisulcatus*

Since 2004 the fishery has been managed with an overall aim of achieving maximum economic yield (MEY⁹¹) (Larcombe & Begg 2008). With a history of overfishing important prawn stocks, Rose & Kompas (2004:1) described the fishery as "operating with too many boats expending too much effort to catch too few prawns". The fishery used 96 working boats in 2001, providing seasonal employment for about 500 staff. Fifty-one working boats were employed in 2007, some having retired in 2006-07 through the Commonwealth's structural adjustment package. The fishery supports additional seasonal employment in the transport and processing of target species. All working boats are licensed to operate in other fisheries during the northern prawn off-season; some work the nearby Torres Strait prawn fishery.

The total 2007 prawn catch was 4310 tonnes (down from 5310 t in 2006) which included 2901 t of banana prawns, 1192 t of tiger prawns, 196 t of endeavour prawns, and 20 t of king prawns (Larcombe & Begg 2008). Minor prawn species, such as king prawns, are mostly taken as byproduct. The overall level of prawn catch was roughly similar to that of the previous five years, but is significantly lower than the highest catch recorded in 2000/01 of 9278 t (AFMA 2008:6). The Gross Value of Production (GVP) for 2007 was \$m 64, down from \$m 73 the previous year. The fishery is one of Australia's largest fisheries in GVP terms.

The fishery is managed by effort restriction. Excess capacity has been addressed partly through buy-back schemes in the 1980s and 1990s (World Bank 2004) and in 2006/07. Effort restriction is achieved through limited entry to the fishery, gear restrictions, spatial seasonal and diurnal closures, and prohibitions on byproduct species. Squid harvest must not exceed the size of the prawn harvest, and a squid harvest trigger of 500 tonne per year

initiates a review of the squid harvest limit. Recent squid harvests have been much lower than the trigger level.

Fishers in the NPTF pay for the costs of management under an AFMA cost-recovery policy, and are also substantial contributors to the costs of research. Past this the community receives no resource rent from the fishery except through the usual personal and corporate taxes⁹². The costs of the three capacity buy-back schemes have been met partly by the public purse, with the remainder met by the industry⁹³.

The fishery has been relatively well studied (mostly by the CSIRO) and the basic biologies of the prawn stocks are partly understood (more below). River runoff influences the abundance of some prawn species, enabling a degree of stock prediction. Shallow seagrass nursery areas have been protected from trawling (with the full support of the industry) for many years.

In spite of important improvements over the last few years, the fishery has major environmental problems, chiefly with respect to incidental catch, but also regarding benthic damage. The fishery's economic problems relate to profitability and maintaining prawn stocks. A high Australian dollar against the Japanese yen (and US dollar) as well as high fuel prices reduce profitability. On the global market wild-caught prawns compete with farmed prawns.

In the past effort reduction strategies have been less successful than anticipated, partly through implementation failures (Dichmont 2006). The spatial structure of stocks has not been adequately appreciated, and component populations have been, and continue to be, overfished⁹⁴ (Dichmont 2006) as the fishery lacks effective spatial controls over fishing effort. Possible prawn metapopulation structure does not appear to have been adequately investigated. According to Dichmont (2006:22) "...it is the inability of management to influence the spatial distribution of effort that is the main reason for poor performance".

Dichmont (2006:17) described NPTF management as having "high levels of inertia"⁹⁵.

Judging by the NPTF's 2001 strategic plan (NORMAC 2001) the industry, as represented by the statutory management advisory committee, is more ambitious than its regulators on the issue of progressive management. For example, the plan announced an intention to seek independent certification⁹⁶ – an extremely ambitious proposal given the fishery's bycatch issues. The strategic plan also foreshadowed the need to establish, monitor and report reference points with respect to bycatch species – some time before this had been recommended by AFMA, DAFF or DEH⁹⁷. Another ambitious proposal in the plan was the preparation of a fishery environmental management strategy (EMS). If such a plan were to be prepared according to ISO⁹⁸ standards, it would involve an auditable commitment to continual improvement, a concept well beyond any AFMA, DAFF or DEH proposal.

Compliance is assisted by good relations between managers and fishers, fostered by a high level of industry consultation, largely through NORMAC, the statutory advisory committee. Also important in regard to compliance are: an industry-sponsored Code of Conduct⁹⁹, random inspections at sea and at port, the use of trained crew observers, and compulsory GPS vessel monitoring systems (VMS – introduced in 1998). VMS reporting frequencies in the order of a few minutes allow fishing intensity data to be collected, as well as providing accurate real-time vessel location information (Deng et al. 2005).

In 2002 the industry (through NORMAC) voluntarily adopted a turtle bycatch target of 5% of the year 1990 turtle bycatch level¹⁰⁰. Under the statutory management plan, turtle excluder devices (TEDs) were made mandatory in 2000 and bycatch reduction devices (BRDs) mandatory in 2001. Current turtle mortality, as reported, meets this target, with a 2007 bycatch of 55 turtles caught and all released alive¹⁰¹. Skippers are required to log certain bycatch records; this information is supplemented by a small number of crew observers and at least one scientific observer per season.

11.2 Is prawn trawling a “destructive fishing practice”?

The fishery employs a trawling technique widely recognised as causing (a) high incidental mortality (bycatch¹⁰² and collateral¹⁰³ damage) and (b) direct damage to benthic habitats and ecosystems. Globally, the environmental impacts of prawn and shrimp trawling have caused, and continue to cause, widespread concern (Gray et al. 2006; Watling 2005; Aish et al. 2003). According to Aish et al., global shrimp and prawn trawling produces one third¹⁰⁴ of the world’s bycatch, while producing only 2% of the total wild harvest. Prawn trawling “has the dubious distinction of having the highest ratio of bycatch to catch of any fishing method” (Haywood et al. 2005:236).

Prawn trawls are nets which are dragged across the seabed, often in fairly shallow water (<100 m). A ground chain lies under the trawl footrope. This “is a substantial amount of heavy gear travelling across the seabed and it is likely to have a severe impact on any biota that it encounters” (Haywood et al. 2005:5). Typical seabeds in the NPTF area are low-relief sediments, populated by diverse communities of mobile and sessile organisms; for example sponge-fields (Long et al. 1995). A single trawl shot is likely to collect around 10% or more of fixed benthos¹⁰⁵, with a similar proportion uprooted or damaged but not collected in the net. Partial excavation and damage of organisms living near the surface of the sediment can attract scavengers (Haywood et al. 2005:5). Repeated trawling over the same ground causes major damage to these communities (Haywood et al. 2005; Burrige et al. 2003). Some of these communities, especially in shallower water, are adapted to frequent disturbance caused by storms and cyclones.

Key questions are: how widespread is the damage caused by trawling, and what are the recovery times for damaged communities from the different habitats affected?¹⁰⁶ What are the implications for the structure and function of wider ecosystems? Bycatch issues include damage to species populations, damage to the ecosystems in which these species reside, and the effects of subsidising scavengers and predators with discards (see below). Haywood et al. (2005:5) commented: “We have a considerable amount of information on the composition of bycatch... but almost no understanding of what is happening on the seabed”.

Australian governments, like the governments of many other nations, are committed to phasing out all destructive fishing practices within their jurisdictions by the year 2012 (Chapter 5). An important question thus arises: *should the Northern Prawn Trawl Fishery be classed as employing a destructive fishing practice?* While recognising the reduction in the size of the fleet, and the considerable efforts of the fishery to reduce its environmental footprint, this question nevertheless must be addressed.

The phrase “destructive fishing practice” is not defined by the *Johannesburg Outcomes Statement 2002* (which sets the 2012 deadline). Neither is it defined by the FAO, or within any international or national agreement to which the Australian Government is a party. Although the Australian Government itself has no formal definition of the term, the 2008/09 re-accreditation process implicitly forced it to decide if prawn trawling should be thus classified. The Northern Prawn Trawl Fishery, through AFMA, requested re-certification under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) in late 2008 (AFMA 2008). This re-certification was required to enable the fishery to service its international markets – essential for its survival. The final date for public submissions on the re-accreditation request closed in mid-October 2008, with recertification due before 9 January 2009, the date of expiry of the previous certification. If, in the Government’s opinion, the trawl fishery qualifies as a destructive fishing practice, moves should have been made during this process to phase the fishery out by 2012, with appropriate compensatory measures.

The Millennium Ecosystem Assessment, a United Nations initiative, used multiple scientific authors for its reports, with multiple scientific peer review. Trawling is included in destructive fishing practices listed by the report (MEA 2005:479). According to a companion report, MEA (2006:20):

Hard bottom and soft sediment seafloor habitats are severely impacted by fishing methods such as bottom trawling and dredging. This type of human

disturbance is one of the most significant threats to marine biodiversity. Soft bottoms cover about 70% of the earth's seafloor and are characterized by extremely high species diversity. There is now strong evidence of fishing effects on seafloor communities that have important ramifications for ecosystem function and resilience.

Aish et al. (2003) using arguments similar to those of the MEA, classify shrimp trawling as a destructive fishing practice (for the purposes of this chapter shrimp trawling includes prawn trawling). *Wikipedia* (accessed 28 Oct. 08) defines destructive fishing practices as including techniques with "excessive levels of bycatch". The FAO, while not providing an explicit definition of 'destructive fishing practices', have provided a discussion (FAO 2004) – according to which such practices include "destructive methods, the impact of which are so indiscriminate and/or irreversible that they are universally considered 'destructive' in whatever circumstances." Here "universally" presumably excludes the fishers employing the practice, as well as those managers providing immediate authority to the fishers.

Prior to the introduction of TEDs and BRDs, bycatch/catch ratios in the NPF were often in the range of 10:1 to 20:1 by weight (Caton & McLoughlin 2005:42). Tonks et al. (2008:279) reported ratios for the Joseph Bonaparte Gulf between 11:1 and 17:1. Pender et al. (1992) reported ratios between 2:1 and 21:1 in the western part of the NPF zone. The lowest ratio of 2:1 is unusual, and indicates a short-duration shot in a concentrated prawn aggregation.

Prior to the introduction of TEDs, around 5000 turtles were caught each year by the fishery, with a mortality rate of 10-20% (Poiner & Harris 1996). While the success of TEDs has been one of the fishery's most notable environmental successes¹⁰⁷, reducing the smaller component of the bycatch has proved more difficult. A problem with free-swimming small fish is that they appear to have difficulty accessing the BRD outlet in conditions of poor visibility, and a particular problem with sawfish (which can be large animals) is that their saw-like rostrums¹⁰⁸ get caught in the trawl net. The best reported bycatch/catch ration achieved in a trial using a relatively efficient TED and BRD (Gregor & Wang 2003:16) was 4:1. While this figure may have been achieved under favourable conditions, it does indicate that TEDs and BRDs can achieve considerable improvements, if properly designed, aligned within the trawl cod-end, and operated.

However, even supposing that a bycatch/catch ration of 4:1 could be regularly achieved in practice through the entire fleet, is this enough? An annual catch of 4000 tonnes of prawn would still kill 16,000 tonnes bycatch – tens of thousands of animals, quite apart from collateral damage, which is likely to be the same order of magnitude. In the terms of the FAO discussion, this bycatch is largely indiscriminate (with the exception of the larger animals ejected through the TED) and in the terms of *Wikipedia's* definition, a ratio of 4:1 can be readily (although arguably) described as 'excessive'. In practice the ratio including collateral damage is likely to be double that – or more.

In judging whether or not such bycatch should be described as excessive, the ethical issue of respect for other life forms should be considered (Chapter 3). The *National Strategy for the Conservation of Australia's Biological Diversity*¹⁰⁹ (Commonwealth of Australia 1996:2) states:

There is in the community a view that the conservation of biological diversity also has an ethical basis. *We share the earth with many other life forms that warrant our respect, whether or not they are of benefit to us.* Earth belongs to the future as well as the present: no single species or generation can claim it as its own [emphasis added].

There will always be differing views on these matters, however my considered opinion is that the destruction of at least four tonnes of living creatures to harvest one tonne of prawns *does not demonstrate respect, and cannot be ethically justified* (see Chapter 3 for a discussion on ethics). These bycatch levels are often exceeded, sometimes greatly.

By way of comparison, the practice of shark finning, prior to 2000, was standard practice in several Australian fisheries. It was banned by the Commonwealth and all State Governments

between 2000 and 2005, partly on arguments of respect for nature, cruelty, and waste of resources¹⁷⁰. Can it be credibly argued that prawn fisheries are better in these respects?

In addition, there are issues relating to the impacts of the NPTF on the functioning of ecological communities, as well as the survival of individual species and populations. These matters will be dealt with below. Considering all these issues, my view is that *the NPTF does qualify as a destructive fishing practice*, and action should have been taken to phase the fishery out by 2012. Although this action was not taken, an argument on ethical grounds nevertheless remains for reducing the size and scope of the fishery (the fishing power) over time as a way of dealing with unacceptable ethical and environmental impacts. Such a reduction should be undertaken in a way which occurs over a suitable period of time, and maintains the viability of a (reduced) fleet during the phase-down. Spatial controls could be used to focus fishing effort to reduce bycatch while increasing the efficiency and profitability of the smaller prawn fleet (more below).

11.3 The fishery's 2008 application for re-accreditation:

Although Australia's States, under the Australian constitution, have primary responsibility for natural resource management, the Commonwealth (Australian) Government retains oversight of export controls – in addition, of course, to its control over Commonwealth waters. The Commonwealth Government has established a process for certification of a fishery to enable export of its products. Under the general framework of the EPBC Act, a fishery is assessed against a list of 'sustainability' criteria. While the criteria themselves are open to serious criticism (Appendix 3), this will not be further discussed here. As previously mentioned, the NPTF was assessed in 2003, and subsequently granted the necessary approvals until January 2009.

The first certification process demonstrated that the fishery met some, but not all, of the assessment criteria. For example *Principle 2 Objective 1* states: "The fishery is conducted in a manner that does not threaten bycatch species". The first assessment (AFMA 2002b:61-75) was unable to demonstrate compliance with this criterion, but did demonstrate that studies were planned which would go some way towards filling relevant knowledge gaps.

The subsequent certification (DEH 2003) sought to address such gaps through a series of recommendations, aimed both at deficiencies in management as well as gaps in relevant science.

In applying for recertification (AFMA 2008) AFMA needed, I believe, to demonstrate that every reasonable effort has been taken to:

- address the DEH 2003 recommendations (which, in fact, were worded as conditions of approval rather than recommendations);
- address the key knowledge gaps exposed in the 2002 assessment report; and
- improve the performance of the industry in regard to its most critical environmental issues – bycatch and habitat damage.

An examination of the AFMA (2008) report reveals partial success in each of these three areas. Some of the DEH recommendations have been addressed; some of the most important knowledge gaps have been addressed, and improved performance has been demonstrated in some areas, particularly with respect to turtle bycatch. However, in other important matters, AFMA has either entirely failed to demonstrate competent effort, or has failed to produce relevant explanatory information. A fourth issue concerns the way in which the results of the CSIRO studies on bycatch vulnerability have been used. The AFMA (2008) report's focus only on 'high risk' categories ignores critical uncertainties, cumulative impacts, and ecosystem issues, and is entirely inappropriate – and the reverse of precautionary. These matters are of considerable concern, and are discussed below.

The DEH 2003 recommendations:

In providing certification for the NPTF, the Commonwealth Department of the Environment and Heritage stated (DEH 2003:9): “The following recommendations *will* be implemented before the next review in 2008” (emphasis added).

Recommendation 1: At the next review of the Management Plan detailed objectives, performance criteria, performance measures and regular review requirements will be formalised and directly linked to the Management Plan.

Status 2008: outright failure – the recommendation has not been implemented, even though the Management Plan has been reviewed on two occasions since 2003 (AFMA 2008:34).

Recommendation 3: At the next review of the Management Plan an amendment will be made to require the assessment of the effectiveness of the Management Plan, including the measures taken to achieve its objectives by reference to the performance criteria mentioned in recommendation (1), at least every five years.

Status 2008: outright failure – the recommendation has not been implemented, even though the Management Plan has been reviewed on two occasions since 2003 (AFMA 2008:34).

Recommendation 5: AFMA will develop and implement harvest strategies for all target prawn species, scampi, squid and slipper lobsters (bugs) within five years. Harvest strategies should include monitoring systems, suitable biological reference points and management responses with clear timeframes for implementation, to ensure that harvesting is conducted at an ecologically sustainable level. Harvest strategies should also be developed for other species as new market opportunities are detected.

Status 2008: partial failure – the recommendation has not been fully implemented. While the non-compliant harvest strategies have not been referenced (AFMA 2008:35) they are summarised by Larcombe & Begg (2008) and do not appear to contain the full suite of components required by the wording of the recommendation.

Recommendation 6: AFMA, in cooperation with the Western Australia, Northern Territory and Queensland fisheries management agencies will, within five years, develop and implement a precautionary and biologically meaningful limit for squid harvest based on sound information about the species ability to withstand fishing pressure. Within 12 months, as an interim measure, AFMA will implement more precautionary management arrangements, based on the best available scientific advice, and taking into account historical catch, to limit the harvest of squid species in the NPTF.

Status 2008: outright failure – the recommendation has not been implemented. No biologically meaningful, precautionary harvest limit has been set for squid. AFMA however indicate that the matter is under study (AFMA 2008:35).

Recommendation 7: Within 3 years AFMA will identify and implement management responses to fishing impacts identified from the ecological risk assessment process.

Status 2008: partial failure – the recommendation has not been implemented, although the first phase – that of identification, has begun and is well underway, with a number of reports published. AFMA indicate that the matter is under study (AFMA 2008:35-36).

Recommendation 12: AFMA, in cooperation with the States, will develop and implement a spatial management system within the NPTF that takes account of the impacts of fishing on:

- species and populations identified by the ecological risk assessment process as high risk;
- the recovery of overfished stocks;
- important feeding/spawning/breeding/refuge grounds for key target, byproduct and protected species; and
- benthic habitats

This spatial management system will be integrated with the regional marine planning process for Northern Australia that is already under way to establish a representative system of marine protected areas in the region and will ensure that the entire fishery area is taken into account.

Status 2008: commenced but behind schedule – the matter is under continuing study in partnership with the Commonwealth Department of the Environment, Heritage and the Arts (AFMA 2008:39).

In summary, in several important instances, AFMA failed to meet the conditions imposed by the first accreditation, and failed, in the second accreditation report, to demonstrate competent effort in attempting to meet these conditions.

Addressing key knowledge gaps: habitat impacts:

Habitat impacts are important. It should be noted immediately that most large areas of seagrass meadow – important as prawn nurseries, have been closed to trawling. The fishery disturbs 30-50,000¹¹¹ km² of seabed each year, in relatively shallow continental shelf water. Given that most of these areas contain high concentrations of prawns relative to un-trawled areas, it appears likely that, at some level, the habitat of the trawled areas is (or was) distinctive in relation to surrounding habitat. The fishery causes damage to benthic organisms and communities – and where areas are repeatedly trawled, damage can be severe (Haywood et al. 2005; Burrige et al. 2003).

Submerged coral is widely distributed throughout the Gulf of Carpentaria, and possibly other relatively shallow areas of the NPTF zone. This coral, together with rock outcropping above the seafloor sediments, forms “untrawlable grounds” The importance of these grounds to prawn populations is not well understood (Haywood et al. 2005:2-7) although it may be significant. Tiger prawn trawling is often concentrated close to untrawlable grounds, suggesting an ecological link between prawn density and the habitat of the grounds.

To assess and manage the habitat-related effects of prawn trawling, knowledge of the affected habitat is essential. Key questions are:

- what specific types of habitat are affected by trawling?
- how widely distributed are these habitat types?
- what communities and species occupy these habitats, and how well have they been surveyed?
- do these communities and species possess special values?
- how are the habitats, and their values, affected by trawling?
- to what extent do the habitats recover once trawling stops, and how long do the stages of recovery take?
- where are the habitats most vulnerable to trawling, and what re their values?
- to what degree are these habitat types and communities protected by no-take reserves, and where, and how large, are these reserves?
- where are the habitats of species at risk from trawling, and to what extent are important and critical habitats protected¹¹²?

None of these questions are addressed, in any substantive way, by either the first or second assessment reports (AFMA 2002b, 2008a).

Figure 11.2 below maps seabed facies in the NPTF area. A number of observations can be made by comparing Figure 11.1 with Figure 11.2. First, considerable areas of the NPTF management area are white in Figure 11.2 – indicating insufficient data. Given that the NPTF is one of Australia’s most important fisheries in terms of GVP, why has the necessary data not been collected? If it has been collected, and benthic facies maps (or better still, benthic

habitat maps) have been completed for the area, why were they not presented or referenced in AFMA (2008)?

It is also apparent that certain benthic facies have been heavily trawled – for example all of the *tide muddy sand* areas, except the farthest northern patch, appear to have been the focus of considerable trawling effort. Four other facies – deep carbonate, plateau terrace carbonate, shale sand, and shale muddy sand, also appear to have been heavily trawled. What attempts have been made, if any, to set aside interim protected reference areas of these facies – pending finalization of the Commonwealth’s planning program for the northern marine planning region? What attempts have been made to prioritize these ‘at risk’ areas for more detailed habitat mapping? These questions should have been addressed in AFMA (2008).

The first assessment report (AFMA 2002b) foreshadowed planned studies which were intended to address, to some extent, the key issues in the dot-points above. The second assessment report (AFMA 2008) should have reported the results of these studies in a way which would provide answers, at a useful level of detail, to the above questions. Ideally, this discussion should have been referenced to readily available research reports.

Unfortunately such a discussion is absent from the second assessment report. This is a major concern, and prevents the reader developing an understanding of the extent and degree of the fishery’s environmental impacts.

With respect to habitat damage, it should be noted that the fishery has been operating since the mid-1960s, with an effort peak in the mid-1980s. Presumably the rate of habitat damage also peaked at that time. An early practice, of which there is little but hearsay evidence, involved dragging a heavy chain between two trawlers, in an attempt to flatten submerged coral which impeded and damaged trawls. This practice, it appears, was widely practiced by the industry in early years, and was referred to as ‘preparation’ or ‘clearing’. The old-timers who talk about the practice still see it as legitimate – equivalent to clearing native vegetation on land to make way for terrestrial crops.

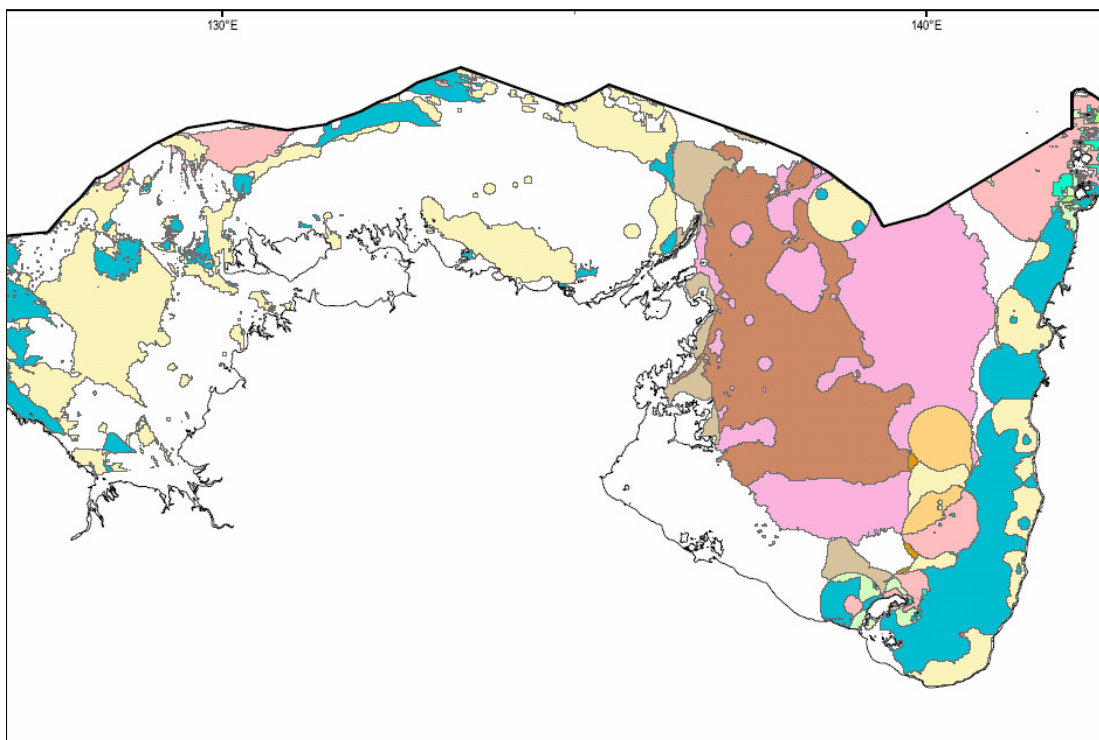
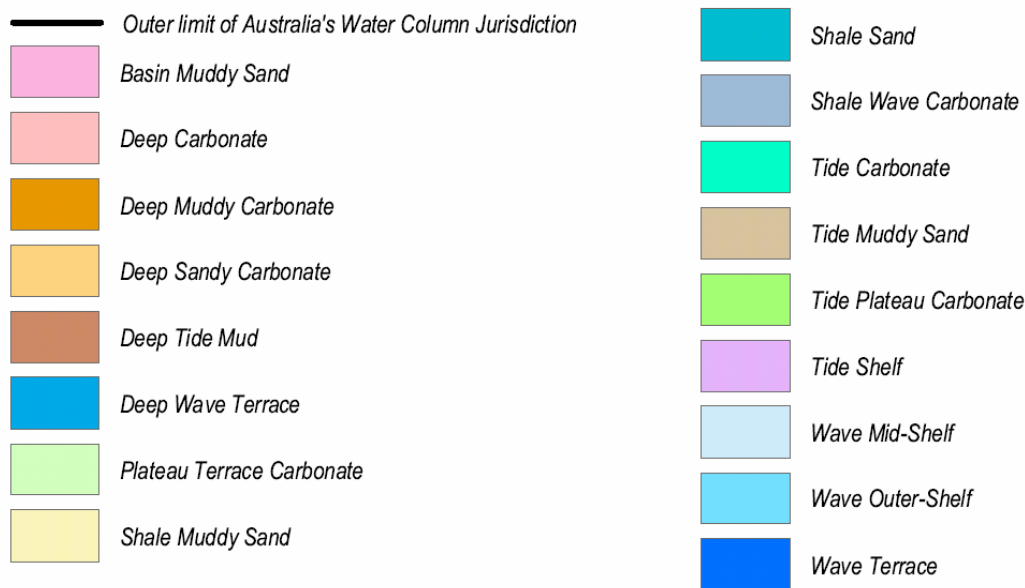


Figure 11.2. *Seabed facies in the Northern Prawn Fishery 2005.* Seabed facies provide broad surrogates for benthic habitats. Source: National Marine Bioregionalisation of Australia 2005.



Given the fact that considerable historic habitat damage occurred, and that some areas trawled long ago would have recovered to variable extents, a useful exercise could be to identify habitats currently subject to no or very low levels of trawling, and to consider trawling bans in these areas. This would limit further damage, especially to remaining untrawled areas, and encourage habitat recovery. This issue was not addressed by AFMA (2008) in their second assessment report.

Addressing key knowledge gaps: species impacts:

Impacts on particular species are important. As noted above, the requested biological reference points for all target prawn species, scampi, squid and slipper lobsters have not been developed – with the exception of limit reference points for brown and grooved tiger prawns, which have been lowered from the previous value of B_{MSY} to $0.5 S_{MSY}$ (Larcombe & Begg 2008). AFMA was specifically asked to establish scientifically defensible harvest limits for squid, and this has not been done. Although king prawns have exhibited long-standing abundance declines¹¹³, adequate steps do not appear to have been taken to explain this decline, or to establish precautionary harvest refugia or seasonal closures to protect king prawn populations. AFMA chose not to mention the king prawn situation (or the seven-year delay in addressing overfishing of brown tiger prawns, or the failure to assess other byproduct stocks) when it assured its minister that “the NPF has a comprehensive stock assessment process and history of strategic decision making to ensure that catches of prawns are at sustainable levels” (AFMA 2006c:1). Endeavour prawns may also be (probably are) overfished, even by conservative standards (Larcombe & Begg 2008).

The existence of fish survey data in unexploited areas prior to trawling (eg: Rainer & Munro 1982) is unusual, and should be used to discuss the effects of subsequent trawling. One study on the impacts of the NPTF on bycatch noted a 500-fold decline in the fishery’s bycatch of a taxa of leatherjacket (Harris & Poiner 1991). Rainer (1984) had earlier drawn attention to the numerical dominance of leatherjackets (*Paramonacanthus* spp.) in some untrawled habitats. Such a marked decline warrants investigation and explanation – however this issue was not addressed in either of the AFMA assessment reports, although presumably it has been addressed in the scientific literature¹¹⁴.

A general discussion of bycatch impacts, based on a comparison of these old records with recent survey data is essential, and is an important oversight within AFMA (2008). The question of the leatherjacket decline should be specifically addressed. In temperate

environments, leatherjacket abundance is often associated with dense biogenic habitat – often macroalgae in southern seas. Could the same apply to northern environments – in which case the removal of biogenic habitat through trawling might explain the observed precipitous decline? Such a discussion should, however, also address the statistical power of these comparisons (Peterman 1990), and the use of the precautionary principle in choosing acceptable probability levels for both Type 1 and Type 2 errors.

The issue of vertebrate bycatch vulnerability is addressed in more detail below, however it should be noted here that there are serious deficiencies in the way AFMA (2008) presents their discussion of this subject. One deficiency relates to the absence (discussed elsewhere in this chapter) of a discussion of temporal and spatial variation in bycatch/catch ratios which would elucidate the differences (in this regard) between the targeting of banana prawn aggregations, and dispersed prawns populations (tiger, endeavour, and red-legged banana).

Another major deficiency relates to the discussion in AFMA (2008:31) regarding the vulnerability of invertebrate bycatch. The only invertebrates listed in the 'at high risk' table are byproduct species. The benthic biota of the NPTF's trawlable grounds includes at least 950 species (Haywood et al. 2005:237) most of which appear at one time or another in trawl bycatch. The report should have discussed how the risk assessment for invertebrates was undertaken: were groups excluded from the assessment? and if so, which groups, and why?

Also missing from AFMA (2008) is a discussion of the importance of 'hotspots' to the tiger prawn fishery. According to Haywood et al. (2005:236) over 90% of the tiger prawn harvest comes from only 6% of the managed area (that is 46,000 km²). It would be of considerable interest to know both the habitat types in these areas, as well as the bycatch ratios from fishing these areas. The impact of trawling on the long-term 'quality' of these areas is also of obvious interest, and should be discussed. In this respect it is disappointing that AFMA (2008) contains no discussion of an important recent scientific study by Dr Rodrigo Bustamante and colleagues: *Effects of trawling on the benthos and diversity of the Northern Prawn Fishery*. The study's report was scheduled for publication in September 2008¹¹⁵.

Another serious deficiency relates to sawfish. Sawfish were identified as species of concern by AFMA (2002b) and DEH (2003). Of the four species in the region the narrow sawfish and green sawfish are most often caught in the NPTF. The discussion in the second assessment report indicates that these species have been re-classified from 'high risk' to 'medium risk' - however the quoted reference deals only with the *direct* bycatch of the NPTF. A study addressing the cumulative impacts of several northern fisheries on elasmobranch species was available to AFMA, yet this report – strangely – was neither discussed nor cited. Salini et al. (2007:125) found that *none* of the four species was sustainable as bycatch in any northern fishery when cumulative impacts were taken into account (other than, of course, those fisheries which do not catch these species¹¹⁶). This oversight – or deliberate omission – within the second assessment report warrants an explanation. It also raises the obvious question – which again needs to be addressed – of how many species now in the 'moderate' risk list will move to a high risk grading when cumulative effects are taken into account?

According to FishBase, the primary known range of *Pristis clavata*, the dwarf sawfish, is northern Australia, although it may be more widely distributed in the Indo-west Pacific in estuarine and shallow marine environments. Its IUCN status is critically endangered. *Pristis microdon*, the freshwater or largetooth sawfish, ranges from east Africa to northern Australia and southeast Asia, in freshwater, brackish and marine environments. Its IUCN status is critically endangered. *Pristis zijsron*, the green or longcomb sawfish, has a similar range to *Pristis microdon*, occupying shallow fresh, estuarine and marine environments. Its IUCN status is critically endangered. The most common species in northern Australia, *Anoxypristis cuspidata*, the narrow or knifetooth sawfish, has a similar range and habitat preference to *Pristis zijsron*, also using fresh and brackish environments. Its IUCN status is critically endangered. While the dangers presented to these species by the NPTF must be addressed and managed, it should be noted that the chief threat appears to come from legal and illegal shallow-water gillnet fisheries along Australia's northern coastline (Salini et al. 2007).

The list of 'species at risk' in AFMA (2008:31) does not fully reconcile with the list of elasmobranchs found to be at risk in Zhou & Griffiths (2008:65), and this should be explained. Notably *Squatina* sp. A (an angelshark) is listed by Z & G in the 'extreme risk' category, but is not listed by AFMA (2008). Notably Z & G found 19 species of elasmobranchs in risk categories medium or above: this should be born in mind in the discussion below. It is also important to note that Z & G's study does not take into account cumulative fishery mortality in other regional fisheries, such as the fishery trawl, and coastal gill net fisheries (both legal and illegal) – and thus substantially underestimates risks for some fish.

Another (less serious) deficiency in AFMA (2008) is the omission of a discussion of bycatch species mis-identification. Some species are readily mis-identified, and in the cases of two sharks this is an issue of concern. These sharks, *Glyphis* sp. A and *Glyphis* sp. C appear to be restricted to rivers and estuaries in northern Australia, although the adults may penetrate into deeper marine waters and thus become vulnerable to trawling. They are similar in appearance to more common whaler and bull sharks, and misidentification is likely without proper training (Stevens et al. 2005). Both are listed as critically endangered by the IUCN, and due to their restricted habitat and high vulnerability to gillnet, trawl and line fisheries, are in imminent danger of extinction.

The second assessment report does identify 11 'high risk' species; five being discards and six being byproduct (AFMA 2008:31). These species warrant detailed discussion particularly in terms of their spatial occurrence and vulnerability to fishing – and thus susceptibility to remedial management. Of particular interest would be different catch rates in the banana and tiger prawn fisheries. Without this discussion the reader is left to conclude that the continued pressure placed on these species by the NPTF may lead to their extirpation or ultimately to their extinction – a matter of the most serious concern. The reader, however, is left without the background information needed to evaluate possible remedial management strategies.

Measuring improvements in fishery performance:

Here the important issue is *trends over time*. If population levels of all species were stable, bycatch levels in the NPTF should fall if overall fishing effort falls, noting however that fleet reductions do not always achieve the expected reduction in effort (Dichmont 2006). However species populations, even under unfished conditions, are seldom stable. Moreover, if a bycatch species is highly impacted by fishing, strong population declines may result.

Recent low bycatch of turtles is reported in the second assessment report (AFMA 2008) and this is a good result. However trends in other critical parameters should have been reported to enable the reader to assess and understand wider bycatch impacts. These include:

- areas trawled should be mapped by year over the last five years, and spatial variation in bycatch composition discussed;
- trends in bycatch/catch ratios over the last eight years¹⁷ (since the introduction of compulsory TEDs and BRDs) differentiating between the banana and tiger prawn sections of the fishery;
- spatial variation in bycatch/catch ratios over say the last five years, with a discussion including depletion effects based on data from independent surveys;
- trends in sawfish and other 'high risk' and 'moderate risk' bycatch since 2006, with spatial and temporal detail.

In a policy response to the *Ministerial Direction 2005*, AFMA committed itself to establish bycatch reductions programs aiming to halve 2005 bycatch levels in all Commonwealth fisheries by 2008 (AFMA 2005). The second assessment report should have presented a progress report for the NPTF. Exactly what degree of success has been achieved in meeting this target? Presumably the information is available to AFMA, as the Commonwealth's *Policy on Fisheries Bycatch 2000* committed AFMA to "monitoring changes in the level and composition of bycatch over time." These important policy commitments (to measure trends and to achieve a specific reduction) are not even mentioned in AFMA (2008). While bycatch

ratios tell little about risks to individual species, they are vital in identifying areas and times where bycatch problems are particularly bad (or good). Such a surprising omission raises serious questions over the competency of AFMA's report and the team which authored it.

Risk assessment of bycatch vulnerability:

A large number of species (~1400) appear in NPTF bycatch, as is typical in tropical trawl fisheries. They include about 900 species of megabenthos¹¹⁸, 450 teleost species and about 56 elasmobranchs. Species of particular conservation interest appear in bycatch, such as reptiles (turtles and sea-snakes) and syngnathids (seahorse, pipefish etc). The appearance of species in bycatch samples varies over space and time. Some species appear regularly, many are uncommon, while others appear rarely (Tonks et al. 2008) reflecting the relative abundances of different species (Blaber et al. 1990). Only a small portion of bycatch is carefully examined, and fishery-independent surveys are limited in coverage. Fisheries dependent survey data does not have the ability to rapidly detect declines in uncommon species¹¹⁹ (Heales et al. 2007). The continuing removal of these animals over substantial areas poses two general questions of considerable importance: (a) what damage is being done to populations of individual species? and (b) what are the ecological effects of their removal?

CSIRO studies have attempted to address the first question by using risk assessment approaches; however these studies have generally focused only on the impacts of the NPTF and do not consider cumulative impacts from all regional fisheries¹²⁰. The second question has not been addressed due to its complexity – with the exception of general observations and discussions on discard effects – such as support for scavenging species (Hill & Wassenberg 2000, 1990; Blaber et al. 1995). Zhou (2008) has argued that the removal of the most abundant discard species (small resilient teleosts) is likely to benefit prawn populations through reducing competition and predation. While having some validity, this argument needs to be discussed within a larger perspective incorporating scientific uncertainty, habitat damage, poorly-understood complex ecosystem interactions, threats to particular species and populations, the cumulative impacts of different fisheries, ethical issues of respect for life, and the poor performance of fishery management so far in applying basic precautionary and ecosystem approaches (see below). In identifying species, populations and communities 'of concern' there are clearly major problems related simply to the scope of current studies – and the reliability of the knowledge base which they provide (discussion above and below).

Given this situation, it is disturbing to see the narrow focus of the discussion of bycatch vulnerability presented in AFMA (2008). This discussion provides no useful information on the importance of cumulative impacts on individual bycatch species, or on wider ecosystem, population or community impacts. Discussion of risk to invertebrate species is cursory and inadequate. Where species data on vulnerability is presented, it is restricted to a list of 11 'high risk' species, and contains no listing and no discussion of 'moderate risk' species. Some of the moderate risk species are in considerable danger when cumulative effects are taken into account (see discussion on elasmobranchs elsewhere in this Chapter) to say nothing of risks to ecosystem function or individual populations and the genetic diversity they carry.

The essential point is that the risk assessments conducted with available information are highly uncertain, even within the limited framework of the studies themselves. While some of the uncertainty can be accounted for where probabilities can be assigned to a range of variable values, in other important areas uncertainty cannot be estimated reliably – and must be ignored within the methodology. However, to ignore the importance of unresolved uncertainty in actually applying the results is dangerous in the extreme – and this is what the AFMA second assessment report does, in effect, by restricting its listing of vulnerable bycatch to 'high risk' species.

The importance of unresolved uncertainties can be illustrated by considering some of the underlying assumptions of the SAFE risk assessment approach (sustainability assessment of fishing effects) used by the CSIRO (Zhou et al. 2007). In an earlier paper on the same

subject, Stobutzki et al. (2001:167) had stated: “The final ranking of the species must be used with caution because of the assumptions made in the process.” The SAFE technique was developed for the rapid assessment of target and bycatch species in data-poor fisheries, and is valuable when results are used in the context of the method’s limitations. The method produces four risk grades: low, medium, high and extreme (Zhou et al. 2007:x) primarily on the basis of estimates in natural mortality and fishing mortality.

In applying the SAFE method to the NPTF (Zhou et al. 2007) a number of simplifying assumptions were necessary. These assumptions, however, introduce unresolved uncertainties:

- a “fished area” was defined making up 6% of the NPTF management zone. The difference between this figure and the figure used by Larcombe & Begg (2008) to represent the ‘actively fished’ area – 29%, should be noted¹²¹. The explanation for the difference appears to lie in defining areas by fishing intensity;
- fishing intensity is assumed to be uniform within the defined fished area. This assumption is known to be incorrect;
- due to sparsity of data, amalgamation of records over the full period – 24 years, was necessary. It was assumed that the relative abundance of each bycatch species in fished and unfished areas remained constant throughout these 24 years. This assumption is known to be incorrect;
- ocean temperature is needed in calculating natural mortality, and was assumed to be 28°C throughout the entire NPTF zone, over 24 years, at all depths. This assumption is known to be incorrect;
- the NPTF zone was divided into five areas by IMCRA¹²² bioregion to give broad surrogates for habitat/community. It should be noted that the updated 2005 marine bioregionalisation, as discussed above, provides more reliable and accurate detail on habitats, but is incomplete, and so was not used. Fished and unfished areas were allocated to each bioregion;
- Fish distribution was modelled by random distribution of individuals into fished and unfished areas within each bioregion. In reality, fish distribution will be far from random, and will be related to habitats at a scale missed entirely by the IMCRA regionalisation;
- populations of bycatch species are assumed to lack structure; discrete isolated populations, or metapopulations. This assumption is likely to be incorrect for some species, especially those whose life-cycles are partly based in estuarine or freshwater environments, and have relatively short larval stages;
- it was assumed that the probability of capture of a particular species remains constant across all surveyed grid cells within each bioregion; this assumption will not hold in reality for the reasons discussed above; and
- where species-specific catch rates were available they were used; where they were not available they were estimated from the catch rates of another species in the same genus: this assumption will not hold well in many cases, but had to be used in the absence of species-specific data for many bycatch species.

Establishing bycatch reference points and decision rules:

While the effects of assumption inaccuracy (above) cannot be calculated in most cases, they must be born in mind when applying the study findings. Under the precautionary principle, increased uncertainty calls for increased caution (Appendix 2). As already discussed, lack of information on cumulative impacts introduces another major uncertainty. Bearing this in mind, how should the results of the risk assessment be used? Could the study’s risk categories be used to establish bycatch target and limit reference points? The SAFE risk categories are (Zhou et al. 2007:page x):

Low risk: fishing mortality rate u is less than U_{msm} ;

Medium risk: fishing mortality rate is greater than *Umsm* but less than *Ulim*;
High risk: fishing mortality rate is greater than *Ulim* but less than *Ucrash*;
Extreme high risk: fishing mortality rate is greater than *Ucrash*.

Where three reference points are defined: (1) *Umsm*--fishing mortality rates corresponding to the maximum sustainable fishing mortality (MSM) at *Bmsm* (biomass that supports MSM, which is equivalent to MSY for target species); (2) *Ulim*--fishing mortality rate corresponding to limit biomass *Blim*, where *Blim* is defined as half of the biomass that supports a maximum sustainable mortality; and (3) *Ucrash*--minimum unsustainable fishing mortality rate that, in theory, may lead to population extinction in the long term (Zhou et al. 2008:page x).

Again, making assumptions which do not hold in practice, the traditional assumption of single-species logistic growth implies that a species at *low risk* will maintain its population at 50% of the 'pristine' unfished level or better. A species at *extreme risk* is destined, sooner or later, for extirpation or extinction.

How could risk categories be used to establish reference points? Given the irreducible uncertainties involved, decisions can only be arbitrary, but they can lie within a logical framework. Suppose we wanted limit and target reference points which would ignore precaution and ecosystem effects, but would seek to save bycatch species from extinction. In this case a 'target' strategy might be to keep all bycatch species below the high risk level, and a 'limit' strategy might be to stop local fishing if a bycatch species reached the 'extreme risk' level.

Bearing uncertainties (including cumulative impacts of all relevant fisheries) in mind, such a strategy would certainly not be precautionary. Taking uncertainties and the need for caution into account, an improvement would be to set a target to keep all bycatch species 'medium or better', and a limit strategy to halt local fishing if a bycatch species reached the 'high' risk level.

Such a strategy might embody a minimum of precaution, but it would not provide even the most basic ecosystem safeguards. CCAMLR's management of the Southern Ocean krill fishery, where ecosystem effects have been carefully considered, is to maintain krill populations at or above 75% of unfished biomass (Kock et al. 2000, 2007). Practical application of the above reference strategy would see some, perhaps many, bycatch species populations reduced to 20-30% of their unfished biomass – or worse if species interactions are high (see discussion in Zhou et al. 2007:112).

The next step should be to maintain a precautionary stance, but also make a more substantial allowance for ecosystem structure and function. This would involve a target reference point strategy to maintain all bycatch populations at or below the 'low risk' level, and set the limit strategy at halting local fishing activities involved in the take of 'medium risk' species. Application of this strategy would, in practice, try to maintain all bycatch populations above 50% of their unfished biomass – even this is hardly progressive by CCAMLR standards, or by the standards of authors who recommend that both target and bycatch species be managed by limit reference points based on population MSY (see the reviews in Chapters 7 & 8 above).

A variation of this approach, which might find more support within the industry, is to base bycatch management on three reference points, or 'traffic lights'. First, a *target* of keeping all bycatch species populations at or below the 'low risk' level would see routine annual bycatch monitoring conducted, with the reporting of findings in temporal and spatial detail. An annual report showing all bycatch species at low risk would signal 'green'. A *warning* reference state, or orange light, would be signalled if one or more species reached the medium risk level. A decision rule would trigger detailed investigations of the state of specie populations, and the development (within a 12-month period) of spatial and/or temporal restrictions to limit bycatch of this species. A *limit* reference state, or red light, would be signalled if one or more species reached the high risk level. A decision rule would put an immediate halt on fishing activities in the grid cells, or local habitat surrounding the grid cell where the animal was

caught. Compliance issues of course need to be considered, noting that the 2005 Ministerial Direction to AFMA encouraged the use of remote on-board surveillance of deck operations.

BRD design and configuration:

The design of the mandatory bycatch reduction device, and its placement within the trawl net both strongly influence the efficiency of bycatch ejection. Tests over a period of several years have shown that the point of location of the BRD (distance from the codend) is critical (Raudzens 2007; Brewer et al. 2006; Gregor & Wang 2003). Placement at distances greater than 66-70 meshes from the codend strongly increases the capture of bycatch. Here it should be noted that the legal distance for placement is up to 120 meshes (AFMA 2008b:22). Table 11.1 compares two BRDs (Fisheye and Square Mesh Panel) located at differing positions from the codend.

Year	BRD type	Position	Difference from standard net (%)			
			Snakes	Bycatch	Prawns	No.of trawl
2004	SQMP	120	- 7.0	0.2	0	156
	SQMP	--	- 4.9	- 7.1	0.4	173
	Fisheye	30	1.7	- 25.6	- 0.7	271
	Fisheye	66	- 50.0	- 19.2	- 0.1	282
	Fisheye	120	- 33.3	- 4.5	0	92
2005	SQMP	120	- 27.2	0	1.4	107
	Fisheye	66	- 43.5	- 17.0	- 2.3	165

Source: Milton et al. (2008:118)

Table 11.1 *Bycatch and prawn catch for Fisheye and Square Mesh Panel BRDs.*

Table 11.1 demonstrates that the Fisheye BRD, placed at 66 meshes from the codend, is remarkably effective at ejecting the bycatch which gets past the TED – particularly with respect to sea snakes. However, its effect drops off dramatically when placed too close or too far away from the codend.

Heales et al. (2008:76) reported on tests of the Yarrow Fisheye BRD: it “reduced the weight of small bycatch by a mean of 22.7%, with no loss of tiger prawn. ... Sea snake catches were “reduced the catches by a mean of 43.3%.”

Bycatch of sea snakes is an important issue. Sea snakes tend to have low natural mortality and low fecundity, are vulnerable to capture by the NPTF (Milton et al. 2008), and have high mortality (~50%) (Wassenberg et al. 2001). Although available evidence indicates that no species is directly threatened by the fishery at this stage, information is not available on population structure which could demonstrate that species genetic diversity is not at risk – and the cumulative impacts of other fisheries have not yet been taken into account. A precautionary approach requires all reasonable steps should be taken to minimise the bycatch of sea snakes.

Although AFMA have been aware of the importance of BRD placement for several years, and in spite of AFMA’s commitment to reduce bycatch levels to half of the levels measured in 2005, the second assessment report (AFMA 2008a) entirely omits a discussion of this important issue. Moreover, it appears (from AFMA 2008b) that the Authority has taken no steps to change the mandatory BRD prescriptions to require BRD placement at the optimum location of 66-70 meshes. As Dichmont (2006) observed, AFMA management appears characterised by considerable inertia.

Ghost fishing:

Another issue which should have been addressed by the second assessment report (AFMA 2008) is that of ghost fishing by lost or discarded nets. Northern prawn fishers are required,

by AFMA, to mark nets with metal identification tags, and to report net losses. A brief discussion of reported losses, their location, and their possible effects, should have been presented.

Does trawling improve or degrade prawn habitat?

Another issue which the second assessment report should have addressed is the effect of trawling on prawn habitat.

Some fishers believe that trawling improves habitat from the prawn's perspective. This is certainly possible if the changes created by trawling (benthos and bycatch removal and addition of discards) increase (directly or indirectly) prawn food supply (perhaps by encouraging the growth of small opportunistic species on which prawns prey). Effects could also appear if trawling significantly decreases competition or predation. At this stage there appears to be no direct evidence for this proposition (Haywood et al. 2005:240) noting however that a study of flatfish in the North Sea reported higher growth rates in trawled areas – confirming general speculation on possibilities.

According to Poiner et al. (1998:s4) "Each [prawn] species tended to aggregate in particular areas that were different between species. Substrate type and rugosity of the seabed were the main features affecting the distribution of prawns." Substrate type will probably not be affected by high intensity trawling, but rugosity might be. A question arises: does high intensity trawling over substantial periods of time affect surface rugosity (roughness), and if it does, does that improve or degrade the value of the habitat for prawns?

If degradation is likely or possible, what are the management implications of this finding? If trawling improves habitat for prawn populations, what is the mechanism, and what are the management implications? These important questions should have been addressed in AFMA (2008).

Compliance enforcement

Compliance cannot be taken for granted. Even in Australia, where fisheries are often perceived to be well-managed, there is ample evidence not only of non-compliance, but of cultures of non-compliance. For example, Poiner et al. (1998:s2) in a study of prawn trawling in the Great Barrier Reef World Heritage Area reported:

...there has been a high level of illegal trawling in the Green Zone and evidence that 40 to 50 boats regularly trawl the area. Misreporting of catch has taken place with catches from inside the Green Zone being credited to adjacent open areas.

Discussing the same issue, Gribble & Robertson (1998:53) reported that illegal prawn trawling amounted to an average of 69 days each year per vessel. This is not an example of one or two "bad apples" – non-compliance on this scale is the result of a culture amongst commercial fishermen that it is acceptable to break the law providing you don't get caught. Cultures of non-compliance will arise where absence of enforcement is predictable¹²³.

11.4 Changing the rules and the facts:

Quantitative performance measures are desirable for any organisation sincerely interested in continual improvement, or interested in meeting specific targets or commitments. However, for an organisation without such commitments, quantitative targets simply expose poor management and operational performance.

As mentioned above, in a policy response to the *Ministerial Direction 2005*, AFMA committed itself to establish bycatch reductions programs aiming to halve 2005 bycatch levels in all Commonwealth fisheries by 2008 (AFMA 2005). For a fishery with serious bycatch problems, like the NPTF, such a move was welcome, and seemed to signal a sincere commitment by management to reduce the fishery's bycatch impacts.

However, two years later, AFMA published its *Bycatch and Discarding Implementation Strategy 2007* (AFMA 2007). “This policy no longer includes any fixed targets for bycatch reduction” (AFMA 2008e:12).

The 2007 bycatch strategy also moved away from another important commitment. The *Commonwealth Policy on Fisheries Bycatch* (Commonwealth of Australia 2000:5) stated: “Decisions and actions to address bycatch will ... use robust and practical *biological reference points* relating to bycatch, where possible, to make decisions on bycatch management. Where the use of biological reference points is not feasible, the precautionary principle will be used as a basis for decision making.” [emphasis added]. According to AFMA (2008e:14): “Under its Bycatch and Discarding Implementation Strategy, AFMA aims to minimise interactions and catch of bycatch species, so the use of target and limit reference points is not appropriate for these species...” This statement appears to signify both a retreat from measurable benchmarks, and something of a retreat from logic.

The removal of quantitative performance benchmarks also characterised the development of the Commonwealth’s own sustainability guidelines (Nevill 2004).

While rules can be changed to disguise poor management, facts can also be changed – through exaggeration, or through distortion, – and AFMA have provided examples of these approaches.

As mentioned above, AFMA adopted the pursuit of Maximum Economic Yield (MEY) as a management objective for the NPTF in 2004. According to AFMA (2008e:11): “The MEY-based harvest strategy also keeps overall effort levels well below the Harvest Strategy Policy proxy of 1.2Bmsy.” This statement is a misleading exaggeration. A perusal of Figure 11.5 below shows that, for example, fishing effort for brown tiger prawns has been in excess of that required to meet the proxy value since 2004, while fishing effort for grooved tiger prawns has remained at a level such that the proxy has barely been met since 2004.

AFMA (2008e:13) suggest that prawn stock levels will “ultimately” exceed 70% of virgin biomass under current management arrangements, citing Dichmont et al. (2008) as a reference. If MEY can be achieved on all prawn stocks then this prediction (equivalent to ~1.4Bmsy under an assumption of logistic density dependence) is correct by Dichmont’s calculations. However, tiger prawn stocks (see Figure 11.4) have not been near this level since the early 1970s, and so far show no substantial trend to return to this level. It should also be noted that AFMA’s recent headrope increase allowance – aimed at increasing effort using the current fleet size, appears premature in terms of achieving MEY across the fishery.

In stressing that shallow habitats are not at risk from trawling, (AFMA 2008e:9) stated that “trawling stops at 8 metre”. However, Haywood et al. (2005, Figure 5.1-4) show that trawling has taken place in depths of around 5 metres – and presumably could do so again.

Facts can be distorted if scientific findings are presented without discussion of the limitations or caveats of the study. Several of AFMA’s important accreditation documents are noticeably devoid of references to source material, as already noted above. However, even when citing findings from a specific report, AFMA cannot be relied upon to describe limitations or caveats accurately. In discussing the findings of Heywood et al. (2005), AFMA (2008e:7) report that:

The authors concluded that due to the selective nature of the trawl, the small proportion of the fishery that is trawled, and the low proportion of attached – and therefore most vulnerable – taxa, the overall impact of trawling in the NPF is low.

The Haywood report was substantially based on trawl recovery trials undertaken at two sites near Mornington Island (Figure 11.3) in the southeastern Gulf of Carpentaria. The sites had been trawled previously, but vessel log data and VMS (available from 1999) indicated no trawling in the last several years. There were 3 trawled locations in each area. At each location there were three lanes (1 km x ~70 m) that were trawled 0, 4 or 20 times. Within each area the locations were between 2 to 8 km apart. The area of the sites sums to 0.4 km²,

compared with the area of the NPF of 771,000 km² or the 'actively fished' area of 220,000 km². The sites represent 2 seabed facies (Figure 11.2). The study had substantial limitations due to the fact that the sites had been previously trawled, the small size of the sites, the limited representation of facies among many in the NPF, and the statistical power of the monitoring regime, which was fairly low. According to (Haywood et al. (2005:3-16):

Given the small proportion of the fishery that is trawled, the selective nature of the trawl and the low proportion of attached – and therefore most vulnerable – taxa in the study area around Mornington Island, we conclude that the overall impact of trawling in this region is low. It is likely that the composition of the benthos in other areas of the NPF is quite different to that in the Mornington Island region. In areas having a higher proportion of sessile biota, the impacts may be more significant.

By 'region' Haywood et al. (2005) appear to be referring to bioregion – likely to be a relatively small proportion of the total NPTF area (see Figure 11.2 above, read in conjunction with IMCRA Technical Group (1998)). It should also be noted that, due to limitations listed above, and the high level of background variation in benthic biota, Haywood et al. themselves placed important general caveats on the wider applicability of their findings.

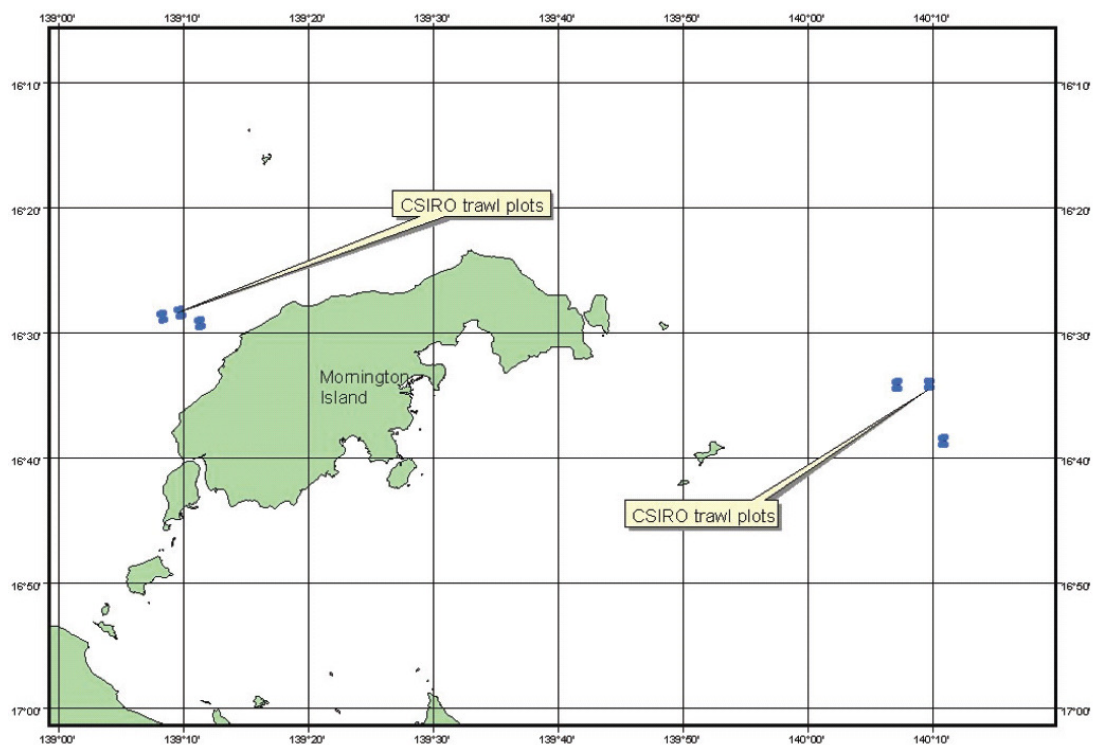


Figure 11.3: CSIRO trawl plots groups (a) west, and (b) east of Mornington Island. Refer to Figure 11.1 above for the location of Mornington Island in the southern Gulf of Carpentaria. Source: Haywood et al. (2005:5-37).

Other examples may be found relating to full and open disclosure of information. Management inertia may be illustrated, for example, by the 20-year delay in introducing mandatory turtle excluder devices, or the seven-year delay in addressing overfishing of tiger prawn stocks (Dichmont et al. 2007:225). There has been a long delay in translating the findings of BRD experiments into management arrangements (discussed in more detail elsewhere in the chapter). However, AFMA (2008e:7) state: “*The fishery also has an excellent record of incorporating the results of research into the management of the fishery in a timely manner*” (emphasis added).

These examples indicate that AFMA’s credibility and integrity do not withstand scrutiny.

11.5 Benchmark assessment: precautionary, ecosystem and adaptive approaches:

The benchmarks used below are derived chapters 7, 8 and 9 above.

Each benchmark is scored as follows:

- 0 – no evidence of policy or implementation;
- 1 – policy in place or partially in place; no significant implementation at this stage;
- 2 – policy in place; evidence of partial implementation;
- 3 – policy in place; evidence of substantial implementation.

Table 11.2 The precautionary approach in the northern prawn fishery:

	Benchmark	Assessment
A1	Management strategies and plans contain clear objectives, indicators and performance targets relating to the protection of: target stocks, populations of dependent and associated species, and habitat.	Score 0.5 A 2003 recommendation to develop “detailed objectives, performance criteria, and performance measures” within the fishery management plan has not yet been implemented (AFMA 2008). Although the fishery is managed with the objective of MEY, the link between this objective and catches of the different prawn species has not been explained in either AFMA (2008) or Larcombe & Begg (2008). Habitat protection objectives, indicators and performance targets need to be established.
A2	Fishery management plans use pre-agreed decision rules based partly on limit reference points equivalent to, or more conservative than, both target stock MSY and bycatch population MSY for the most vulnerable species of bycatch.	Score 0. The fishery was using a tiger prawn limit reference point of B_{MSY} , however this was replaced in 2008 with a limit reference point of 0.5 S_{MSY} , accompanied by the adoption of a decision rule to cease fishing at the limit reference point (Larcombe & Begg 2008:31). The fishery has only one other effective decision rule, which allows seasonal extensions depending on prawn catch levels.
A3	Undesirable outcomes which could result from excessive fishing pressures are identified, and monitoring programs are in place with sufficient power to rapidly detect these changes should they occur.	Score 1. Stock assessments are undertaken for the principal prawn species. Three ecological risk assessments have been undertaken in 2001, 2007 and 2008 (listed in AFMA 2008:32) which identify undesirable outcomes. The statistical power of ecosystem/bycatch monitoring programs is not addressed in AFMA (2008) although it is a critical issue ¹²⁴ .
A4	The risks to ecosystem health and integrity are assessed for each major fishery, and additional caution applied to management programs for high-risk fisheries	Score 1. Three ecological risk assessments have been undertaken in 2001, 2007 and 2008 (listed in AFMA 2008:32) and studies continue into both bycatch and benthic impacts. Precautionary actions were taken prior to the 2002 assessment, for example regarding area closures and requirements for TEDs and BRDs. The fishery causes damage to benthic ecosystems, catches far more bycatch than product, and appears to threaten the viability of a number of marine species. The fishery is ‘high risk’. The AFMA (2008) second assessment report should have described in some detail additional precautionary measures (and their effectiveness) undertaken since 2003. Current treatment of <i>at risk</i> species does not appear to be precautionary (see above).

Table 11.2 Precaution I the northern prawn fishery (continued).

	Benchmark	Assessment
A5	Independent peer review is used as quality assurance for major management policies, strategies and plans.	Score 1. Effective peer review needs to be independent and transparent – review reports need to be public. AFMA does use peer review in developing some stock models or assessments (AFMA 2002b:43) however these reviews appear to fail the transparency test. Major strategies: for example AFMA's recent Harvest Strategy do not appear to have been subject to independent peer review (Commonwealth of Australia 2007:ii) but were opened for public comment, and used an expert steering committee. Neither of the prawn fishery assessment reports (AFMA 2002b, 2008) appear to have been peer reviewed. The fishery management plan does not appear to have had independent peer review. Major impact studies, such as Haywood et al. (2005) do not appear to have been peer reviewed ¹²⁵ .
A6	Management procedures provide for rapid response in the light of unexpected declines in target stocks, bycatch populations, or habitat value. Such provisions provide for fisher compensation where necessary.	Score 0.5 One of the fishery's two current action-oriented decision rules applies to limit/extend the second harvest season in the event of low/high prawn catches in the early part of that season. This is a rapid response, where the timeframe for action is weeks. According to AFMA (2002b:54-55) the fishery management plan provides for rapid response, with possible 'emergency' closures applied in only three weeks. Have these provisions been used? AFMA (2008) supplies no information. However, with regard to other important matters, the fishery has not demonstrated an ability to respond rapidly. AFMA have failed to implement a number of important recommendations made by DEH (2003) in the first accreditation report, in spite of a pointed request that they be acted on by 2008 (see discussion above). Long-standing declines in king prawn stocks have not been adequately investigated or managed, or if they have, reporting in AFMA (2008) is inadequate. Although sawfish were identified as bycatch species of concern in 2002, logbook reporting was not introduced until 2006. The fishery operated without TEDs and BRDs for two decades after the development of TEDs in the USA, before the NPTF management acted to mandate their use in 2000. TEDs were made compulsory by the US government in shrimp fisheries in 1987 ¹²⁶ , ten years before the NPTF fishery implemented controlled trials of TEDs. According to Dichmont (2006), it took NPTF management seven years to address identified overfishing of brown tiger prawn stocks.

Table 11.3 The ecosystem approach in the northern prawn fishery:

	Benchmark	Assessment
B1	There is formal periodic assessment of the impacts of particular fisheries against agreed objectives, including ecosystem-based objectives.	Score 2.5 The five-yearly assessment and review processes under the provisions of the EPBC Act meet this criteria. The effectiveness of the review is open to question (see discussion).
B2	There is monitoring and reporting of agreed ecosystem indicators based on stated ecosystem objectives.	Score 1.5 Ecosystem-based performance criteria and ecosystem indicators have not yet been built into the fishery management plan – although there is an intention to do so (see above). Bycatch of turtles and sawfish are recorded, and bycatch counts of sea snakes and syngnathids are recorded. Scientific observers record ‘other elasmobranches’ but do not at this stage record other bycatch species identified as ‘at risk’ (AFMA 2008:19).
B3	There is a substantial program in mapping, protecting and monitoring critical and vulnerable habitats, funded by the fishery agency or responsible government.	Score 1.5 All known areas of seagrass meadow are protected from prawn trawling by fishery regulations: these are important prawn nursery areas. The Commonwealth Government, through its regional ocean planning process (initiated under <i>Australia’s Oceans Policy 1998</i>) intends to identify and protect representative marine ecosystems, and habitat mapping is being undertaken as part of this exercise. However, as discussed above, there appear to be considerable current gaps relating to issues of identifying and protecting habitat vulnerable to prawn trawling, as well as critical habitat for species identified as ‘at risk’ from trawling activities.
B4	There are effective programs in place to monitor and maintain old-growth age structure in specific fisheries.	No score. Not applicable to this fishery.
B5	The agency has a substantial program to account for evolutionary change caused by fishing.	Score 0. AFMA has no program to account for the evolutionary effects of the NPTF, either on target stock or bycatch; or, if such a program exists, it is not reported in AFMA (2008).
B6	There are effective programs in place to maintain the spatial extent of all major sub-populations (both target and bycatch) affected by specific fisheries, and maintain and monitor population genetic diversity.	Score 0.5 As noted, seagrass nursery areas are protected. Past this arrangement, populations at risk (including target, byproduct and bycatch) have not been identified and protected by targeted spatial closures; or if this has been done it has not been reported in AFMA (2008). Concern exists over king prawn stocks, and bycatch and byproduct species identified by risk assessment studies as being at ‘moderate’ or ‘high’ risk. Action needs to be taken in these areas. It should be noted that a project <i>Benthic trawling, biodiversity and ecosystem indicators</i> (under the direction of M. Burford and P. Rothlisberg) has been underway for several years, however AFMA (2008) contains no discussion of its preliminary findings.

Table 11.4 Active adaptive management in the northern prawn fishery:

	Benchmark	Assessment
C1	The performance of the fishery management agency itself is subject to independent periodic review against stated objectives, and quantifiable indicators and performance targets.	Score 3. AFMA, while not under independent periodic review, has been the subject of several reviews ¹²⁷ including a one-off independent review, and is under scrutiny from its 'policy' department ¹ (Agriculture Fisheries and Forestry) as well as through the reports of other agencies, such as the Australian Bureau of Agriculture and Resource Economics (ABARE).
C2	The management program uses mathematical modelling to pinpoint uncertainties and generate alternative hypotheses.	Score 0. There is no evidence of this activity.
C3	The assumptions behind the models are clearly set out and evaluated.	Score 0. There is no evidence of this activity.
C4	Reports incorporating the use of active adaptive management set out the bounding of management problems in terms of explicit and hidden objectives, and practical constraints on actions.	Score 0. There is no evidence of this activity.
C5	There are changes in management controls, designed to test clearly stated hypotheses, which are sufficiently large to reasonably produce detectable effects; the size of these effects is estimated in advance, and sufficiently powerful field surveys undertaken, and statistically examined to deduce the probabilities of both Type I and Type II errors.	Score 0. There is no evidence of this activity.
C6	Formal organizational requirements are established for evaluating and reporting the results of the experimental management strategies, both to managers and stakeholders.	Score 0. There is no evidence of this activity.

¹ AFMA does not develop Australian fishery policy; this is the responsibility of the Commonwealth Department of Agriculture, Fisheries and Forestry.

11.6 Discussion:

Attitudes towards fisheries damage to the marine environment have changed considerably over the last few decades, and continue to change. When the second Australian National Prawn Conference was held in 1984 (Rothlisberg et al. 1985) not a single paper in the 350 page proceedings dealt with the environmental impacts of the fishery. Today, the two great challenges the fishery faces are environmental and economic. Over the last few decades, habitat impact and loss of biodiversity have often been considered as the normal costs of seafood production. However, as the impacts of damage to coastal seas worldwide becomes more apparent, and continue to increase, the tide of opinion amongst fishery scientists, managers and other stakeholders is turning against destructive fishing practices.

Some scientists have proposed reversing the current situation – closing most of the seas, with only a small proportion, perhaps ~20%, open to intensive fishing (Walters 1998, 2000). According to Walters (2000): “A revolution is underway in thinking about how to design safe and sustainable policies for fisheries harvesting”. Fish stocks repeatedly declining in the face of modern management, major ecosystem damage, and an awareness of the degradation of global biodiversity resources call for a new approach. According to Walters: “Sustainable fisheries management may eventually require a reversal of perspective, from thinking about protected areas as exceptional to thinking about fishing areas as exceptional. This perspective is already the norm in a few fisheries, such as commercial salmon and herring net fisheries along the British Columbia coast”. Walters points out that, historically, many apparently sustainable fisheries were stabilised by the existence of ‘effective’ protected areas, and the erosion of these areas through adoption of new technology subsequently resulted in the collapse of the fishery. Russ & Zeller (2003), in their call for ocean zoning, reinforce Walters’ ideas. It may be that the coming decades will see destructive fishing practices phased out around the planet, and where they are not entirely phased out they will be greatly restricted in area.

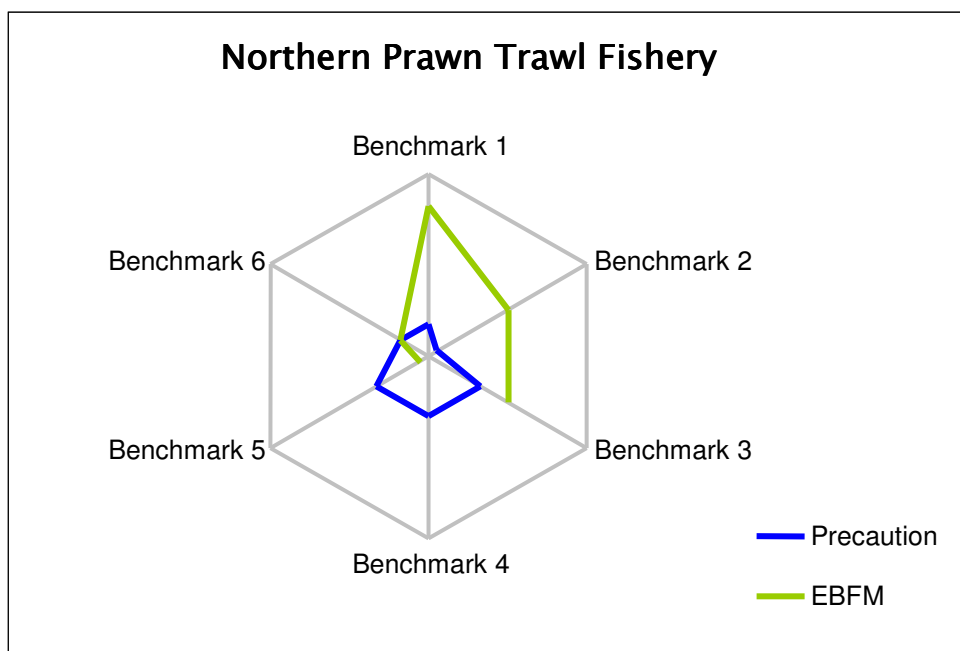


Figure 11.4. Kite diagram showing benchmark performance of the NPTF on precaution and ecosystem based management.

Australia’s northern prawn fishery is sometimes cited as demonstrating a high level of cooperation between fishers, managers and scientists (Dichmont et al. 2007). Some commentators see it as well-managed by Australian standards, and there is evidence that

the views of the fishery advisory committee (NORMAC) are considerably more progressive than those of AFMA.

Although overfishing has occurred, the NPTF fishery has so far escaped catastrophic output declines due to overfishing, after three decades of operation. Nevertheless a careful examination of the management of the fishery demonstrates major weaknesses, and at a practical level there is considerable room for improvement. A strategy which could perhaps make a major difference to the environmental impact of the fishery is to restrict the fishery to prawn aggregations rather than dispersed prawn populations. Fishing for dispersed prawns involves long trawls of about three hours (Tonks et al. 2008:277) which produce poor bycatch/catch ratios, and high mortalities even amongst bycatch groups with resistance to mortality. Fishing for dispersed prawns also has the highest costs to the fishery in terms of fuel, time and wear on gear. Long trawls cover more seabed than short trawls, and thus over comparable habitats are likely to cause more extensive damage.

Under the current assessment, the Northern Prawn Trawl Fishery scores 4/18 for adoption of precautionary management, 6.5/15 for adoption of the ecosystem approach, and 3/18 for adoption of active adaptive management. A low score in active adaptive management is not unusual – although the approach is often praised or advocated, enthusiastic implementation is rare worldwide. It should also be noted that the fishery has no formal commitment to the application of active adaptive management, other than that stemming from the Australian Government's endorsement of *Agenda 21* (Chapter 5). The fishery does employ passive adaptive management, but this is common-place even in poorly managed fisheries globally. With respect to the precautionary and ecosystem approaches, the Australian Government has formal commitments to their implementation dating back a considerable time.

Defining overfishing:

The international literature linking the precautionary approach with the use of biomass or spawning stock estimates demonstrates a broad consensus that B_{MSY} or S_{MSY} should be used as a *limit* not a target reference point (see Mace 2001, and Chapter 7. Despite the fact that AFMA is *required* to apply the precautionary approach under its legislation, the limit reference point for tiger prawns, endeavour prawns and king prawns has now been set at *half* S_{MSY} (Larcombe & Begg 2008:31) – in line with the Australian Government's harvest strategy policy (Commonwealth of Australia 2007).

A point of critical importance in regard to defining and identifying overfishing is that a level of fishing intensity which successfully meets traditional stock sustainability criteria (for example fishing a stock at maximum sustainable yield) is likely to be considerably higher than a level of fishing intensity which meets maximum economic yield criteria (Dichmont et al. 2008; Grafton et al. 2007) which in turn is likely to be considerably higher than a level designed to protect marine biodiversity (Jennings 2007, Walters et al. 2005, Murawski 2000, May et al. 1979). The wide endorsement of the *Convention on Biological Diversity 1992* implies that the latter level is the critical level by which overfishing should be measured.

The Australian Department of Agriculture, Fisheries and Forestry (DAFF), through its agencies of AFMA and the Bureau of Rural Sciences, continues to define overfishing in terms of a fishery's position in relation to MSY, where "overfished" is defined where stock biomass drops below half of B_{MSY} . The logic behind this definition is not explained¹²⁸. The term "overfishing" applies to any fishing below this level, or above this level to a fishing rate which is driving the stock towards this level (Larcombe & Begg 2008).

However the NPTF has set the achievement of MEY as a primary overall objective, and Dichmont et al. (2008) and Rose & Kompas (2004) have pointed out that the biomass necessary to achieve MEY is likely to be considerably greater than B_{MSY} – as discussed in the preceding paragraph. Using a modelling approach, Dichmont et al. (2008) estimate that MEY for the NPTF would be achieved at a general spawning stock level of $1.6 \times S_{MSY}$ for tiger prawns. For the purposes of this discussion the technical difference between the B and S indicators may be neglected. If logic dictates that measurement of the status of fishing level on a stock should be directly related to management's objectives for that stock, then a stock which has been fished below the MEY level ($1.6 \times S_{MSY}$) should be designated as overfished.

Moreover this logic takes no account of either the need for precaution, or the ecosystem approach, both of which, when accounted for, would recommend that B_{MSY} should be a lower limit reference point. While logic dictates an ‘overfished’ status for all NPTF stocks, the official government position is that none are designated as overfished.

Although the Australian government is committed to apply the ecosystem approach through its participation in the *Convention on Biological Diversity 1992* as well as its own *Oceans Policy*, Larcombe & Begg reach the conclusion that stocks of banana and tiger prawns “are not overfished or subject to overfishing” on the basis of the definitions discussed above – see Figure 11.5. If the balance of probabilities indicates biomass is around B_{MSY} , then biomass is well below B_{MEY} – and thus, by the industry’s own standard, the stock is overfished. *The official finding of “not overfished” contradicts the fishery’s MEY objective, and runs directly counter to Australia’s international commitments to apply the ecosystem approach.* Notably, Larcombe & Begg find that endeavour and king prawns are possibly (probably) overfished (using the same non-precautionary benchmarks) although stock estimates have a high level of uncertainty (L & B 2008:35).

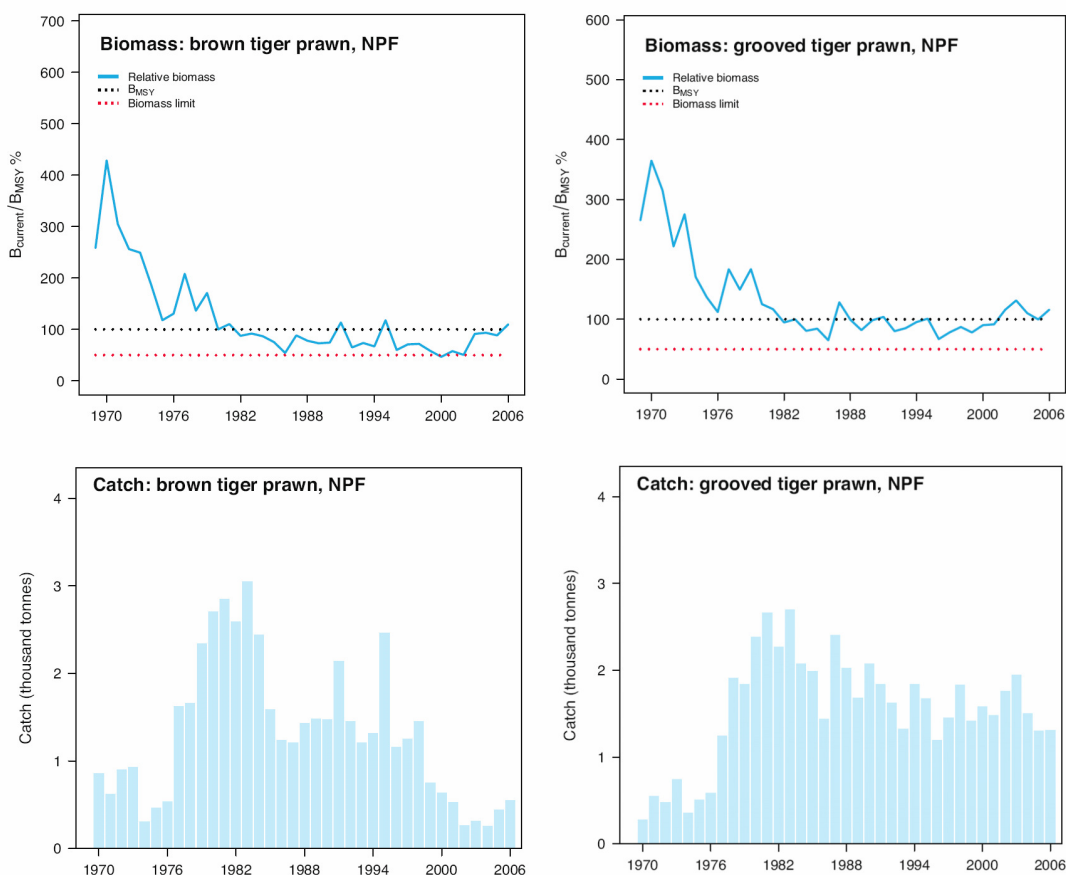


Figure 11.5. Catch and biomass of brown and grooved tiger prawns.

Blue line: relative biomass;

Dark blue dotted line: biomass equivalent to B_{MSY} ;

Red dotted line: biomass equivalent to half B_{MSY} – the limit reference point incorporated in the management regime in 2008.

Source: Larcombe & Begg (2008:33).

Adaptive management:

There are two obvious opportunities to apply active adaptive management to the NPTF. First, where banana prawns (or other target species) exhibit the characteristics of “a set of separate spatially bounded stocks” (Larcombe & Begg 2008:33) fine-scale management at the level of the metapopulation or sub-stock should be used as a means of investigating

uncertainties regarding recruitment and stock structure. Secondly, concerns are widely acknowledged over the status of king prawn stocks, and NPRAG has “concluded that seasonal closures in August had been beneficial for the king prawn species” (L & B 2008:35). In this light it seems surprising that the 2007 season was opened on August 1 in areas where king prawns are harvested. An adaptive management approach would use seasonal closures to investigate uncertainties regarding king prawn recruitment.

Destructive fishing practices:

The fishery remains a destructive fishery in terms of its bycatch and benthic impacts, and to some extent its byproduct impacts. It arguably qualifies as a ‘destructive fishing practice’ (for example by the standards of the Millennium Ecosystem Assessment 2005). However the Australian Government’s re-accreditation of the fishery implicitly finds against this definition – although without apparent consideration or explanation.

The Australian Government nevertheless needs to act on its commitment to phase out destructive fishing practices by 2012. Many fisheries around Australia, both commercial and recreational, can arguably be considered destructive. For example gillnet fisheries in some areas have high bycatch levels, including bycatch of endangered species (for example threatened elasmobranchs in gillnet fisheries along Australia’s northern coastline). Fisheries cannot be shut down overnight – phase out periods will undoubtedly be necessary in some instances. Action must be taken now – well before the 2012 deadline. An immediate need is to publish a discussion paper on the issue, with the objective of developing recommendations for a national strategy. A Commonwealth/State steering committee should be established under the direction of two lead agencies – DAFF and DEWHA (or alternatively under the single direction of the Commonwealth Department of Foreign Affairs). An advisory committee should be established to inform the steering committee and the staff preparing the discussion paper. AFMA, CSIRO and BRS should be represented on the advisory committee, along with representatives of State commercial and recreational fishing interests, and conservation and humanitarian groups.

The northern prawn trawl fishery regained accreditation in January 2009 in circumstances where it had failed to implement important conditions attached to the first accreditation in 2003.

The information gaps in AFMA’s second re-accreditation report (AFMA 2008) are sufficiently extensive and important (see discussion above) to warrant preparation of a supplementary report, however the timeframe of the process (see discussion below) precluded such an option. AFMA’s accreditation review (AFMA 2008) was essentially incompetent in many respects (see discussion above) and this fact, combined with the tight decision timelines, substantially undermine the integrity of the entire accreditation process. Ideally, a second report should have been prepared addressing the gaps in the first report, and this should have been provided to all stakeholders who had made submissions based on the AFMA (2008) assessment report, with an invitation to make further comment.

If re-certification is to be approved and the fishery is to continue indefinitely, I have argued above that major improvements and restrictions are needed in several areas:

- fishing for relatively dispersed prawns is likely to create higher bycatch/catch ratios compared with fishing prawn aggregations, for example for banana prawns. Long soak trawls are also energy intensive and are likely to disturb more benthic habitat. Serious consideration should be given to restricting or phasing out fishing for low-to-medium dispersed prawns.
- urgent investigation and protection of byproduct and bycatch species identified as at moderate or high risk, particularly where a species is caught as bycatch/byproduct in more than one Australian fishery. Cumulative impact assessments are required. Practical protection may involve the creation of substantial protected areas *by the fishery*¹²⁹ on an interim or temporary basis to protect critical habitat of species at risk. Such an approach may involve a loss of target or byproduct harvest;
- the establishment of substantial protected areas to compensate or balance habitat destruction in heavily trawled areas, or an alternative habitat protection regime of

rolling closures based on the recovery times for different habitat types impacted by the fishery. Such arrangements might not result in declines in fishery harvests, depending on how protected areas are chosen, and whether rolling closures improve prawn habitat values;

- better monitoring regimes to detect the environmental impacts of the fishery, or, if such regimes are unrealistically expensive, precautionary area closures could be used; here again such arrangements may result in reductions in fishery harvests. Where monitoring programs continue, the statistical power of the programs must be carefully considered and reported (with respect to both Type I and Type II errors) and precaution applied;
- increased allowance of annual prawn production for the ecological benefit of prawn predators – which could be an important benefit of the harvest reductions occurring from the above strategies;
- more comprehensive and more transparent reporting of fishery impacts (see discussion above – for example regarding bycatch/catch ratios, with spatial and temporal detail); the extent and nature of the fishery's benthic impacts; the condition of critical habitats¹³⁰; and the effects of trawling on prawn-preferred habitat;
- the establishment of bycatch/catch ratio targets and limit reference points, which should be progressively tightened over time. Decision rules should stop fishing activities immediately when limit reference points are reached. This approach could also use 'move-on' provisions (see below);
- immediate steps should be taken to change the NPTF statutory requirements relating to type and positioning of BRD (particularly the specified distance from the trawl codend; see discussion above) with the intent of implementing current knowledge of the efficiency of bycatch escapement;
- the establishment of explicit target and limit reference points¹³¹ relating to bycatch species (see discussion above). Where a limit reference point is reached (which might, for example, be the capture of a particular 'at risk' bycatch or byproduct species within a grid cell, a decision rule should stop fishing in that grid cell (or habitat patch if that data is available) immediately for the duration of the current season;
- addressing the same issue in the dot-point above, the possible benefit of move-on provisions triggered by the bycatch of 'species at risk' should be examined in the context of data on the spatial variation of this catch;
- active adaptive management should be trialled with respect to managing banana and tiger prawns on a metapopulation basis, and with respect to the protection of king prawns through spatial and temporal closures;
- the issue of serial depletion of prawn metapopulation stocks (component populations) needs to be specifically studied and addressed, possibly through the imposition of spatial controls over effort, as recommended by Dichmont (2006).

If the example of the Northern Prawn Trawl Fishery can be used as a yardstick, AFMA's attempts to apply the precautionary and active adaptive approaches to fisheries amount to little more than lip-service (in spite of AFMA's statutory duty to apply precaution). However a more substantial attempt has been made with regard to application of the ecosystem approach, although key elements or all three approaches are entirely missing from the NPTF management regime. Many years have passed after organisational commitments were made within Government to apply at least the precautionary and ecosystem approaches. The current level of progress is disappointing, and appears to imply less than full commitment by AFMA management to the statutory requirements under which they operate. It certainly implies neglect of some of the key goals embedded in the CBD, to which Australia is (on paper) a strong supporter (see, for example, the question of defining overfishing – discussed above and below).

Judging by the experience of CCAMLR (Chapter 10¹³²) there are three basic areas of action which should be immediately tackled in applying the ecosystem approach to any fishery: *bycatch, habitat damage, and predator allowance*. With respect to the issue of bycatch, the NPTF's most notable success has been in curtailing turtle bycatch; however action came many years late. The fishery has, however, continued serious attempts to address wider bycatch issues, both by risk assessment studies, and by the practical development of more effective bycatch reduction technology. More needs to be done with respect to spatial and temporal bycatch management controls, however. With respect to habitat damage, the fishery has sponsored research into habitat damage and recovery, however effective amelioration controls have yet to be taken. With respect to the allowance of a proportion of target stock productivity to support predation within the ecosystem, the fishery has done nothing¹³³. The issue of the ecosystem effects of bycatch removal has also not been addressed in any comprehensive way, although studies have addressed the biological impacts on populations of individual bycatch species.

An important issue is the way 'overfishing' is defined and measured. The analysis presented above suggests that the fishery has been overfished since 1980, and remains overfished and subject to overfishing – contrary to the views expressed in the 2007 fishery status report (Larcombe & Begg 2008). The fishery status report uses traditional criteria which have now been widely rejected within the international literature (Jennings 2007, Mace 2001). The two approaches to defining overfishing are very different. The traditional approach is simply to define overfishing in terms of B_{msy} – for example the current definition used by both AFMA and BRS is that a fishery is overfished if it is below half B_{msy} . But what, exactly, is the logic which underpins this approach? It is the logic of a now-discredited single-species fishery management paradigm. The second approach is to say that a fishery is overfished if a population has been reduced below a level necessary to achieve a stated management objective. The logic seems clear. In the case of the NPTF, populations are below levels necessary to achieve the core management objective: MEY (Dichmont et al. 2008). Fishing levels necessary to protect ecosystems, as required by the CBD, are lower still.

AFMA's assessment reports (AFMA 2002b, 2008) have many important omissions. The Australian Government's re-assessment timetable closed public comment on November 10, 2008, with the existing accreditation expiring on January 9, 2009. Taking the Christmas holiday into account, this timetable allowed, in effect, less than seven weeks for DEWHA to make a decision regarding re-accreditation. This tight timetable meant that a decision had to be made by the assessing officers in spite of whatever failings AFMA's assessment report contained – the timetable was too tight for AFMA to address major gaps in the report in any substantial way, let alone in a public fashion (eg: by publication of a supplementary report). The use of such tight timelines, as well as the fact that, since EPBC Act accreditation was introduced in 2001, no fishery has been refused accreditation, calls into question the independence of the whole accreditation process. Assessment of one Commonwealth Government Agency by another Commonwealth Government Agency is not, in practice, producing results which are transparently independent, or based on adequate information.

The fishery, in spite of great improvements, still catches excessive bycatch, and still causes extensive benthic damage – although for the most part this damage is concentrated on areas which have already been trawled (Haywood et al. 2005). Given historic benthic trawling damage, it can be argued that, at least where trawling is concentrated (hotspots for example) the important damage was done years or decades ago. However the long-term ecosystem effects of cumulative habitat damage remain unknown. Continuation of the fishery at current levels, assessed in conjunction with the threats posed by other northern Australian fisheries, appears to pose unacceptable risks to the long-term survival of some bycatch populations and even some species – and to some extent the habitats on which they depend. It can also be argued that the targeting of dispersed prawn populations, with attendant bycatch and habitat damage, can no longer be ethically justified.

11.7 Summary:

s1.1 The Northern Prawn Trawl Fishery is sometimes cited as a good example of co-management (Dichmont et al. 2007). Under AFMA's cost recovery policy, the fishery pays the substantial costs of government regulation. Moreover, the fishery has contributed many millions of dollars both to research, and towards the costs of industry re-structuring undertaken to maintain the industry's profitability. Through the fishery's management advisory committee, voluntary bycatch targets have been undertaken. The committee has also proposed progressive strategies such as seeking independent certification, and the development of an ISO-compliant fishery environmental management strategy. While these strategies have not come to fruition, they signal a proactive approach by the fishery. The Commonwealth Government, through agencies such as CSIRO and FRDC, is to be congratulated in supporting major scientific investigations related to the fishery over a long period of time. The scientific outcomes of some of these projects have been impressive.

s1.2 The environmental impacts of the fishery relate mainly to high proportions of bycatch and subsequent discarding, as well as the largely unseen impacts of the trawls on the seabed. These issues continue to cause serious concern relating to prawn and shrimp trawling worldwide (Gray et al. 2006). The trawls damage benthos, and repeated trawling may destroy benthic ecosystems – resulting in replacement with opportunistic species and communities (Burrige et al. 2003). While some benthic ecosystems in the NPF area may be adapted to disturbance from storms and cyclones, others (especially those in deeper water) are likely to be adapted to more stable conditions. Trawling also causes damage to small organisms which pass through the trawl net – many of which are killed or damaged. While the industry has adopted the use of turtle excluder devices (TEDs) and bycatch reduction devices (BRDs) major problems still remain.

s1.3 The fishery is managed by effort control. The primary stated aim of management is to achieve maximum sustainable economic yield (MEY), while minimizing environmental impacts. Stocks of brown tiger prawns have rebuilt to some extent following reductions in effort. However, there is evidence that (a) substocks of some prawn species have become seriously depleted, and (b) most stock levels remain well below the levels necessary to achieve MEY (Dichmont et al. 2008). Judged by the standards of the fishery's key objective, the fishery appears overfished, although overall stocks of tiger and brown prawns are above the Commonwealth Government's 'overfished' threshold of half B_{MSY} (Larcombe & Begg 2008). A precautionary approach to the assessment of endeavour and king prawn stocks, bearing in mind the uncertainties involved, suggests that these are overfished even by conservative standards (Larcombe & Begg 2008).

s1.4a The second re-assessment report (AFMA 2008) does not provide the reader with sufficient detail to understand the impacts the fishery has had (and continues to have) on benthic habitat, or individual species in this habitat. The total area of the NPF fishery zone is 771,000 km², of which 29% is 'actively fished' (Larcombe & Begg 2008). A much smaller proportion is intensively trawled each year, with trawls repeated over the same ground during each season (AFMA 2002b, 2008). The areas of habitat disturbance are substantial.

s1.4b AFMA's accreditation documentation contains examples where facts have been altered (through exaggeration, distortion, and plain falsification) to understate the environmental impacts of the fishery. The presentation of false and misleading information destroys any reputation AFMA may have for integrity or credibility.

s1.4c To assess and manage the habitat-related effects of prawn trawling, knowledge of the affected habitat is essential. Key questions are:

- what specific types of habitat are affected by trawling?
- how widely distributed are these habitat types?
- what communities and species occupy these habitats, and how well have they been surveyed?

- do these communities and species possess special values?
- how are the habitats, and their values, affected by trawling?
- to what extent do the habitats recover once trawling stops, and how long do the stages of recovery take?
- where are the habitats most vulnerable to trawling?
- to what degree are these habitat types and communities protected by no-take reserves, and where, and how large, are these reserves?
- where are the habitats of species at risk from trawling, and to what extent are important and critical habitats protected?

A discussion related to the need for this information is not contained in the second assessment report (AFMA 2008), and does not appear in the references cited by this report.

s1.4d With respect to habitat damage, it should be noted that the fishery has been operating since the mid-1960s, with an effort peak in the mid-1980s. Presumably the rate of habitat damage also peaked at that time. Given the fact that considerable historic habitat damage occurred, and that some areas trawled long ago would have recovered to variable extents, a useful exercise could be to identify habitats currently subject to no or very low levels of trawling, and to consider trawling bans in these areas. This would limit further damage.

s1.5 The second assessment report identifies 11 species of bycatch and byproduct which are at high risk from the fishery (AFMA 2008:31). However, this list does not take into account cumulative risk from other regional fisheries. The NPF zone contains substantial legal and illegal coastal gillnet fisheries, legal and illegal longline fisheries, and a small legal finfish trawl fishery. It is important that cumulative risks to NPF bycatch and byproduct species be taken into account. For example, the list of 11 species mentioned above does not contain any of the four species of sawfish found in the region; however, when cumulative effects are taken into account, all these species appear at high risk (Salini et al. 2007). It is also noteworthy that the risk assessment on which the identification of the 11 species was based does not account for population structure and a number of other variables – thus introducing additional uncertainty. I conclude that AFMA (2008) should have addressed the issue of cumulative impacts, and that the report should have listed both species at high risk *and* those at medium risk.

s1.6a The reporting of bycatch/catch ratios is important. Fishing dispersed prawn populations involves trawls of 2-4 hours, which, not unexpectedly, can produce high ratios. Fishing areas of aggregated prawns conversely should produce lower ratios, unless prawn predators also aggregate in the same areas. Even in these circumstances, the shorter net soak time will reduce bycatch mortality in some species. It is thus critical that bycatch/catch ratios be reported in both temporal and spatial detail, along with a discussion of the issue of fishing different densities of prawns. This discussion is entirely missing from the second assessment report (AFMA 2008).

s1.6b In a policy response to the *Ministerial Direction 2005*, AFMA committed itself to establish bycatch reductions programs aiming to halve 2005 bycatch levels in all Commonwealth fisheries by 2008 (AFMA 2005). The second assessment report should have presented a progress report for the NPTF in this regard.

s1.7 The Commonwealth Government supported the Johannesburg Outcomes Statement 2002 (United Nations World Summit on Sustainable Development) and in so-doing agreed to phase out destructive fishing practices from all Australian jurisdictions by 2012. The UN-sponsored Millennium Ecosystem Assessment 2005 identified both prawn/shrimp trawling, and deep-sea trawling over vulnerable habitats as destructive fishing practices. Although all Australian jurisdictions have outlawed a number of destructive practices such as blast-fishing and shark-finning, other practices remain in common use which may arguably be classed as

destructive fishing practices. Prawn trawling, with its high associated bycatch and habitat damage, is one such practice.

s1.8 In 2003 the Commonwealth Government issued accreditation for the fishery between 9 January 2004 and 9 January 2009 (Commonwealth of Australia 2003, AFMA 2008). This accreditation was accompanied by a list of 12 recommendations, which the Government clearly stated “will be implemented before the next review in 2008” (Commonwealth of Australia 2003:9). A number of important recommendations were not been implemented by the second accreditation review. The explanations for implementation failure/delay provided by AFMA (2008) lack sufficient detail, and in some cases appear to lack logic. A more thorough explanation should have been provided.

s1.9 Although the Australian Government is committed to apply both the precautionary and the ecosystem approach to the management of fisheries, no allowance has been made in current arrangements for support of prawn predators. By way of comparison, management of the krill fishery in Antarctic waters by CCAMLR aims to maintain krill fishing at levels which do not deplete overall krill stocks below 75% of their unfished levels – with provisioning of krill predators specifically in mind (Kock et al. 2000, 2007). Rebuilding stocks sufficient to reach biomass levels commensurate with MEY (approximately $1.6B_{MSY}$) coupled with maintaining all substocks at or over B_{MSY} would assist in this regard.

11.8 Recommendations:

r2.1 The information gaps in AFMA's second re-accreditation report (AFMA 2008) are sufficiently extensive and important (see discussion above) to warrant preparation of a supplementary report. This report should have been provided to all those who have made submissions, with an invitation to make further comment. However, tight timelines precluded such an option – undermining the integrity of the accreditation process. Procedures should be reviewed to allow time for the production of a supplementary report where necessary.

r2.2 Considering the evidence presented above, and the Commonwealth Government's commitment to phase-out destructive fishing practices in the Australian fishing zone, there remain important arguments for the phase-out of the industry by 2012. If the fishery is not phased out, it should be subject to radical reform, which unavoidably will include a major contraction of fishing power (see dot points below), and a significant expansion of protected areas.

r2.3 It is important to acknowledge that the fishery is, within its constraints, progressive – in fact more progressive in some respects than government management (as discussed above). The fishery has contributed substantial funds both to research and to restructuring programs aimed to reduce fishing effort and to increase fishery profitability. While the fishery is to be congratulated on progress over the last decade, there remains a great deal of room for important improvements in several areas:

- a) fishing for relatively dispersed prawns is likely to create higher bycatch/catch ratios compared with fishing prawn aggregations, for example for banana prawns. Long soak trawls are also energy intensive and will disturb more benthic habitat, other things being equal. Restricting or phasing out fishing for low-to-medium density dispersed prawns would significantly reduce the fishery's environmental footprint.
- b) urgent investigation and protection of byproduct and bycatch species identified as at moderate or high risk (particularly where a species is caught as bycatch/byproduct in more than one Australian fishery) is needed. Cumulative impact assessments are required. Practical protection may involve the creation of substantial protected areas *by the fishery*¹³⁴ on an interim or temporary basis to protect critical habitat of species at risk (noting that around 8% of the NPF area is already either permanently or seasonally closed). Such an approach is likely to involve a loss of target or byproduct harvest;
- c) the establishment of substantial protected areas to compensate or balance habitat destruction in heavily trawled areas, or an alternative habitat protection regime of rolling closures based on the recovery times for different habitat types impacted by

the fishery. Such arrangements might not result in significant declines in fishery harvests, depending on how protected areas are chosen, and whether rolling closures improve prawn habitat values;

- d) better monitoring regimes to detect the environmental impacts of the fishery, or, if such regimes are unrealistically expensive, precautionary area closures should be used; here again such arrangements may result in reductions in fishery harvests. Where monitoring programs continue, the statistical power of the programs must be carefully considered and reported, and precaution applied;
- e) increased allowance of annual prawn production for the ecological benefit of prawn predators – which could be an important benefit of the harvest reductions occurring from the above strategies;
- f) immediate steps should be taken to change the NPTF statutory requirements relating to type and positioning of BRD (particularly the specified distance from the trawl codend; see discussion above) with the intent of implementing current knowledge of the efficiency of bycatch ejection;
- g) more comprehensive and more transparent reporting of fishery impacts (see discussion above – for example regarding bycatch/catch ratios, with spatial and temporal detail); the extent and nature of the fishery's benthic impacts; the condition of critical habitats¹³⁵; and the effects of trawling on prawn-preferred habitat;
- h) the establishment of bycatch/catch ratio targets and limit reference points, which should be progressively tightened over time. Decision rules should stop fishing activities immediately when limit reference points are reached;
- i) the establishment of explicit target and limit reference points relating to bycatch species (see discussion above), with action-oriented decision rules;
- j) the issue of serial depletion of prawn sub-stocks (possibly metapopulation component populations) needs to be specifically studied and addressed, possibly through the imposition of spatial controls over effort (Dichmont 2006, 2008) noting that the fishery has already begun a major study looking at possibilities for new spatial management arrangements.

Complex scientific studies of the impacts of the fishery are currently underway, and the results should provide important direction to efforts to ameliorate the damage caused by the fishery.

In this context a major study of the impacts of prawn trawling off the east coast of Queensland should be noted. 'Objective no.6' of this major study (Pitcher et al. 2007) was: "to develop and provide maps of the distribution of vulnerable seabed habitats and assemblages to fishery managers and stakeholders...". Here "vulnerable" refers to vulnerability to the effects of prawn trawling. Such a study is needed over the entire area fished by the NPTF. If such a study is contemplated at some time in the future, it would be important to note that the maps produced in Pitcher et al. (2007) are at a scale so coarse as to be more-or-less useless for management purposes (matchbox size). This completely defeats the purpose of the exercise; such a mistake should not be made again.

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Endnotes:

⁸⁹ At this approximate latitude each 6 min x 6 min grid cell contains about 123 km² (Poiner et al. 1998:s17) corresponding to a grid cell 11 x 11 km.

⁹⁰ According to the Australian Department of Agriculture, Fisheries and Forestry: "Australia has many examples of well-managed fisheries. In particular, the western rock lobster and most of Australia's penaeid prawn fisheries are internationally renowned for management which provides for biological sustainability and economic success"

(<http://www.affa.gov.au/content/print.cfm?objectid=D2C48F86-BAiA-11A1-A220006.htm>)
accessed 11/8/2004.

⁹¹ MEY – maximum economic yield, is defined as “a sustainable catch or effort level that creates the largest difference between total revenue and the total costs of fishing for the fishery as a whole (Dichmont et al. 2008).

⁹² Given the extensive tax concessions for primary production in the Australian taxation system, resource rent through this avenue would appear to be negligible.

⁹³ According to NORMAC (2001:5), the second buy-back loan cost the industry \$m31.

⁹⁴ For some species metapopulation structure appears to exist. Areas of high prawn abundance have been heavily fished – providing evidence of serial overfishing. According to Dichmont (2006:15) assessments undertaken in 2000/2001 “suggested that some stock areas were highly depleted with spawning stock sizes much lower than suggested by single stock models.” Moreover “the present management targets, coupled with stock assessments applied at large spatial scales, may not be sufficiently precautionary and serial or local depletion may not be prevented” (Dichmont 2006:15). Dichmont (2006:23) recommended the adoption of spatial effort controls, as well as increased management transparency: “changing the *ad hoc* way the fishery is currently managed to one in which the approaches used to determine effort levels and season length are clear to all is an essential ingredient...”.

⁹⁵ Management inertia may be illustrated, of example, by a 20-year delay in introducing mandatory turtle excluder devices (discussed elsewhere in this paper). Another example is provided by overfishing of tiger prawn stocks, where there was a 7-year delay between the identification of overfishing and decisive action by AFMA (Dichmont et al. 2007:225). There has been a long delay in translating the findings of BRD experiments into management arrangements (discussed in more detail elsewhere in the paper). Ian Kirkegaard (pers. comm. 12/1/09) provides another example: size limits for slipper lobsters (bugs) were set at 3 inches (carapace width) in the early-1960s in Queensland on marketing, not biological grounds. Research in the late-1960s showed that most adult male bugs from the Gulf of Carpentaria did not reach this size, while adult females exceeded it. Adherence to the minimum size limit has the effect of selectively harvesting females – not a good outcome for the management of the stock. The minimum size limit set by AFMA, still current in 2008, is 3 inches (75 mm).

⁹⁶ “Independent certification” here means certification through an agency such as the Marine Stewardship Council.

⁹⁷ DEH – the Commonwealth Department of the Environment and Heritage (now the Department of the Environment, Water, Heritage and the Arts. DAFF – the Commonwealth Department of Agriculture, Forestry and Fisheries.

⁹⁸ ISO – International Standards Organization.

⁹⁹ Pownall, P & Jarrett, A (2004) *Code of Practice for Responsible Fishing in the Northern Prawn Fishery*, Northern Prawn Fishing Industry Organisation NPFIO, Cairns.

¹⁰⁰ This level is estimated at 5370 turtles caught per year (AFMA 2002:73).

¹⁰¹ Unlike turtles, most discards other than bivalves have a low survival rate (Hill & Wassenberg 2000).

¹⁰² Here ‘bycatch’ refers to that part of the catch which is not retained by the vessel, either because it has little or no commercial value, or because regulations prohibit its retention. The impacts of bycatch mortality can be sufficient to reduce populations of bycatch species, affecting their viability at different spatial scales. Discarding bycatch from trawlers has the

effect of transferring large quantities of biological material from the bottom to the surface – this makes available to surface scavengers (such as some bird species) food which would otherwise be inaccessible (Bill & Wassenberg 1990). Rapid assessment of bycatch mortality is usually based on whether bycatch looks dead or floats after discard. More thorough assessment uses tanks on board the vessel to hold a bycatch sample for a period of time (usually 6 hours). However, there are no effective measurement techniques for estimating mortality due to sublethal effects: for example stressed or damaged or displaced animals are likely to suffer increased mortality through predation.

¹⁰³ Here 'collateral' damage refers to organisms which are damaged or destroyed by the process of fishing, but are not retained by the trawl net. This will include benthos which is damaged by the footrope or ground chain but not caught by the net, and small organisms which are damaged by being passed through the net mesh (small fish and cephalopods, for example). According to Haywood et al. (2005:2-5) the trawl "is likely to have a severe impact on any biota that it encounters".

¹⁰⁴ According to Zhou (2008:309) an updated estimate is that prawn and shrimp fisheries produce something over 21% of total global fisheries discards.

¹⁰⁵ In a study in the Gulf of Carpentaria, Haywood et al. (2005:1-2) reported that a single pass of a prawn trawl removed on average 12% of seabed biota. Poiner et al. (1998) in a study of the effects of trawling on the northern sections of the Great Barrier Reef suggest that removal rates for sessile benthos are approximately 10% per shot (much less than had been reported by Sainsbury 1987 see below). In a more detailed report, Burrridge et al. (2003) found 13 repeated trawls over an area of soft bottom in the Great Barrier Reef removed 27% of algae, 74-86% of ascidians, sponges, echinoids, crustaceans and gorgonians, 95% of gastropods, and 54% of other taxonomic groups. Moran & Stephenson (2000) in a study of otter trawling on Australia's northwest shelf, found an overall benthos removal rate of 16% per shot, including both retained and non-retained benthos bycatch. Only 4% of the detached benthos was actually retained by the net. Sainsbury (1987) in the same region reported large sponge removal rates for a single trawl shot of up to 90%, with little retained in the trawl. Sainsbury (1991) also reported the effects of trawling off Australia's northwest coast, showing that the removal of large epibenthic organisms by trawling affects the abundance and types of benthic and demersal fish associated with these habitats. Engel & Kvitek (1998) reported similar findings. Wassenberg et al. (2002) using underwater video found removal rates of 14% for sponges and 3% for gorgonians per shot. Aish et al. (2003) quoted a study recording a benthos removal rate of 25% in a single shrimp trawl shot.

Poiner et al. (1998) reported on the overall effects of trawling on the northern GBR: "though 50-70% of trawled grids have been trawled only lightly (<700–1000 hrs) each year, over the last 20 years the cumulative effect of this has been that:

- vulnerable types of fauna (ie. those easily removed and/or slow to recover) have been severely depleted, thus causing:
- substantial changes in the composition of the faunal community, and
- the overall faunal biomass may have been reduced by ~20%, but it would be dominated by "weedy" species [fast growing, opportunistic, wide habitat range].

¹⁰⁶ Habitat impacts and recovery times were discussed by Haywood et al. (2005:241). While both study sites near Mornington Island in the Gulf of Carpentaria recovered rapidly, with mobile assemblages returning in 6-12 months, full recovery was estimated to take around a decade (here "full" means recovery to the state existing at the commencement of the study – noting that ecosystems at the study sites lacked complex benthic structures such as coral or old-growth sponge gardens): "Running the model using the depletion rates measured in the present study showed definite changes – for example we found that bryozoans, holothuroids and hydrozoans were more vulnerable and echinoids less vulnerable than had been found using Queensland East coast data. These differences vindicated the decision to measure the rates in the Gulf of Carpentaria as recommended by Ellis et al. (2002). The modelling showed that, following reductions in effort it would take around ten years for the seabed biota to stabilise to a new level. It also showed that some groups are particularly vulnerable to

trawling and populations are likely to be reduced to very low levels under current trawling regimes. Even under a moderate trawl effort scenario, gastropods will be reduced to 10% of original levels. Other groups – such as asteroids and echinoids – would increase under the same trawl effort scenario. These differences highlight the complexity of the seabed biota responses to trawling.

This study has shown that for most of the managed area of the NPF, prawn trawling has no direct impact. Over 80% of the area is not trawled at all and vulnerable areas of seagrass are closed to trawling. In addition, the NPF has seen large reductions in effort in recent decades. Overall we are dealing with a system in which trawl impacts are limited spatially and reducing. Nevertheless, trawling does take place over a significant area. The results of the present study and those in other areas, especially the Queensland east coast, show that trawling has an impact on the seabed biota. The nature of this impact is complex because it varies between species. In general, slow growing organisms that are vulnerable to trawling – sponges for example – are most impacted. Rapid growing species and those with a low catchability are likely to be least impacted or can rapidly recover from an impact. We suspect that indirect effects such as suspension of sediments are of low importance because of the relatively frequent and major disturbance caused in shallow water by cyclones. We consider that the major impact of trawling in the NPF is to hold the community in trawled areas in a steady state which favours the fast growing or ‘weedy’ species over the slow growing ones. Thus trawled areas still have a rich biota, but it is not the same as the original ‘prefishing’ one. Our study has shown that this is not a steady state but a highly dynamic one in which the seabed biota is changing in response to factors other than trawling. Many of the major species showed significant increases in biomass on our control plots through the course of the experiment. These are natural changes that are not occurring in response to trawling. Although trawling occurs in only a minor proportion of the NPF, it is possible that the trawl grounds represent a special environment. In this case, trawling may be taking place in a very large proportion of some unique habitat. It is important to bear in mind however, that these quite limited areas are extremely important to the fishery and it is in the interests of the industry to ensure that they are not altered in such a way that they are no longer productive for prawns as well as for other biota.”

¹⁰⁷ While turtle bycatch has been greatly improved, the issue of turtle habitat damage by trawling has not yet been studied or addressed.

¹⁰⁸ Technically the correct plural is “rostra”.

¹⁰⁹ It should be noted that all States, as well as the Commonwealth of Australia, formally endorsed this strategy in 1996.

¹¹⁰ It should be noted that AFMA and the Australian Government apparently considered shark finning to be an acceptable practice prior to its banning in 2000, in spite of long-standing concerns voiced by both conservation and scientific interests, and the FAO. Although the Commonwealth Government decided to end the practice in AFMA-managed fisheries in 2000, it apparently took several years for AFMA to act in ending the practice in individual fisheries (see for example Direction No. SSJFDIR2 ‘Prohibition on shark finning’ 26 October 2005. Concerns about shark finning rested on three grounds – ethical, avoidance of waste, and sustainability. With respect to the ethics of shark finning, it is noteworthy, for example, that Australian politicians used adjectives such as “barbarous” and “horrible” to describe this fishery practice (NSW Hansard 16 Nov 2000, p. 10107). Prawn trawling, likewise, condemns huge numbers of fish and other animals to an extremely unpleasant death, either in the trawl codend, on the trawler deck, or as disabled animals thrown back to the ocean. The issue of waste is obvious, with each tonne of harvested prawn resulting in the destruction of 4 to 10 tonnes (or more) of discards and collateral damage. The third issue for shark finning – sustainability – is also an issue for some species of prawn trawl bycatch, as discussed elsewhere in this paper.

For a more detailed discussion of other relevant ethical issues, see Nevill, J (2005) *Environmental ethics and marine protected areas*, OnlyOnePlanet Australia, viewed 23 April 2007, <<http://www.tucs.org.au/~cnevill/marineProtectedAreaEthics.doc>>.

¹¹¹ The most recent reported figure for area trawled (2007 – 70,000 km² see above) must be reduced as it applies to grid cells each having an area of around 120 km², not all of which is disturbed by trawling. However areas within grid cells that are disturbed are often trawled dozens of times (Haywood et al. 2005).

¹¹² Noting that one of the objectives of the NPTF Bycatch Action Plan (AFMA 2007) is to “provide protection for areas that are important habitat for vulnerable species of marine life” http://www.afma.gov.au/fisheries/northern_trawl/northern_prawn/at_a_glance.htm.

¹¹³ Stock / catch declines in king prawns: AFMA 2002:52, AFMA 2008:7,26.

¹¹⁴ Searches via Google Academic, and several academic databases failed to locate relevant information.

¹¹⁵ AFMA staff no doubt had access to the studies preliminary findings some time ago.

¹¹⁶ Salini et al. (2007:125): “The only fisheries in which sawfish were likely to be sustainable were those fisheries which did not capture these animals (the NT mackerel fishery, trap fisheries, and drop line fisheries targeting teleosts).”

¹¹⁷ The need for reporting on the level of, and trends in bycatch/catch ratios is implied by the *Commonwealth Policy on Fisheries Bycatch* which specifically calls for “monitoring changes to the level and composition of bycatch over time” (Commonwealth of Australia 2000:6).

¹¹⁸ See Haywood et al. (2005:237).

¹¹⁹ According to Heales et al. (2007:153): “Our results indicate that the power to detect even quite large declines in catch rates of rarely caught species would only be possible after some years of modest-sized annual surveys.”

¹²⁰ Coastal gill netting, and the northern (fish) trawl fishery are of particular interest when considering cumulative bycatch impacts.

¹²¹ Note also that the map of effort 1970-2004 presented by Dichmont et al. (2008) shows a fished area of approximately one third of the total NPTF zone.

¹²² IMCRA – Interim Marine and Coastal Regionalisation of Australia (IMCRA Technical Group 1998).

¹²³ Further examples are discussed in Chapter 12.

¹²⁴ The fishery has an obvious problem in developing a monitoring program which could rapidly detect an undesirable change caused by fishing. The bycatch includes hundreds of species, some of which are common, many uncommon, and others rare within bycatch samples (Haywood et al. 2005:5). Reliable samples and reporting of bycatch come only from scientific observers, who routinely monitor only one of the fleet’s vessels during the two fishing seasons each year. Less reliable data comes from the reports of crew observers, of which there were only 10 in 2007. Under these circumstances, the chances of reliably and rapidly detecting an “undesirable outcome” affecting an uncommon or rare species is extremely remote if not impossible. It would appear at first sight that the cost of a program which could do this might be unrealistically high – however this is a critical point, and without doubt should have been addressed in AFMA’s second assessment report (2008). What kind of monitoring program would be needed to rapidly and reliably detect unsustainable bycatch of a rare or uncommon species? How much would such a program cost? If the cost is unrealistically high, what alternative strategies are available to meet *Principle 2 Objective 1*

of the Commonwealth's sustainability criteria? – requiring the protection of populations of affected species.

¹²⁵ While the standard of the science presented by Haywood et al. (2005) is high, the appearance of minor but obvious errors in the text casts doubt on the internal quality control applied to major reports. See for example pp. 8, 35 and 237.

¹²⁶ Wikipedia: "turtle excluder device" accessed October 12, 2008.

¹²⁷ According to AFMA (2002:5): "In addition to specific legislative accountability provisions, AFMA has been subject to a number of external reviews and audits. AFMA's management effectiveness has been reviewed by the Australian National Audit Office (twice), a Senate Standing Committee (1993 and 2000) and a House of Representatives Standing Committee (1997). In response to these reviews, and as part of good corporate governance, AFMA has strengthened its planning, performance assessment and reporting arrangements. The strategic assessment process under the EPBC Act is also a process of review and audit."

"Independent reviewer ACIL Pty Ltd reviewed AFMA's management advisory committees (MACs) in late 2000. The ACIL report highlighted concerns over a number of MAC and AFMA processes and practices, although strongly supporting the MAC concept and the contribution of MACs to Commonwealth fisheries management. These concerns were dealt with in a series of 31 recommendations, the majority of which have been adopted by the AFMA Board. The Board noted that actions had already been initiated to address some of the issues covered in the report but that further action will be required to implement the remaining agreed recommendations. AFMA is currently developing a timetable and plan for implementing these recommendations."

¹²⁸ The logic behind policy positions should always be explained.

¹²⁹ These protected areas probably need to be created *in addition* to the protected areas created by the more wide-ranging Commonwealth regional planning program, which incorporates the National Representative System of Marine Protected Areas.

¹³⁰ AFMA (2004:28) identified monitoring of critical habitats as a high research priority. If comprehensive monitoring has been undertaken and reported, this has not been referenced in AFMA (2008).

¹³¹ Such an arrangement would introduce compliance and enforcement issues, which could be addressed by the adoption of mandatory remote surveillance of deck operations. Such surveillance was encouraged by the 2005 Ministerial Direction.

¹³² CCAMLR, the Commission for the Conservation of Antarctic Marine Living Resources, is required under its enabling convention to apply the ecosystem approach to managing fisheries in Antarctic waters, and has been at the front of developments in this area. See the separate case study on the CCAMLR krill fishery.

¹³³ Here it is worth noting that the CCAMLR fishery sets a target reference point of 75% of B_0 , consciously allowing a margin of 25% of B_0 to support predators (see separate case study on the CCAMLR krill fishery).

¹³⁴ These protected areas probably need to be created *in addition* to the protected areas created by the more wide-ranging Commonwealth regional planning program, which incorporates the National Representative System of Marine Protected Areas.

¹³⁵ AFMA (2004:28) identified monitoring of critical habitats as a high research priority. If comprehensive monitoring has been undertaken and reported, this has not been referenced in AFMA (2008).

12. Benchmark appraisal: Australia's orange roughy trawl fishery

12.1 Preface:

The collapse of Australia's orange roughy fisheries has been described by several authors (eg: Lack et al. 2003, Bax et al. 2005, Koslow 2007). It is examined again here in some detail as it represents a classic example of overfishing under regulation. The behaviour of key stakeholders is a critical factor. Amongst the key players were:

- greedy¹³⁶, short-sighted¹³⁷ and dishonest¹³⁸ fishers;
- weak¹³⁹ and overly-optimistic¹⁴⁰ fishery managers;
- fishery scientists willing to use improbable and unsubstantiated arguments to oppose the creation of marine reserves over orange roughy fishing grounds;
- a conservation group who attempted to have the orange roughy listed as 'vulnerable' under Commonwealth threatened species legislation;
- a government environment department who approved an orange roughy recovery plan which ignored the link between the species and its habitat; and
- a fisheries management agency who submitted false and misleading information to a Commonwealth accreditation review.

Although the detailed biology and ecology of the orange roughy still remain largely a mystery, the findings of this examination reinforce a conclusion which has been reached many times before: overfishing under regulation results, not from failures in science, but from failures in governance. While Australia is sometimes seen as a world leader in effective fisheries governance, the fundamental flaws (arguably resting on organisational cultures) underpinning the collapse of most of Australia's orange roughy stocks remain in place today. Importantly, most of the key players displayed a cavalier attitude to the precautionary and ecosystem approaches, in spite of token commitments to their application.

12.2 Introduction:

The main purpose of this appraisal is to compare Australia's orange roughy fishery management regime to benchmarks representing key aspects of three broad 'modern' management approaches: active adaptive management, and the precautionary and ecosystem approaches.

This appraisal also discusses the fishery in the specific context of Lord Perry's question: *why does overfishing occur under government regulation?* In this context the fishery provides a case study illustrating the importance of what Koslow (2007) has referred to as "backbone" – relating both to fishery managers and fishery scientists. A close examination of the history of Australia's orange roughy fishery leaves little doubt that absence of managerial backbone is a key factor in answering Lord Perry's question – at least in regard to orange roughy.

There also appear to be important lessons relating to the application of the precautionary approach – and these are briefly discussed below. Using this case study it can be argued that a clear statutory obligation to apply precaution does not ensure that it will be applied, if cultures within both managerial and scientific cliques downplay or ignore moral or legal responsibilities.

The story of the development of Australia's orange roughy fishery is in essence a story of the failure of both fisheries management and the science (and scientists) it relied on. This failure extended not only to the target stocks, but to wider environmental responsibilities. Yet the elements for success appeared to be in place in the fishery's early days. The Australian fishery began in the 1980s when early lessons from the New Zealand orange roughy fishery were already available. Through *Offshore Constitutional Settlement* (OCS) arrangements, the Australian Fisheries Management Authority (AFMA) had undisputed control over the fishing industry¹⁴¹ – and scientific advice was available through the CSIRO which should have been up to the challenge. Yet by 2006, all but one of the orange roughy stocks had

plummeted below the limit reference point, and the orange roughy itself was listed as a threatened species under the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999*.

By examining the fishery's recent history, this chapter attempts to find insights into the factors which lay behind the collapse of Australia's orange roughy stocks.

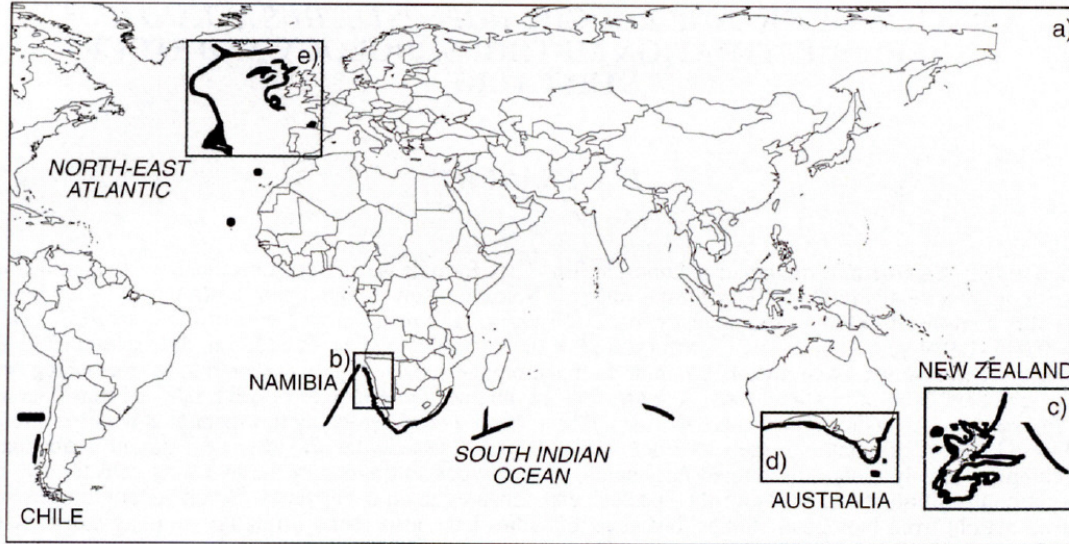


Figure 12.1: Worldwide distribution of orange roughy.

Source: Branch 2001

12.3 Background:

Orange roughy (*Hoplostethus atlanticus*) is a fish which inhabits a depth range of 700-1200 m (most usually 800-1000 m) in temperate waters (~4 to 7°C) of both southern and northern hemispheres (Figure 12.1)(Lyle 1994). Within the Australian EEZ, orange roughy is found from deepwaters off the southwest of Western Australia, across the continental slope of the Great Australian Bight, the slopes, seamounts and plateau around Tasmania, to the New South Wales slopes and the seamounts, and the plateau of the Lord Howe Island Rise. Orange roughy feed on small pelagic and demersal fish and invertebrates (Bulman & Koslow 1992).

Within its preferred habitat, orange roughy is an important, sometimes dominant, member of the fish community. It matures aged 20-40 years, and can attain an age in excess of 180 years (Tuck 2006). Natural mortality is clearly very low. It reaches a maximum adult size of 40-55 cm, showing little increase in length or weight after maturity¹⁴². A proportion of adult fish are believed to spawn each year¹⁴³; however recruitment is thought to be highly episodic¹⁴⁴. Stock structures are often poorly understood, but it is sometimes assumed that an entire spawning stock aggregates at a single site. In the southern hemisphere spawning usually occurs between early June and mid-August each year (Bruce et al. 2002:35; Bell et al. 1992:107).

Orange roughy form both spawning and non-spawning aggregations, the former being highly predictable in space and time, while the latter may be related to feeding activities. Being slow-growing, late-maturing, and long-lived (and having very edible flesh) the fish is highly vulnerable to over-fishing. Orange roughy also occupy highly vulnerable habitats (discussed in more detail in the separate section on bottom trawling below). According to Koslow (2007:220): "the seamounts around New Zealand and Tasmania, the centre of the [southern hemisphere] fishery, characteristically contain dense coldwater coral reefs, with species of stony corals forming the reef matrix, and many hundreds of fish and invertebrate species living in association with them." These habitats are largely unstudied, but clearly of great biological value (Koslow 2007).

New Zealand has extensive areas of seamount and submerged plateau, at the depth orange roughy prefer (and at the preferred latitude) within its EEZ (Figure 12.2). The world's first major orange roughy fishery started on these areas in 1972, under the Soviet distant-water trawling fleet¹⁴⁵. Soviet catch over 1972-77 is thought to be relatively small, with 3500 t in 1977 the maximum annual catch¹⁴⁶. Following the lead of several other nations, New Zealand declared an EEZ of 200 nm in 1977, and Australia did the same in 1979. New Zealand vessels subsequently took over the fishery, which became, over the next decade, the largest and most valuable deepwater fishery in the world¹⁴⁷ (Figure 12.3). Catches declined, but overall remained relatively stable for nearly two decades. This was, however, achieved by the serial depletion of more than a dozen separate stocks¹⁴⁸.

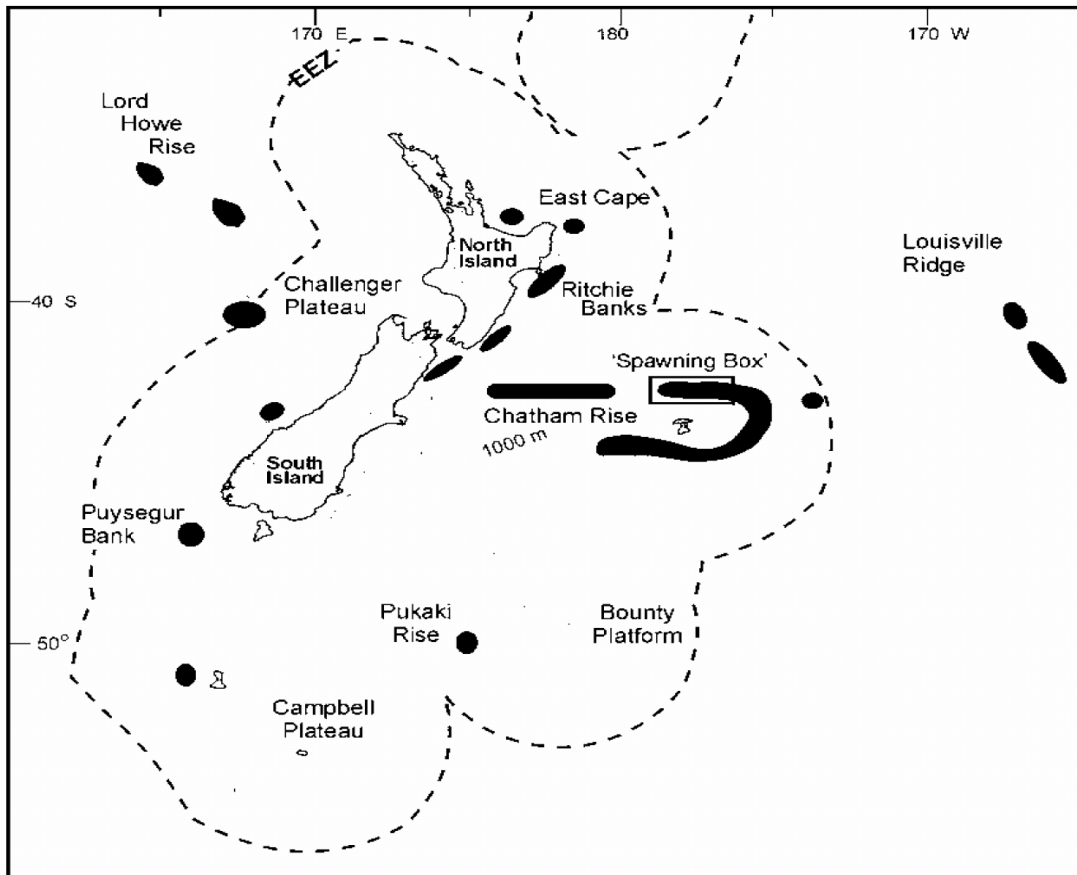


Figure 12.2: Distribution of orange roughy around New Zealand (from Clark et al. 2000).

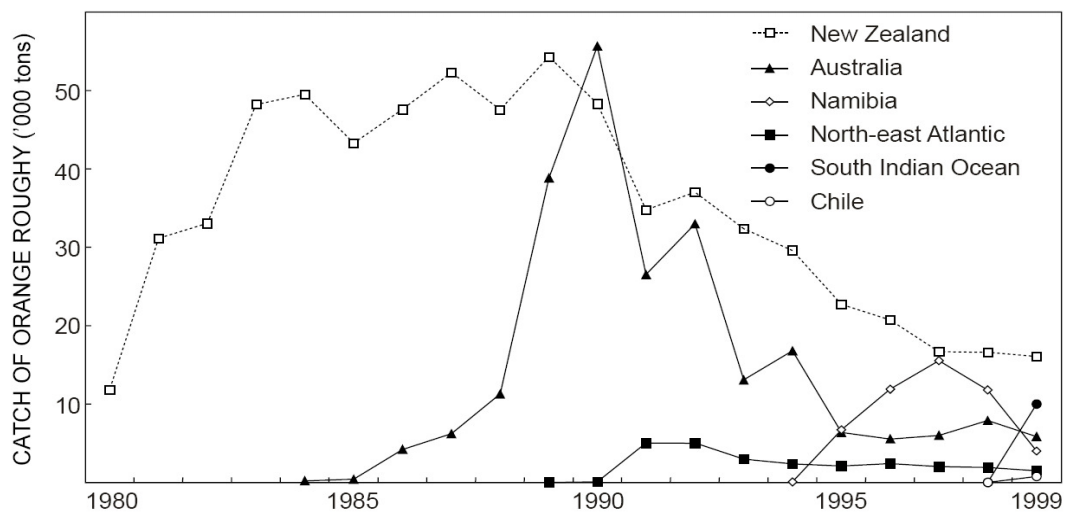
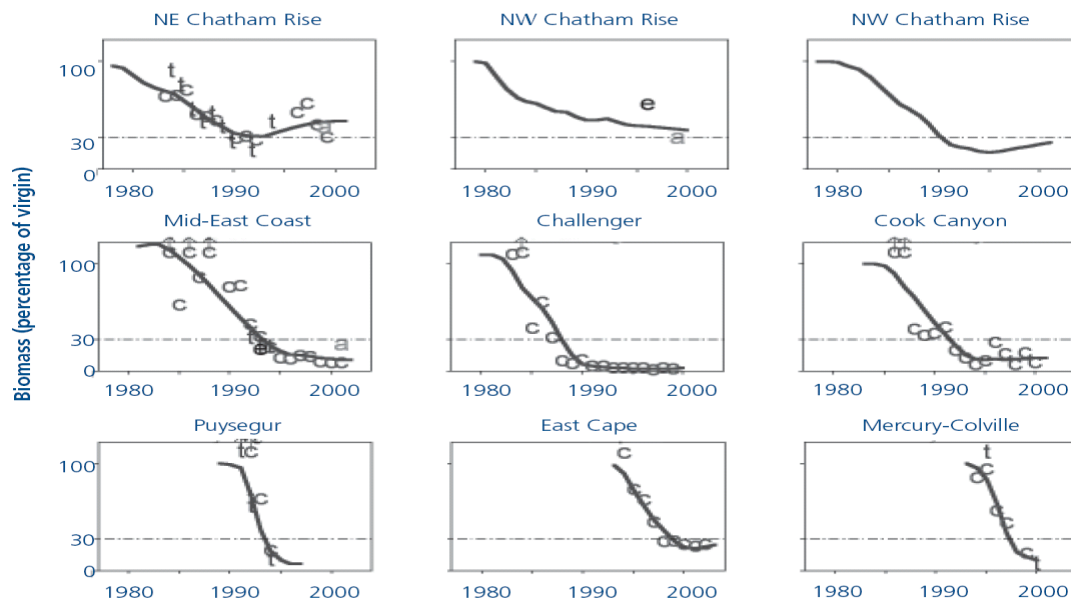


Figure 12.3: Catch history of orange roughy from major global fishing grounds

(source: Branch 2001 quoted in Stevens 2003)

The fishery on the New Zealand Challenger Plateau has been one of the most long-standing, and provides an example of the overfishing which occurred on most NZ stocks. Catch rates were, however, declining by the late 1980s, and quotas were steadily reduced from 1992, with the fishery formally closed in 2000, at an estimated biomass level of only 3% of its original size¹⁴⁹.

Today NZ's wider Chatham Rise fishery remains, in spite of the serial depletion of local stocks (Figure 12.4) perhaps the only 'sustainable' orange roughy fishery in the world, with a 2006-07 TAC of 11,500 and a catch of 11,271 tonne (MoF NZ 2008) both of which have been roughly steady for several years.



Note: letters on the graphs refer to the type of stock assessment: c = catch per unit effort, a = acoustic survey, t = trawl survey, e = egg survey
 Source: Malcolm Clark, National Institute of Water and Atmosphere (NIWA), New Zealand.

Figure 12.4: Orange roughy stock declines in New Zealand. The dotted line represents the NZ target reference point of 30% of original biomass – a proxy for MSY (see NZ Fisheries Act 1996 (s.13). Source: Wallace & Weeber 2005.

Catch statistics from orange roughy fisheries world-wide generally show similar patterns, often related to serial overfishing of stocks (Figure 12.3).

12.4 The rise and fall of the orange roughy fishery in Australia:

Orange roughy were first discovered in commercial quantities in Australia in 1981, after small non-spawning aggregations were found off South Australia, Tasmania and Victoria (Bulman & Elliot 1994). The Tasmanian fishery started in 1982 with the harvesting of an aggregation off Sandy Cape, northwestern Tasmania (Bax 1996:5). Between late October 1986 and the end of January 1987, a non-spawning aggregation in small area off Sandy Cape was heavily fished, with about 5000 t being taken (Sainsbury 1988:4). This aggregation has not been detected since that time. However the fishery commenced in earnest after a major spawning aggregation was located at a small seamount named St Helens Hill, off the northeast coast of Tasmania, in 1989 (Bax 1996:5).

By this time scientists had already expressed concern about the likelihood that the species was long-lived, slow-growing and unproductive – which would imply that, although a substantial accumulated biomass might be available for fishing, long-term yields might be very low (Sainsbury 1988). Importantly the Sainsbury (1988) report also discussed the possibility that recruitment might be highly episodic, interspersed with long periods of poor spawning success.

Warning signals came quickly from the NZ fishery indicated that orange roughy natural mortality had been seriously over-estimated (on the basis of incorrect age-structure data) and that stock recovery was much slower than expected¹⁵⁰. Even using lower natural mortality rates, fishery models assuming steady annual recruitment had not been able to predict the stock collapses which occurred, and the resultant serial overfishing. These warning signals, combined with the early concerns of scientists (Sainsbury 1988) should have encouraged a cautious approach to the development of the Australian fishery.

Trawling in this region was then (and still is) under the control of the Australian Fisheries Management Authority (AFMA) or its predecessor, the Australian Fisheries Service. The existing trawling fleet was over-capitalised, and had depleted the traditional grounds of the continental shelf¹⁵¹. Discovery of the St Helens Hill spawning aggregation looked like a god-send, provided the trawlers could obtain the necessary permits to fish the stock. Koslow (2007:206) describes what followed in terms of two strategic errors – opening the fishery too fast¹⁵², and allowing intensive fishing of a spawning aggregation:

AFMA buckled under pressure, and granted deepwater licences to the mass of trawl operators. By the second year of the fishery, 66 vessels were involved. The reported landings of orange roughy soared to 40,000 tonnes, and at least 30% more is estimated to have been lost due to the inexperience and greed of the fishers, who too often trawled up more than they could land, causing them to spill dead fish back into the water. 'Burst bags' were often reported: nets filled to the point that they burst, losing the entire catch. How long could such a fishery last when the total population was estimated at less than 200,000 tonnes?

Intensively fishing a spawning aggregation, when it is massed and most vulnerable, leaves no margin for error. And there was ample opportunity for error when the methods to assess the fishery – the deepest in the world to date, on a previously obscure species – were still under development.

Koslow (2007:207) describes a 'third strategic error' – establishing a management target, then abandoning it in the face of pressure from fishers to keep fishing: "Early in the development of the fishery, it was agreed that the [spawning] stock would be maintained above 30% of its original size. If it slipped below this level, quotas would be reduced to allow the stock to rebuild. If the stock fell below 20% of its original size, the fishery would be closed." Smith & Wayte (2003:173) note that "if there is to be less than 10% chance of the stock being below 30% of original biomass, then the current spawning biomass should be kept at around 38% of original biomass."

As the fishery progressed, and stocks fell sharply, quotas were not reduced in line with the agreed management strategy or the recommendations of fishery scientists, who themselves appeared to ignore the obligations to apply the precautionary principle under which AFMA operated. Non-precautionary harvest options were put forward by fishery scientists, under the terminology of "optimistic" scenarios. Fishery managers, again ignoring their obligations to apply precaution, either accepted the "optimistic" harvest scenarios, or even ignored them in favour of continuing existing quotas which were the direct cause of the collapsing stock. As time progressed, the tone of the language of the stock assessments moved from optimism to pessimism, yet the TACs set by AFMA remained above the scientist's recommendations.

Koslow (2007:207) expressed the view that these actions "might be crudely termed lack of backbone – the failure to follow scientific advice, and the agency's own management objectives." These are strong claims, but reinforced by the discussions of Lack et al. (2003) and Bax et al. (2005). A closer scrutiny (see detail discussed below) shows them to be correct.

It should also be noted that the dependence of orange roughy on cold-water corals and associated habitats is not understood. If there is an obligate dependency on these vulnerable

habitats, this has profound ramifications for the management of the species, as the fishing technique in general use destroys these habitats.

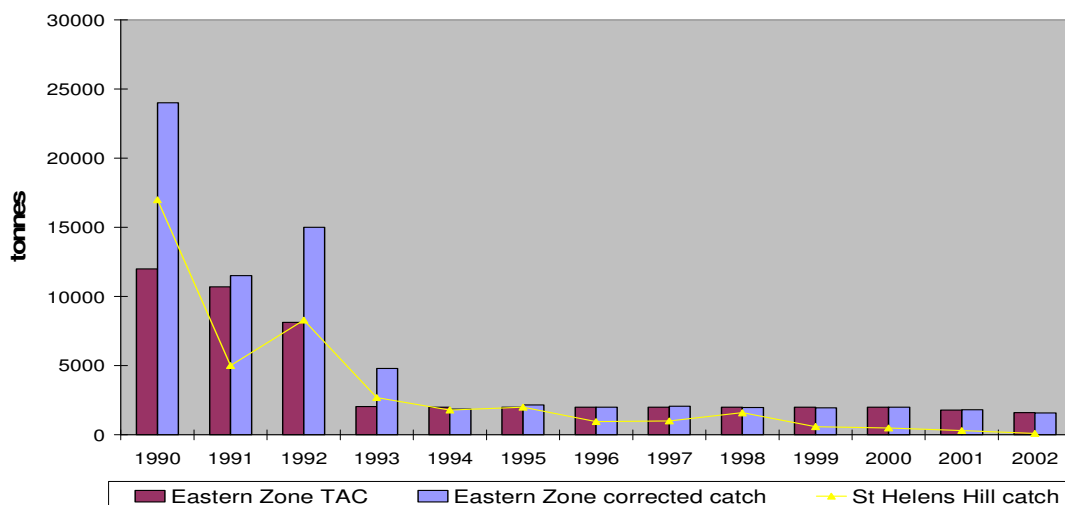


Figure 12.5: Orange roughy catch and TACs in the eastern zone and St Helens Hill. Further detail is contained in the figures below. *Source Lack et al. (2003).*

The failures of fishery managers did not, of course, go unnoticed. The Bureau of Rural Sciences (BRS) publish fishery status reports on Commonwealth-managed fisheries each year. They noted, in their 2002 assessment, that even where decision rules were in place for setting TACs they were not followed (Caton 2002). Management failures also frustrated some scientists. Tilzey & Rowling (2001) quoted in Lack et al. (2003:28) state:

In general assessment scientists are frustrated by the failure of managers to apply the precautionary principle, despite the fact that biomass estimates for major species such as gemfish and orange roughy have fallen well below the biological reference points adopted by management as minimum desirable stock sizes... Good science does not translate into good management without the political will to act on scientific findings.

In spite of findings in the annual *Fishery Status Reports* that orange roughy stocks were overfished (starting with the 2001 report) with overfishing continuing, AFMA failed to adhere to its strategic objectives for the fishery. Criticisms of AFMA's management standards within the Status Reports were expressed clearly and repeatedly. Caton & McLoughlin (2005) in the *Fisheries Status Report 2004* (p.124) noted that although the limit reference point had been breached for the western orange roughy stock, fishing was continuing in spite of "strong evidence for adopting a zero TAC". The authors also expressed concern that "no decision rules have been formally agreed for any species [in the southeast fishery] (p.99), and that "the nature and extent of possible habitat damage within the southeast fishery are unquantified and little studied (p.132).

The Status Reports (eg: Caton & McLoughlin 2005) also highlighted AFMA's poor enforcement – discussing the southern and eastern zones: "Despite a catch limit of 12,000 t each for the eastern and southern management zones, the estimated catch rose to a peak of about 53,000 t in 1990. In 1992 TACs totalling about 18,000 t and allocated as ITQs were adopted for the eastern, southern and western zones collectively. However the quota monitoring system was inadequate and some operators substantially under-declared their catches. The total 1992 catch was subsequently estimated to have been about 31,000 tonne" (p.121) (Figure 12.5).

Caton & McLoughlin (2005) expressed concern over non-quota bycatch species (p.135): "Landings of oreos, deepwater sharks and some other species are almost certainly above sustainable levels." "Despite numerous debates about the need to control catches of southeast fishery non-quota species of commercial values, virtually nothing has been done about it since ITQs were introduced in 1992." "The success of AFMA's management

objective to 'maximise economic efficiency in the utilisation of fish resources' must continue to be questionable if effort increase continues and catches do not improve" (p.135).

While there appears to be little evidence of a thoughtful response by AFMA's management to these (and many other earlier criticisms made in the Bureau of Rural Sciences fishery status reports) it seems highly likely that the findings of the BRS led to the *Ministerial Direction* later in 2005 (Macdonald 2005). Under AFMA's enabling legislation, the responsible minister may only direct the Authority under unusual and urgent circumstances. Broadly, the purpose of the Direction was to bring an end to the overfishing of stocks under Commonwealth management (more below).

As a participant in the early days of the Australian orange roughy fishery, Koslow's observations carry a good deal of weight. His comments on the role of the fishers, though lengthy, are worthy of careful consideration¹⁵³:

Much of the responsibility for the failure of the fishery lies with the industry. Its short-sighted self-interest, combined with its power and influence, proved virtually unstoppable in running down populations as valuable, vulnerable and unproductive as the orange roughy. The sustainable yield for this species was estimated to be only a few percent of the original biomass. So, an industry consultant asked at a meeting of scientists, industry and management, why not just 'mine' it out? Whether explicitly stated or not, that became the industry objective, and it used every means at its disposal to delay the inevitable quota reductions required to sustain the fishery. A time-honoured tactic was to exploit uncertainty in the scientific assessments – and there is always uncertainty in this science – to argue that severe quota reductions were not yet justified. And the strategy succeeded: each year AFMA acquiesced and compromised, setting the quota higher than the scientists recommended.

When all other avenues failed, the industry under-reported its catches. One year, however, Tasmanian police secretly videotaped the trawlers in port. Orange roughy landings were estimated at approximately twice the amount officially reported. The police implicated virtually everyone in the industry, but only one operator was prosecuted. In addition, catches from the spawning ground were mis-reported as coming from other areas where quotas were more difficult to fill. Cheating is one more facet of the tragedy of the commons; once it becomes rampant, any individual who does not participate appears foolish. When everyone's hands are in the bag grabbing for the lollies, it's clear that they will soon be gone (Koslow 2007:208).

AFMA set itself a management target in the mid-1990s to rebuild depleted orange roughy stocks to 30% Bo by 2004. Over the next few years AFMA maintained TACs in spite of scientists' warnings that major reductions were needed. When it became clear that there was no chance of the management target being met, rather than take strong action to close fishing on the declining stocks, AFMA developed new 'softer' performance indicators:

- "that TACs are set such that the eastern/southern stock(s) are rebuilding towards 30% Bo; and
- that data relevant to the annual assessment of each orange roughy stock has been collected and analysed and considered by the South East Fishery Advisory Group." (Smith & Wayte 2003:176).

These are good examples of 'Claytons' performance indicators: the sort of performance indicator you have when you're not having a performance indicator.

12.5 Scientists' biomass estimates and catch limit recommendations:

This section presents some details relevant to the discussion above: for the different fishing management zones, estimates of biomass are listed with notes on the recommendations made by fisheries scientists to AFMA relating to catch limit recommendations. The management zones (or sectors) are set out in Figure 12.6 below.

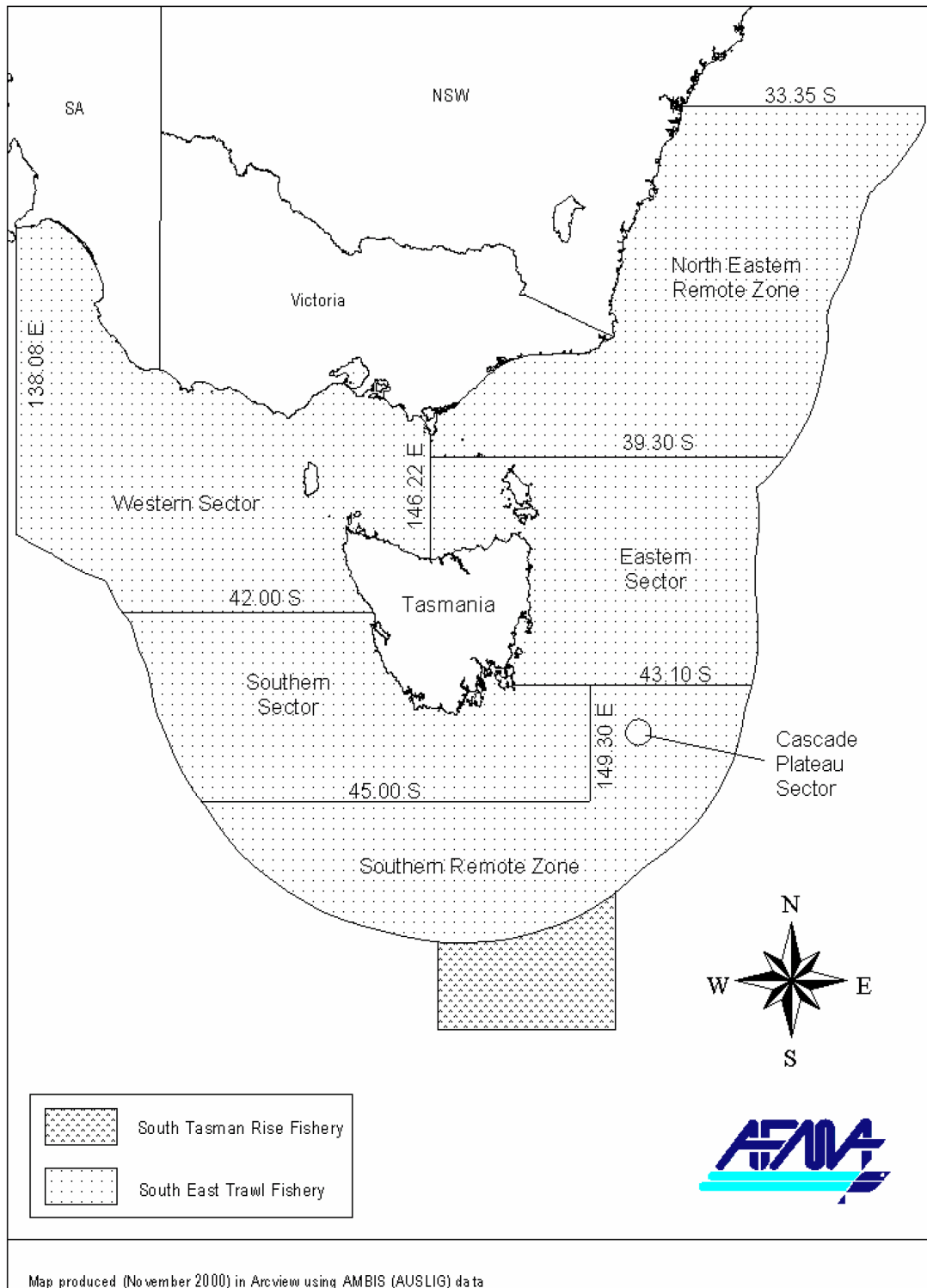


Figure 12.6: Orange roughy management zones (sectors) in the south east region.

Bax et al. (2005) have described the commencement of the orange roughy fishery in Australia. The first major aggregations located were off Sandy Cape and Beachport (on the continental slope to the northwest of Tasmania). These were located in 1986 and 1988, and fished heavily. The aggregations did not, and have not re-appeared. The cause is not understood, but it seems possible that trawling either seriously damaged the local stock or the local habitat. According to Bax et al. (2005:264) fishery scientists urged caution in expanding the fishery, pointing out “very little catch is forgone by slow development of the fishery”. This advice was not adopted by managers¹⁵⁴. Scientists initially recommended a target reference point of 50% Bo; however it was soon clear that some stocks had been fished below this level in only a few years, and managers switched to a target of 30% Bo. Major errors were made in early stock assessments, due to “optimism” and ignorance of technical errors.

SE eastern zone

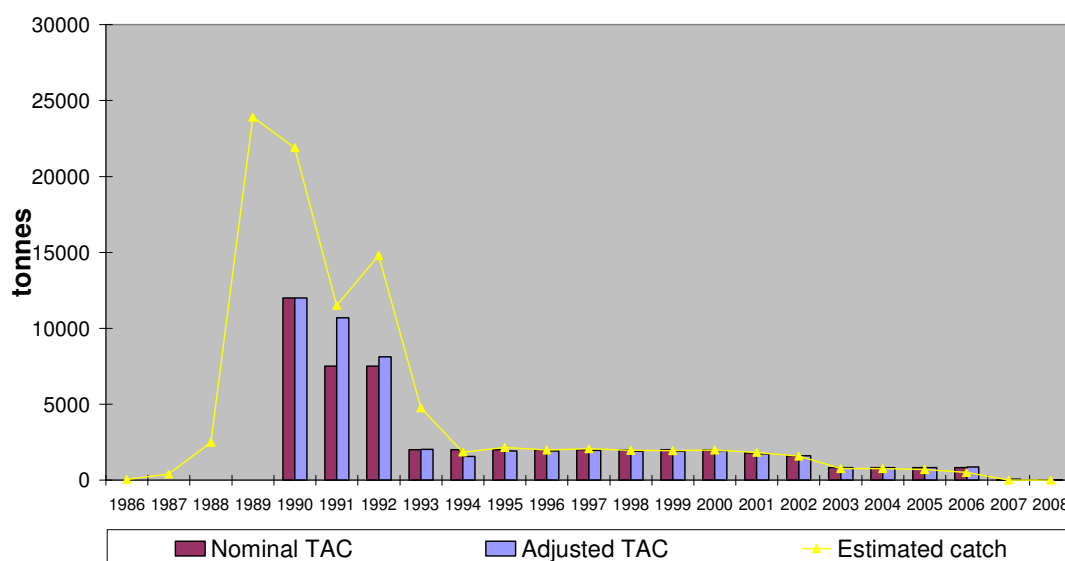


Figure 12.7: Orange roughy TACs and estimated catch for the eastern zone.

Adjusted TACs may be greater than, or less than agreed (nominal) TACs due to quota carry-over arrangements. These arrangements were criticised by McLoughlin (2006) as creating unnecessary distortions in TACs which were often already set too high. The data in the accompanying figures are sourced largely from CSIRO assessment reports, with more recent figures from AFMA’s ‘Catch Watch’.

Prefishery biomass: 109,000 – 97,000 t (Koslow et al. 1995:819).

Biomass estimates: 1990 ~50,100 t; 1992 ~34,600 t (Koslow et al. 1995:819); 1996 – Bax (1996:25) found that there was at least a 50% probability that the limit reference point (20% Bo) had been breached for the combined southern and eastern stock, and that “catches should be reduced to zero if necessary to ensure stock rebuilding”. 1999 ~5200 t (Kloser 2001:4); 2002 ~11,500 t (Wayte & Bax 2002);

Scientist’s recommendations on sustainable catch limits:

Campbell et al. (1991): 2792 t.; AFMA’s TAC for 1991,1992: 7500 t. (12,000 t in 1990).

Bax (1996) recommends catch reduction, to zero if necessary; AFMA’s TAC for the following year: unchanged at 2000 t.

Bax (1997:32) “If the [combined southern and eastern] stock has the lower rate of natural mortality [0.048 rather than 0.064] AFMA’s performance criteria would be achieved with catch levels for the combined zones of 1000-2000 tonne.” The TACs at the time for this ‘stock’ summed to 3000 t and remained at this figure the following year.

Wayte & Bax (2002): recommended a TAC of zero for 2003. AFMA’s TAC for 2003: 820 t.

DAG (2005:3) recommended TAC of zero for 2006. AFMA’s TAC for 2006: 820 t.

SE southern zone

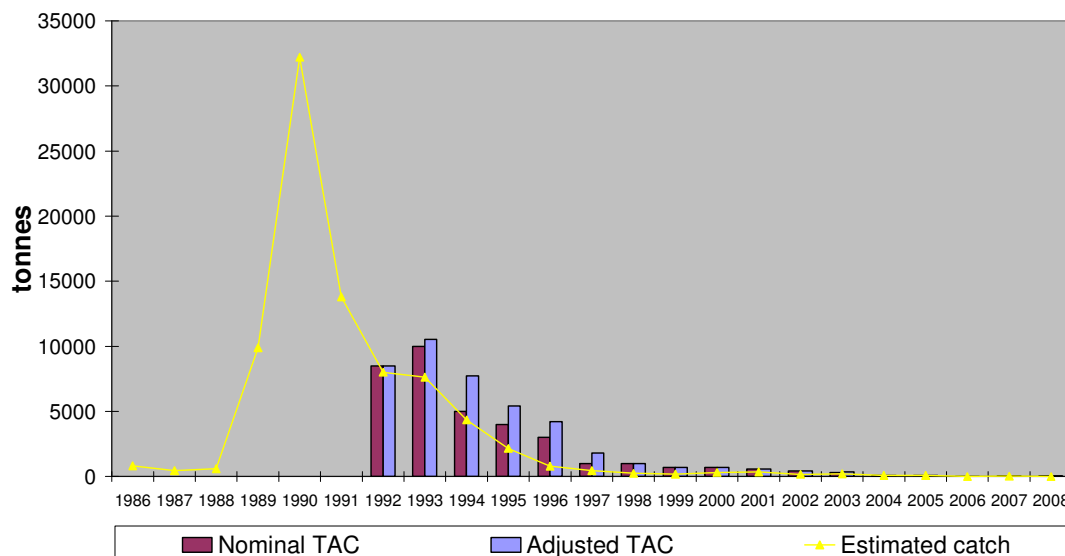


Figure 12.8: Orange roughy TACs and estimated catch for the southern zone.

Prefishery biomass: 55,800 tonne (Bax 1996).

Biomass estimates: 2000 ~6,870 t (DEH 2006);

Scientist's recommendations on sustainable catch limits:

Bax (1996) recommended strong reductions in TAC (see eastern zone discussion above). Bax (1997) again recommended strong reductions (see above). AFMA's response: TAC dropped from 3000 t in 1996 to 1000 t for 1997 and 1998. The combined southern and eastern TAC for 1998 was 3000 t, compared with Bax's recommendation of 1000-2000 tonne. Wayte & Bax (2002) recommended a zero TAC for 2003. AFMA's TAC for 2003 was 300 t (reduced from 420 the previous year).

SE western zone

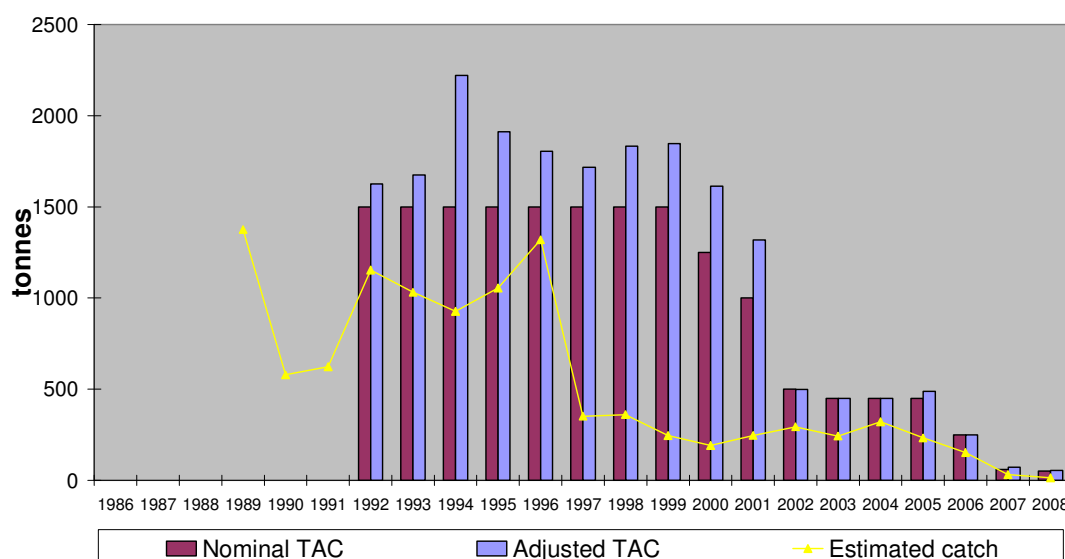


Figure 12.9: Orange roughy TACs and estimated catch for the western zone.

Prefishery biomass: 18,600 tonne (DEH 2006).

Biomass estimates: 2002 ~1,480 t (Wayte & Bax 2002).

Scientist's recommendations on sustainable catch limits:

Wayte & Bax (2002) recommended zero TAC. AFMA's TAC for 2003: 450 t (down from 500 t in 2002).

DAG (2005:9) recommend zero TAC. AFMA's TAC for 2006: 250 t (down from 450 t in 2005).

Tasman Rise

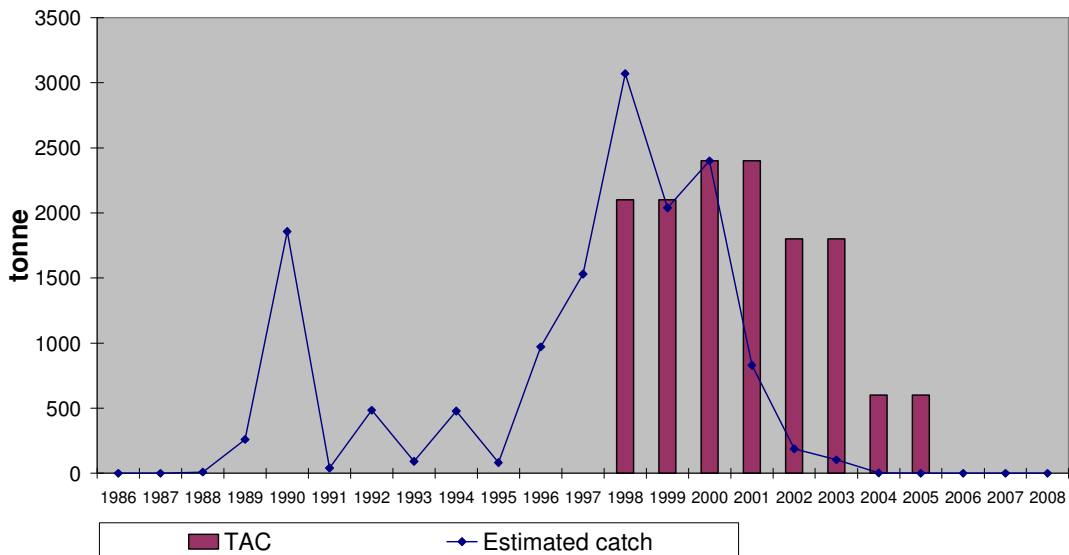


Figure 12.10: Orange roughy TACs and estimated catch at the Tasman Rise.

I have not been able to locate estimates of prefishery biomass, biomass over the fishing period, or scientist's recommendations for catch limits. Prince & Diver (2001) – reporting on a stock survey, expressed concern that the stock was being overfished, but made no specific recommendations related to the setting of TACs.

Cascade Plateau

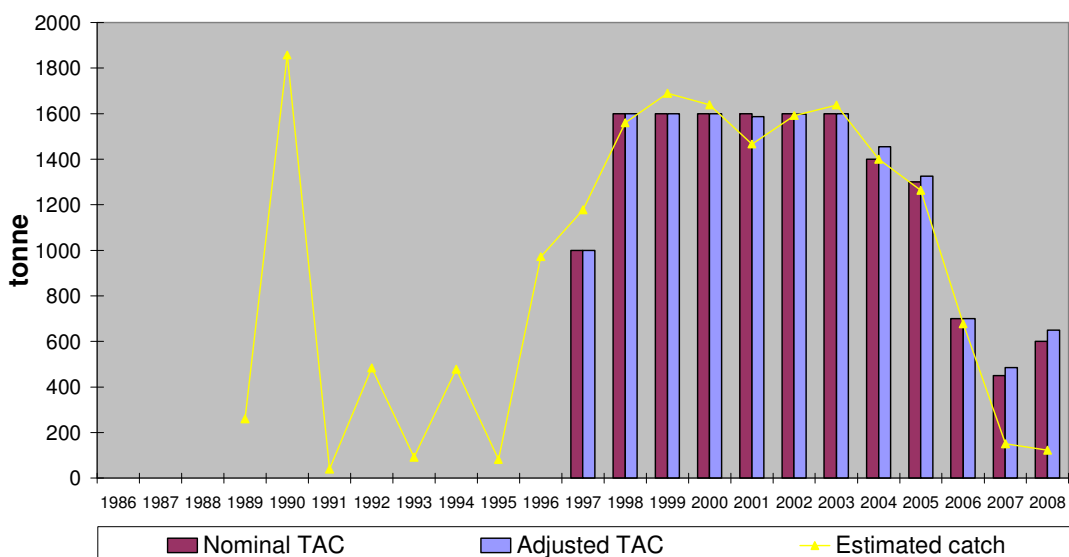


Figure 12.11: Orange roughy TACs and estimated catch at the Cascade Plateau.

Prefishery biomass: 20,000 – 38,000 tonne (Wayte 2004).

Biomass estimates: 2001 5000 – 15,000 t (Larcombe 2005). 2003: Honkalehto & Ryan (2003:2) reporting on a survey, estimated spawning biomass between a range of 5000 – 53,000 t, with a 'most likely' range 7500 – 11,800 t. 2004: Wayte (2004) ~ 13,600 t. 2005: ~12,600 t (AFMA (2006:8)(letter to DEH) "the Cascade stock is estimated between 33-42% Bo".

Scientist's recommendations on sustainable catch limits:

Wayte & Bax (2002) comment that there is "no declining trend" and do not recommend a RBC. Wayte (2004) recommended a sustainable RBC of 200 – 400 tonne. DAG (2005:6) recommend an RBC in the range 124 – 408 tonne, noting "without firm evidence a precautionary approach is appropriate...". Smith & Wayte (2005:71): "It is recommended that, following the precautionary principle...catches be reduced". "DAG recommends that catches be reduced to a TAC of 400 t over the next three years". AFMA's response: The TAC was set at 1300 t in 2005. This was reduced to 700 t in 2006, 450 t in 2007, and increased again to 600 t in 2007.

Summary:

In summary: information presented in this section confirms comments made by authors quoted above that AFMA did not adhere to its stated fishery management strategy, and did not follow advice provided by CSIRO fishery scientists (through the Research Advisory Group, or RAG) regarding catch limits. Over several years AFMA consistently set catch limits above the 'sustainable' figures in the advice made by scientists – in several cases well above (Figure 12.12).

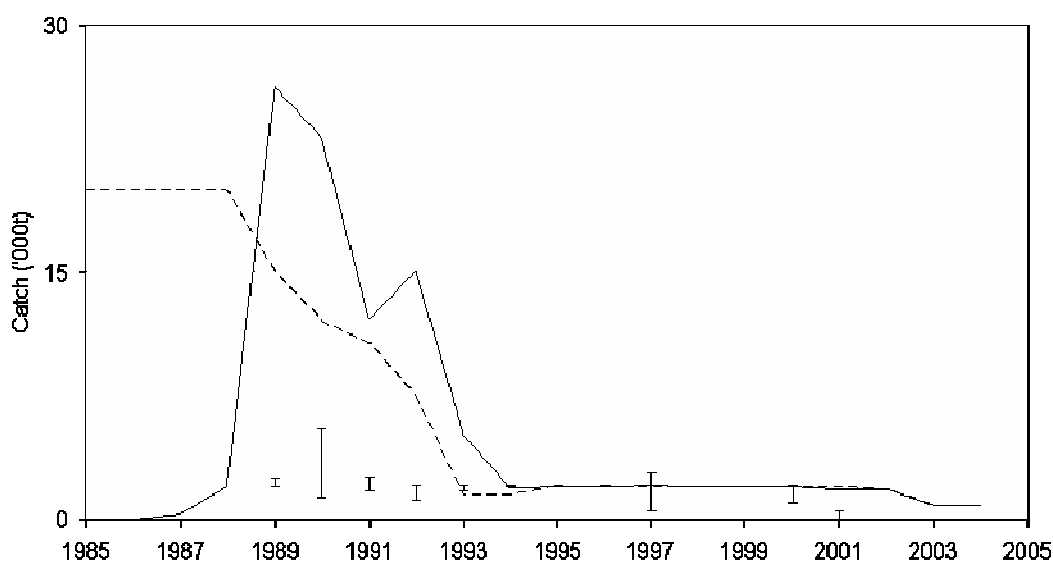


Figure 12.12: Estimated total catch (solid line), total allowable catch (TAC) dashed line, and scientific assessment group catch recommendations (given as a range) for Australian orange roughy fisheries. From Bax et al. (2005).

12.6 Lessons in precaution from the orange roughy:

Uncertainty is a key prerequisite for the application of the precautionary principle (see Appendix Two). Uncertainty is a pervasive aspect of fisheries management, which also has a global history of stock collapse resulting from management failures (or optimism, or foolishness) (Pauly et al. 2005, Rosenberg 2003, Caddy & Agnew 2003, Tilzey & Rowling 2001). Yet, in spite of this track record of failure, it is often hard to find modern examples of

precautionary management even in the fisheries of economically advanced nations. This section looks briefly at one of the underlying reasons: self-interest on the part of fishery managers.

There is no doubt that AFMA has a legal obligation to apply the precautionary principle to the management of Australia's fisheries. This requirement was not only written into AFMA's enabling legislation in 1997, but stems from obligations extending as far back as 1982, when the Australian Government endorsed the UN General Assembly's *World Charter for Nature*. The Australian Government's commitment to the precautionary management of natural resources has been re-affirmed through a number of national and international agreements (discussed in more detail in the section above dealing with international obligations). Not least of these agreements is Australia's commitment to the FAO *Code of Conduct for Responsible Fisheries 1995*, as well as Australia's long-standing endorsement of the United Nations fish stocks agreement (also 1995) – an agreement which is directly relevant to the management of the South Tasman rise orange roughy fishery, which overlaps Australian and international waters (see below).

Uncertainty is an unavoidable aspect of fisheries management, and sources of uncertainty are discussed in detail in an earlier chapter of this report. In providing scientific advice to managers, stock assessment scientists must, implicitly or explicitly, deal with uncertainties. Key questions relate to:

- the age structure of stocks, and estimates of natural mortality;
- in egg surveys, assumptions of dispersal rates of eggs, vertically and horizontally, as well as rates and locations of egg production, the proportion of females releasing eggs, the duration of spawning, as well as the degree of capture of eggs in samples;
- in acoustic surveys, the species composition of acoustic marks and the target strength of ensonified¹⁵⁵ species;
- the degree of aggregation of discrete stocks;
- the frequency and consistency of spawning events;
- the meaning of variations in measures of catch rate (CPUE) over time and between different operators;
- catch losses caused by discarding or burst bags, and
- the reliability and accuracy of spatial catch records in fisher log books.

In some cases a range of variable values can be estimated, with estimated probabilities, and a sensitivity analysis run to determine variation in model output. In other cases this approach is too complex or too time-consuming, and 'best guess' estimates are used. At the end of the day, a range of estimated output values are selected for presentation to fisheries managers, but in reality the accuracy of these estimates, and the probabilities of the value lying above (or below) any particular point in the range, are to a large extent little more than informed guesses.

Management targets are often expressed in probabilities – and the methods of estimating these probabilities should be clear to all concerned. In practice, these methods are seldom presented in stock assessment reports. This would perhaps not be of great concern if all the implicit assumptions were carefully presented, but again this is seldom or never attempted. Perhaps to do so would be to expose the soft underbelly of the rather shaky science on which these important estimates rest. Again, Koslow's comments make thought-provoking reading:

Some responsibility for the failure [to prevent stock collapse] resides with the scientists, particularly those who proposed and placed their faith in management models that had little margin for error – and the human elements in the management process. The models used to manage orange roughy indicated that the population could be fished down to 30% of original biomass without ill effect. But in a world with the usual greed, mendacity, weak managers, and strong political and economic pressures, it was virtually inevitable that the

fishery would not be adequately restricted until the stock was well below the target.

Consider a hypothetical example. Suppose original biomass is estimated at between 150,000 and 250,000 t, and current biomass is estimated at between 20,000 and 40,000 t (ignoring the probabilities discussed above for the moment) then the estimate of current biomass as a percentage of original biomass will lie in the range 8% to 27%¹⁵⁶. If a management limit reference point has been set where fishing is to cease if biomass falls below 20% - how should an obligation to apply the precautionary approach influence the ultimate decision? Simply interpreted, the precautionary approach can be seen as an admonition to err on the side of caution. In this case, the fishery should be closed, as there is a possibility (in practice of only vaguely known probability) that the limit reference point has been breached. A simple 'precautionary' approach to this situation is simply to apply the lower, most conservative end of the confidence interval.

However, there is also the possibility that the limit point has not been breached. Given that fishers need income to pay the mortgages on the loans which have secured their boats, what direction should the fishery manager take? The fishers are a very tangible part of the manager's working life. What is more important to the manager? If he applies the precautionary principle (as his legislation says he must) he must then deal with angry and insistent fishers. If he ignores the need to apply precaution – the stock may be increasingly likely to collapse. But if it does, who will complain? Not the fishers, for their interests will move elsewhere¹⁵⁷. Not the public, for they are far removed from the important detail of fishery management – as are the media. Not his political masters, for he can easily invent an argument laying the blame on unusual or unforeseen circumstances. And he can, as he has done before, report to his political masters that the precautionary approach has been applied (see the example below in the section dealing with the integrity of the Commonwealth's assessment process). AFMA has no working guidelines on how the precautionary approach *should* be applied – and apparently no intention of producing such guidelines. In their absence, the benchmarks on which a precautionary approach could be judged are sufficiently broad to enable the creation of plausible (though essentially fallacious) arguments sufficient to satisfy both his political masters and 'independent' auditors, should they be appointed to scrutinize management performance. The decision is clear – the fishery stays open.

The precautionary approach is somewhat more complicated than simply erring on the side of caution. A more detailed discussion of the approach is contained in Appendix Two; however here it is important to note that the application of this approach implies a reversal of the burden of proof. In the case above it should no longer be the responsibility of government fisheries scientists to demonstrate that the limit reference point has not been breached – this should now be the responsibility of the fishers or their consultants. It should also be noted that the precautionary approach applies in the absence of certainty. The greater the uncertainty, and the greater the possible harm involved, then the greater should be the caution applied (Preston 2006). As discussed above, uncertainties relating to predictions of orange roughy stock behaviour and reproduction were (and remain) large – probably very large. Moreover, the possible 'harm' involved was great – at risk was the commercial extinction of significant orange roughy stocks, having high extrinsic and intrinsic value (as an important component of deepsea ecosystems).

12.7 Precaution in fisheries assessments:

As mentioned above, Australia has long-standing national commitments to apply precautionary management to natural resources. In 1997 Commonwealth fisheries legislation was amended to require the application of the precautionary principle. The precautionary principle and approach have received much consideration in academic and fisheries management literature. The history of fisheries management provides numerous examples of overfishing in the face of uncertainty leading to stock collapse. The FAO – an influential fisheries agency – developed detailed guidelines on the use of precaution in fisheries in the mid-1990s. Against this background, it would not be unreasonable to expect that the use of precaution would feature prominently in stock assessment reports – but does it?

This section examines how the precautionary principle was used (or avoided) by the scientists engaged in assessing the state of orange roughy stocks. The evidence discussed below indicates that precaution was not discussed in anything but a cursory way in the reports where it should have been a key consideration. An avoidance of careful consideration of the precautionary principle is evident not only in the recommendations of fishery scientists, but in their language.

Bax (1996, 1997 and 1998) discusses uncertainties in stock assessment, especially related to estimating stock boundaries and stock natural mortality rates. These variables have a significant effect on the assessment of sustainable yield, and the likelihood that reference points are met or exceeded. However Bax does not at any time discuss the choice of model variable values in the context of the precautionary principle. Natural mortality is an obvious variable where uncertainty exists, and a precautionary approach would seem to favour choice of the lower rather than higher value. Even this simple concept received no explicit discussion in early stock assessment reports.

Do cliques develop within fisheries management and science organisations in which it is “unfashionable” to discuss issues such as a responsibility to take precaution into account? Three fishery scientists working for the CSIRO, McDonald et al. (1997:66) discussing the southern and eastern orange roughy zones, reported that: *“It is thought that current stocks are at about 30% of virgin biomass.”* Bax (also employed by the CSIRO, and also discussing the southern and eastern zones) had earlier reported that “there is a 82 to 86% probability that the biomass of orange roughy is below AFMA’s performance criteria of 30% of prefishery biomass” (Bax 1996:25). This example provides evidence that fishery scientists were taking a highly optimistic view of likely fishery biomass, which they know has a very high probability of being incorrect. Like Bax, McDonald et al. avoid discussing the issue of precisely what the precautionary approach should mean to stock assessment scientists or fishery managers.

Wayte & Bax (2002:19) in a stock assessment of the orange roughy, drew attention to the need to rebuild the eastern stock:

Under the preferred scenario for this stock, the biomass will have a 50% probability of being greater than 30% of the prefishery biomass by 2018 if the catch is zero. With an 800 or 1,600 tonne catch the time frame for stock rebuilding expands out to 2028 and >2060, respectively. Timeframes for rebuilding are shorter, but not markedly so for other scenarios that use all the data. Only under the most optimistic scenario (one that includes none of the age composition information), would the stock rebuild to meet AFMA’s current performance criterion in less than 10 years with a zero catch (2007). There is no obvious justification for discarding the age composition information and accepting this most optimistic scenario.

It is noteworthy that the scientists, in this summary for managers, do not draw attention to the apparent problems with the modelling approach used, nor do they draw attention to AFMA’s legal requirement to apply precaution to fishery management (and what that might mean in terms of setting TACs). Note too that the word “optimistic” in their text could have been written as “non-precautionary” in this same context. Discarding age composition information could also have been termed non-precautionary¹⁵⁸.

Another CSIRO report, Wayte (2004) provides further examples of the points made above. Here Wayte (2004:1) finds that “it is likely that a sustainable long-term annual catch level for the Cascade Plateau could be between 200 and 400 tonne.” She continues to describe *“the most optimistic scenario”* using the highest acoustic biomass estimate, the highest proportion spawning correction, and the mortality rate estimated for the eastern zone stock. It should be noted that the mortality estimate from Cascade data had been determined at 0.02, half that calculated for the eastern zone stock. The logic behind applying the eastern zone mortality to the Cascade stock estimation is not described – perhaps there is none. This “optimistic scenario flies in the face of the precautionary principle – which is never mentioned, in spite of its statutory relevance to management decisions. The very use of the word “optimistic” is

counter-precautionary – “risky” would appear to have been a much more appropriate adjective. Wayte does however state in the conclusion that: “half the [modelled] scenarios suggest that a precautionary long-term catch level for the Cascade Plateau should be *less than 200 tonne* (emphasis added). Rather than apply the precautionary approach and recommend a TAC for the following year of 200 tonne, Wayte states: “A sensible first step would be to reduce the catch in 2005 to 1,200 tonne...” (from the 2004 TAC of 1400 tonne). Recommending a TAC of 1200 t was endorsing a rapid fish-down – the same approach which had produced the collapse of the eastern stock.

In fact AFMA subsequently set the 2005 TAC at 1300 tonne. In this example not only is the science ignoring the precautionary approach, but AFMA ignored even the “optimistic” science. Later scientific assessments (eg: Wayte & Bax 2006; Wayte 2006) similarly avoided a careful consideration of how a precautionary approach might be applied to orange roughy stock assessments.

The BRS fishery status reports continued to class the Cascade orange roughy fishery in 2005 and 2006 as “not overfished” but noted “overfishing is occurring” (Larcombe 2006, and Larcombe & McLoughlin 2007). The importance of definitions of overfishing is discussed in Chapters 1, 11 and 17.

Scientists reporting through the Australian Deepwater Assessment Group (DAG 2005) appeared reluctant to apply or recommend precautionary approaches. The following example also calls into question the use of “best available science”. After discussing the Eastern Zone orange roughy fishery (which includes St Helens Hill) where estimated biomass fell from an initial 109 k tonnes in 1989 to 11.5 k tonnes in 2002, DAG noted that: “Current management objectives, strategies and performance indicators can no longer be reached for this stock.” Noting also that a 20% Bo limit reference point “is below that recommended for a long lived species and 30% would be more appropriate” DAG (2005:3) go on to recommend: “that an immediate management objective could be to rebuild stock to above the limit reference point (20%) with 50% to 90% probability.” Such advice, given the severity of the decline, and the wide probability range, *is arguably the reverse of precautionary*. It can also be argued that ‘best available science’ was being ignored.

The concept of a recommended biological catch (RBC) was developed for the SESSF by a working group convened by Tony Smith and Paula Shoulder (Anon 2005). It was subsequently applied to orange roughy stocks by Wayte (2005). The RBC is intended to estimate then total fisheries-caused mortality, including discards, net losses and collateral damage. Obviously, designated TACs, one aspect of fishing mortality, must be set at a lower level than the RBC.

In discussing how the RBC should be estimated for the Cascade stock (DAG 2005:6) highlighted the uncertainties involved, and found that the available information produced a RBC range from 124 to 408 tonne/year. The TAC had been set in 2005 at 1300 tonne – implying a RBC of considerably greater than that. DAG stated that “without firm evidence a precautionary approach to quotas is appropriate...” (DAG 2005:6). Bearing in mind the FAO’s precautionary recommendation that: “where the likely impact of resource use is uncertain, priority should be given to conserving the productive capacity of the resource¹⁵⁹,” a ‘precautionary’ RBC of 124 tonne would seem a reasonable recommendation, which might lead to a TAC recommendation (allowing for other fisheries mortality) of 100 tonne.

In making their final recommendation, the DAG stated: “It is recommended that, following the precautionary principle .. catches should be reduced.” .. “DAG recommends that catches be reduced to a TAC of 400 t over the next three years (Smith & Wayte 2005:71). The ‘precautionary logic’ behind this recommendation was not explained. The recommendation in fact seems the very reverse of precautionary. AFMA subsequently set TACs for the Cascade orange roughy fishery over the next three years at 700, 450 and 600 tonne – all higher than the least precautionary RBC estimate.

12.8 The Tasman Rise orange roughy fishery:

Australia's endorsement of the United Nations *Fish Stocks Agreement* UNFSA (the short title¹⁶⁰) conferred on the Australian Government (through its Departments and AFMA) moral and legal responsibilities to manage migratory and straddling fish stocks. This section presents evidence that AFMA ignored several of the most important of these responsibilities. Australia endorsed the UNFSA on its creation in 1995 (when moral responsibilities to manage fisheries in the spirit of the Agreement commenced) however legal responsibilities followed from its entry into force in 2001.

The Australian Government holds a view that the provisions of the UNFSA complement the widely supported *FAO Code of Conduct for Responsible Fisheries*, and should be widely applied to discrete stocks as well as straddling and migratory stocks. The Australian Government stated (Government of Australia 2006:6) quoting discussions at the UNFSA Review Conference 2006 supporting the view that "the UNFSA...provides appropriate general principles for RFMOs to manage discrete fish stocks... and they should start doing so immediately." This wide view of the applicability of the UNFSA would certainly support applying the agreement's principles to Australian fish stocks.

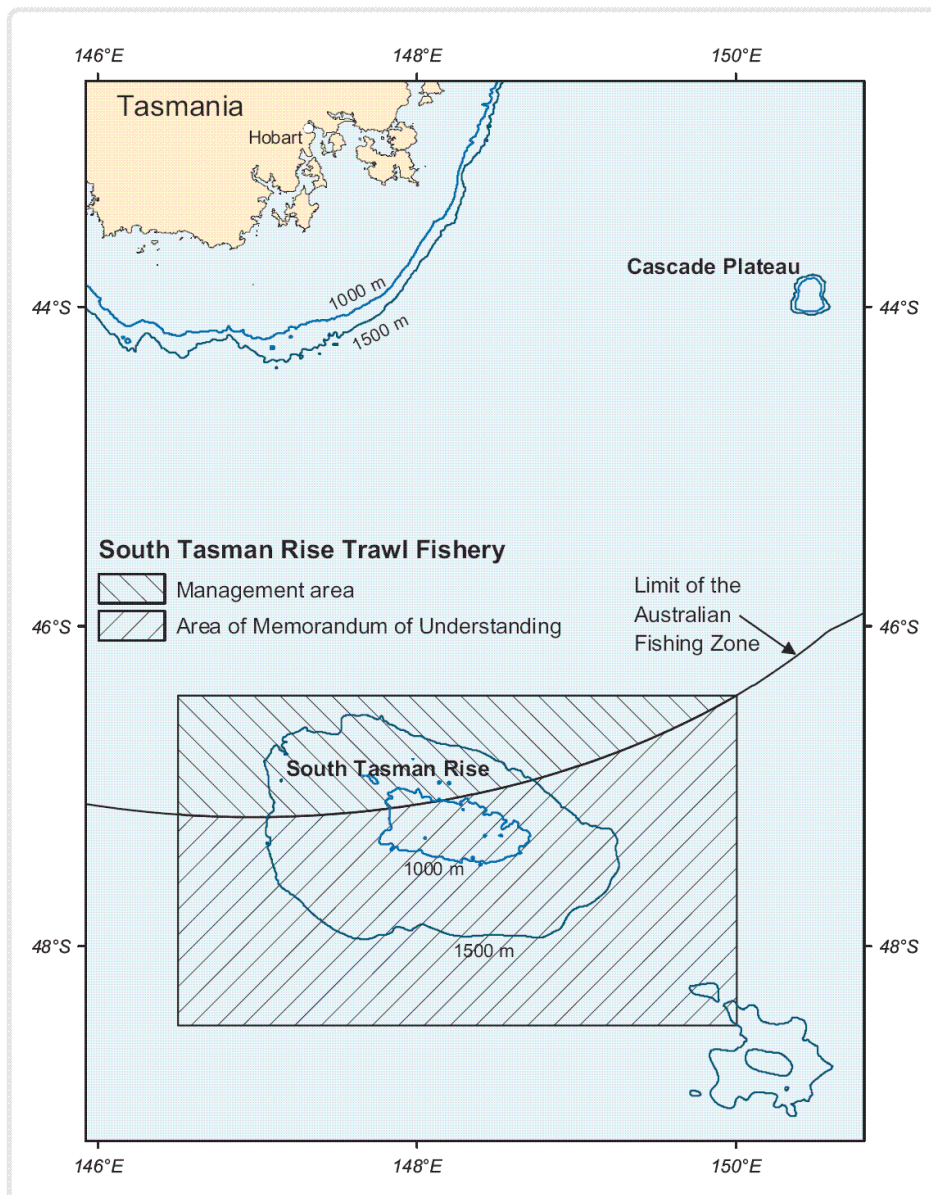


Figure 12.13: The orange roughy fishery at the South Tasman Rise overlaps the boundary of Australia's EEZ.
Source: Larcombe & Begg (2008)

The Tasman Rise is a seabed feature of plateau and seamount which straddles the most southeasterly section of Australia's EEZ (see Figure 12.13). The northern section falls within the SESSF zone known as 'Southern Remote'. The southern section to the south of the EEZ boundary is known as the Tasman Rise Zone. Australia and New Zealand are the fishing nations with best access to, and most interest in the Tasman Rise fishery. Orange roughy catches are recorded from this zone from 1998 to 2004.

The UNFSA is particularly important as it expands certain general provisions of the Law of the Sea as they relate to straddling and migratory fish stocks, and these expanded rights and obligations are not restricted to ratifying parties (referred to in the Agreement as "States Parties") but bind all States and other parties engaged in high seas fishing (Article 1 clause 3, and Articles 33, 34 and 35).

Articles 5, 6 and 7 establish the principles and core obligations of the Agreement. Under these Articles, all States involved in fishing of straddling and migratory fish must:

- apply the precautionary approach (further guided by Article 6 and Annex II), including an obligation to assess the impacts of fishing (Art. 5(c,d));
- adopt the ecosystem approach (Art. 5(e));
- minimise pollution, waste, discards, bycatch and ghost fishing (Art. 5(f));
- "protect biodiversity in the marine environment" (Art. 5(g));
- eliminate over-fishing (Art. 5(h)); and
- conduct necessary surveillance and enforcement (Art. 5(j,k,l)).

These are non-discretionary and powerful obligations, and would, if adhered to, do much to alleviate the crisis facing the global marine environment. They echo several of the core voluntary provisions of the FAO Code of Conduct. However, as discussed above, these provisions appear to be widely ignored, even by States expressing strong support for them.

Article 6 clause 6, elaborating the application of the precautionary approach to the management of straddling and migratory fish stocks, again echoes the provisions of the FAO Code of Conduct:

For new or exploratory fisheries, States shall adopt as soon as possible cautious conservation and management measures, including, *inter alia*, catch limits and effort limits. Such measures shall remain in force until there are sufficient data to allow assessment of the impact of the fisheries on the long-term sustainability of the stocks, whereupon conservation and management measures based on that assessment shall be implemented. The latter measures shall, if appropriate, allow for the gradual development of the fisheries.

AFMA, under these provisions, had a clear responsibility to protect the benthic environment, both for its intrinsic values and for its importance as the structural basis of the benthic ecosystem. However, Australia's use of scientific observers to monitor bycatch appears to fall far short of that of New Zealand (Anderson & Clark 2003). Australia's scientific observer coverage appears to have been extremely poor, and Australian reporting of bycatch information from this area is non-existent or inadequate, in spite of the recommendations by Francis & Hilborn (2002) discussed above, and a specific obligation in the Australian/New Zealand Tasman Rise Memorandum of Understanding for the employment of scientific observers.

Bottom trawls destroy coral structures within their sweep¹⁶¹. Anderson & Clark reported one of the few observer studies of coral bycatch from a virgin seamount site – the South Tasman Rise. In the first year of the study (1997-98) trawls averaged in excess of 1.5 tonne of coral per tow¹⁶² (about half the weight of orange roughy caught per tow), with the seasons operations taking around 1750 tonne of coral bycatch. The actual tonnage destroyed would be far higher, as a substantial proportion of delicate coral falls through the trawl mesh. Catches of 10 t per tow were not uncommon, with the maximum coral bycatch in one tow put at 50 tonne. Close to 100% coral cover was reported on unfished seamounts compared with

only 2-3% cover on heavily fished seamounts. Not unexpectedly, coral bycatch from the South Tasman Rise dropped dramatically over the three years of the observer study (Anderson & Clark 2003).

Article 1 of Annex 1 of the UNFSA sets out principles for the collection of data, and states: "Data collected should also include information on non-target and associated or dependent species." AFMA appears to have given this responsibility, together with responsibilities for protecting marine ecosystems, virtually no serious consideration. Over the course of the fishery (17 years) no attempts appear to have been made to identify habitat vulnerable to fishing in the South Tasman Rise, and exclude fishing operations from these areas.

The UNFSA also provides advice on the precautionary use of limit reference points (Annex II article 2): "Limit reference points set boundaries which are intended to constrain harvesting within safe biological limits within which the stocks can produce maximum sustainable yield." The Annex recommended that F_{msy} be used as a limit, not a target, reference point.

AFMA applied the same target reference point (30% B_o) and limit point (20% B_o) to the Tasman Rise orange roughy stock as it used in setting management targets for the other stocks. For species displaying a classical logistic growth curve (see separate section on uncertainty above) the biomass level producing MSY will be close to 50% B_o . AFMA appear to have made no attempt to argue that 20% B_o is compatible with a limit reference point of F_{msy} , at least in information available to the public. Where uncertainty exists, a precautionary default of 40-50% B_o should have been used. However in practice, AFMA's 20% B_o limit reference point was given the same lack of respect in the Tasman Rise Fishery as it was in other areas – it was ignored in setting catch limits as biomass declined (see discussion above).

After a boom period of record catches in the late 1990s, the fishery crashed in 2002 (Figure 12.10).

In summary, the UNFSA conferred on AFMA clear responsibilities to apply an ecosystem approach to the management of straddling stocks, and to widely protect marine biodiversity, including associated or dependent species. Given the fragile benthic habitats often associated with orange roughy, these responsibilities had, in this case, the most serious ramifications. AFMA also had clear responsibilities to apply precaution in setting catch limits, and in managing access and effort in the fishery, with the objective of preventing overfishing of the target stock.

Available documentation does not provide evidence suggesting AFMA took any of these responsibilities seriously or thoughtfully.

12.9 Minimisation of bycatch:

Bycatch here refers to both non-target organisms retained in the trawl, as well as collateral damage caused by the trawl as it moves across the sea floor.

As mentioned above, and as discussed in more detail in the appendix on deep sea trawling below, orange roughy, in undisturbed situations, appear to favour habitats created by cold-water corals. Like shallow water corals, these habitats are characterised by high structural complexity, high species diversity, and high vulnerability to destructive fishing practices. Once destroyed or badly damaged, the recovery times of such habitats are measured in centuries to millennia (Koslow 2007).

Australia, in endorsing the *FAO Code of Conduct for Responsible Fisheries 1995*, accepted an obligation to minimise the destructive effects of fishing, including bycatch. Much earlier, in the 1972 Stockholm Declaration, Australia had accepted an obligation to protect fragile natural habitats. The 1982 *World Charter for Nature* repeated this obligation, also embodied in the *United Nations Convention on the Law of the Sea 1982* (UNCLOS). Well before the time the orange roughy fishery commenced in Australia, AFMA has a clear responsibility to take action to minimise the destructive effects of fishing, including bycatch. Even the most elementary form of this obligation would logically involve identifying the destructive impacts

of different fisheries, identifying areas vulnerable to these impacts, identifying possible ameliorative measures, and taking every practical action to implement such measures.

An examination of the history of the Australian orange roughy fishery provides a striking absence of documentation relating to these four basic steps.

In terms of the identification of the impacts of the fishery, available literature contains no indication that any serious attempt was made by AFMA to identify and measure the impacts of deepsea trawling on cold-water coral habitats. However, information available from the New Zealand government is sufficient to show (un-surprisingly) that the impacts were extremely damaging, at least in places where independent observations were taken. According to Koslow (2007:220):

[New Zealand observers] provided the first good data on bycatch of coral and other species, from the outset of the deepwater fishery. The South Tasman Rise fishery proved relatively small: the total orange roughy catch through about half of the 2001-2002 fishing season was 11,000 t, with landings of about 4000 t per year in the first two years. Coral bycatch in the first year of the fishery was 1.6 t per hour of towing, for a total of 1762 t – about 44% of the orange roughy landings that year. The coral bycatch consisted predominantly of the reef-forming coral *Solenosmilia variabilis*, although many other species were obtained as well. Two years later the coral bycatch rate had dropped 76% to 428 kg per hour of towing – still sizeable, but an indication that the deepwater reef was being removed from the fishing ground.

Not surprisingly, surveys that compared fished and unfished seamounts off New Zealand and Tasmania found virtually no intact reef-forming coral on heavily fished seamounts, whereas coral cover on unfished or lightly fished seamounts was as high as 50-100%. In both regions, the most heavily fished seamounts had been towed across several thousand times, based on fishery logbook records. Given the size of the trawls and the small extent of the seamounts, typically only several hundred meters high and a few kilometers across at their base, it is little wonder that heavily-fished seamounts were scraped clean (Koslow 2007:221, also discussed in Anderson & Clark 2003).

These issues are discussed in more detail in Appendix 4 dealing with deepsea trawling. It should be noted immediately, however, that the coral catch figure mentioned above (1762 t) does not include broken pieces of brittle coral which escape through the trawl meshes after disintegration within the codend. It is entirely possible that the total bycatch, including collateral damage, was in excess of twice this figure – making the tonnage roughly the same as the target species tonnage.

Larcombe et al. (2001) published an examination of the spatial distribution and intensity of trawl operations in the southeastern region. While fishing intensity was low over the continental shelf (expressed as a proportion of the area subject to repeated trawling) the reverse was the case on the continental slope – home to the orange roughy and its fragile benthic habitat. In the 200-1000 m depth range, over 50% of the area (measure in 1x1km grids) was fished “with some intensity” (p.419). It is also worth noting that trawling effort remained relatively stable between 1989 and 1991, then increased considerably between 1992 and 1999 (the end of the study’s survey period). This corresponded to the period of exploratory trawling deeper waters, following the discovery of the orange roughy “bonanza”.

Judging by the lack of observer coverage or deepsea trawls, and the lack of scientific examination or mapping of deepsea habitats, the Australian Government’s (and AFMA’s) responsibility to protect fragile deepsea benthic ecosystems received virtually no systematic or strategic consideration during this period. AFMA strongly supported an increased emphasis on habitat mapping in their 2002 accreditation assessment report (AFMA 2000a) but did not follow up with substantial funding for this proposal (see the discussion in the next section).

12.10 AFMA's bycatch management measures:

This section examines the effectiveness and transparency of AFMA's bycatch management measures affecting the orange roughy fishery, as indicated by documentation available from AFMA's website.

The Commonwealth Department of Agriculture, Fisheries and Forestry (DAFF) published the *Commonwealth Policy on Fisheries Bycatch* in 2000. This policy generated a number of *bycatch action plans* applicable to major Australian fisheries or sub-fisheries. Those of direct interest to discussions on orange roughy are:

- the Great Australian Bight Trawl Fishery Bycatch Action Plan 2001;
- the South East Trawl Fishery Bycatch Action Plan 2001; and
- the Southern and Eastern Scalefish and Shark Fishery Bycatch Action Plan 2007.

These plans identified a number of activities, some of which were carried out within existing program funding, some of which were carried out under special-purpose funding, and some of which, if carried out at all, appear to have left no trace. An examination of available documentation raises serious questions concerning non-implementation of key commitments to monitor and alleviate problems relating to bycatch associated with trawl fisheries in general, and the orange roughy fishery in particular.

The *Policy on Fisheries Bycatch* is an important document, setting the scene for the action-oriented fishery-specific *Bycatch Action Plans*. It takes an overview of Australia's international and national responsibilities, and emphasizes the importance of key statutes, such as the Fisheries Management Act 1991, and the Environment Protection and Biodiversity Conservation Act 1999. It points out that bycatch planning (at least at the Commonwealth level) also needs to heed the broad commitments for the protection of the marine environment contained in *Australia's Oceans Policy 1998*, as well as similar responsibilities stemming from the United Nations Convention on the Law of the Sea (UNCLOS). The Policy defines bycatch broadly to include discards and collateral damage (that part of the 'catch' damaged by gear which does not reach the deck of the vessel).

The *Policy on Fisheries Bycatch 2000* contains a number of broad commitments which can be tracked through the relevant action plans, and the programs they initiated. From the perspective of our present discussion, the most important are the following (page references refer to the *Policy*):

- the establishment of bycatch monitoring programs (p. 6),
- the reporting of bycatch trends over time (p. 6);
- the establishment of bycatch limits to ensure that populations of bycatch organisms are not pushed beyond sustainable limits by the impacts of the fishery – consisting of reference points where data exists, and where data is absent the establishment of precautionary limits which can be enforced (p. 5);
- the establishment of temporary or permanent reference areas by which long-term bycatch impacts may be measured (p. 7);
- biennial reviews of bycatch action plans;
- a commitment to consistency and transparency in the establishment of bycatch action plans; and
- the broad application of 'best available knowledge' and precaution to bycatch management (p. 2, 3, 5, 7).

Table 12.1 below measures the progress of these commitments as far as can be judged from documents available on the AFMA website (www.afma.gov.au) bearing in mind the commitments made to transparency and accountability in the Policy itself, and by AFMA and the government generally¹⁶³.

Commitment	GAB Bycatch Action Plan 2001	SET Bycatch Action Plan 2001	SESSF Bycatch Action Plan 2007	Documents showing full or substantial implementation	Documents reporting on detailed program outcomes
establishment of bycatch monitoring programs	partial p. 7 ²	partial p. 6 ³	none ⁴	none ⁵	none
reporting of bycatch trends over time	none ⁶	none	none	none	none
establishment of enforceable bycatch limits	none ⁷	none	none	none	none
establishment of temporary / permanent bycatch impact reference areas	none ⁸	limited ⁹	none	limited	none
biennial reviews of bycatch action plans			n/a	-	-

Table 12.1. implementation of selected bycatch policy commitments with respect to Australian's orange roughy fishery 2000 – 2008.

The SESSF BAP Background Paper (2007) reported that a commitment to “map the habitat and habitat usage [of the SET fishery]” made in 2001 “has not been developed by AFMA” (p.37). A complementary proposal in the SET BAP to “assess the fishery to identify all grounds fished” and “identify significant habitat types in the fishery” was identified as high priority in October 2002 but had not been actioned by AFMA (p.46).

Table footnotes:

² According to the GAB Bycatch Action Plan (2001:6): “[Trawling] may cause short or long term impact on the benthos, the extent of which is currently unclear. However, worldwide experience suggests that the impacts may be significant, but can vary greatly depending on the nature of the environment and the frequency of trawling.” The Bycatch Action Plan describes a funded FRDC project to run a pilot bycatch monitoring program – however I have been unable to locate the report from this project.

³ The background paper to the SET BAP reports that scientific observers cover 4% of the shots in the SET Trawl Fishery, however reports from this program are not discussed or referenced.

⁴ None proposed for the orange roughy fishery.

⁵ I am unable to locate report from GAB funded pilot FRDC project.

⁶ None proposed, but perhaps implicit in commitment to bycatch monitoring.

⁷ Discussed but no definite proposals made.

⁸ Defers to the marine protected area establishment program within the Australian Government's regional ocean planning program.

⁹ The SET BAP 2001 reports (p.10): “An area encompassing the seamounts off the coast of New South Wales in the newly incorporated East Coast Deepwater Trawl Zone has been closed to trawl fishing.” The SESSF BAP Background Paper reported: “The closure of the Australasian seamounts in the East Coast Deepwater Zone and the Commonwealth Trawl Sector has been implemented” (p.38). It should also be noted that the St Helens Hill orange roughy spawning ground off the northeast of the Tasmanian coast was temporarily closed to fishing in 2003, although the eastern fishery remained open even though the limit reference point had been breached (see discussion above).

In summary, Table 12.1 indicates that important commitments made in the *Policy on Fisheries Bycatch 2000* either have not been actioned, or action has been weak, ineffectual, and poorly reported. Perhaps the most important failings relate to:

- reporting on bycatch and habitat damage associated with the orange roughy fishery, including an analysis of variation in space and time, and
- (b) inaction regarding habitat mapping in conjunction with habitat vulnerability identification.

While the fishing industry has supported the creation of small reserves to protect some deepsea seamount habitat, these reserves have not been on a scale sufficient to establish significant representative deepsea ecosystem reserves. Even the reserves which have been established over seamounts in general permit mid-water fishing, which may itself impact on deeper seamount ecosystems. A precautionary approach to the establishment of deepsea reserves is notably absent from the Australian Government's regional marine planning program to date.

12.11 Use of peer review in the management of orange roughy:

Drs N Deriso and R Hilborn (and later Francis and Hilborn) were contracted by AFMA to provide independent peer review of orange roughy stock assessments in 1994 and 2002. In both cases they found that leading-edge science was being used, although in some respects poorly applied (in both studies the reviewers highlighted several obvious errors in the stock assessment reports – see for example Francis & Hilborn 2002:13).

An interesting – and concerning – aspect of the reviews regards action taken (or not taken) on the reviewers' recommendations. Bax (1998:9) listed five important recommendations which had not been implemented four years after the first review. The second review (2002) made two extremely important recommendations which again were not funded by AFMA or the Australian Research Council (ARC) – presumably after due consideration¹⁶⁴. The first was that the fishery be subjected to a full management strategy evaluation. The second was that future stock assessment reports explicitly deal with issues of trophic impacts, bycatch and benthic damage caused by the fishery, focusing on identifying historic and current impacts, and examining methods to ameliorate damage caused. The fact that this latter recommendation remained – and still remains – without funding is an issue of grave concern, given the severe impacts often associated with deepsea trawling (see Appendix Four on deepsea fisheries below).

Certain aspects of the peer reviews also raise concerns about how well briefed the reviewers were. International reviewers are clearly heavily dependent on adequate briefing – which in this case was presumably the responsibility of AFMA. Taking the 2002 review as an example, Francis and Hilborn highlighted certain actions inherent in a precautionary approach to fishery management, including:

- prior identification of undesirable outcomes, and measures that will avoid or correct them;
- that any necessary corrective measures are initiated without delay; and
- that where the likely impact of resource use is uncertain, priority should be given to conserving the productive capacity of the resource.

With respect to the prior identification of undesirable outcomes, AFMA's lack of attention and action concerning the destruction of the benthic coral habitats has already been mentioned. AFMA's responsibilities in this respect are long-standing, as has been discussed. With respect to rapid corrective actions, AFMA's inaction in reducing TAC levels had already been highlighted by Tilzey & Rowling (2001) (quoted above) and this report should have been provided to the reviewers. With respect to the protection of the productive capacity of the resource, Kloser (2001) had found a dramatic reduction in the St Helens Hill spawning biomass (in excess of a ten fold decline). Again, presumably this report was provided to the reviewers – or should have been.

In spite of these well-documented failings, the reviewers found (Francis & Hilborn 2002:8): *“From the documents available to us the fisheries management approach adopted in Australia certainly meets these criteria...”*. They also found that: *“There is an existing management system that limits entry and quotas, catches and stocks are monitored, and catch levels are adjusted to conserve the biological productivity of the resource”* (emphasis added). This last point seems to be the key issue.

These findings directly contradict information in scientific reports which should have been made available to the reviewers.

12.12 Preserving scientific integrity within debates on fishing:

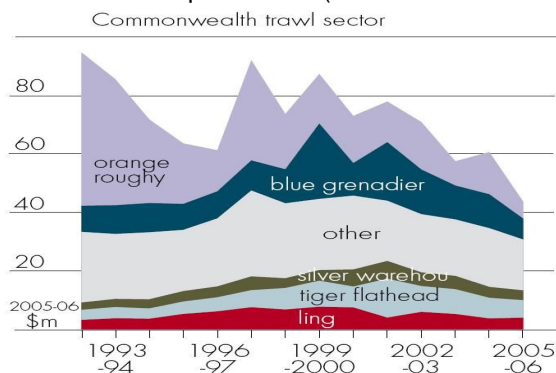
Tony Koslow’s views have been extensively quoted in this review. Naturally enough, his perspective is not shared by all fishery scientists. Both Tony Koslow and Colin Buxton are fishery scientists; Koslow based in Hobart over the heyday of the Australian orange roughy fishery, and Buxton a scientist/lecturer with Rhodes University and later the Australian Maritime College. Koslow was directly involved (employed in the CSIRO, contracted to supply scientific advice to AFMA) while Buxton was not directly involved in the fishery. It is of some interest to compare the perspective contained in Buxton et al. (2006) with Koslow’s perspective. The purpose of the Buxton report was to identify the economic costs associated with draft proposals for marine protected areas over Commonwealth waters in the southeast of Australia.

On the subject of bycatch, Koslow emphasised the destructive nature of the fishery, quoting New Zealand data as well as the results of Australian studies. However, according to Buxton et al. (2006:135): *“Catches on the main commercial grounds are usually very ‘clean’ with extremely low levels of bycatch...”*. Here the authors cite Knuckey & Liggins (1999) to support this statement, who report observer data indicating bycatch from the SESSF orange roughy fisheries as usually less than 30% by weight of the total catch. This bycatch rate was reported as comparatively low in comparison with other SESSF trawl fisheries¹⁶⁵.

Koslow emphasised the link between declining catches and stock collapse. However, according to Buxton et al. (2006:135): *“The fishery has reduced significantly since the late 1980s in response to management intervention and close monitoring of TAC levels, with the fleet reduced to a small number of dedicated vessels that concentrate their activities in deepwater.”* Here no mention is made of overfishing or stock collapse.

According to Buxton et al. (2006:139): *“Orange roughy are caught when they aggregate during spawning time, and as such cannot be taken viably during the remainder of the year in other areas.”*

Noting that the spawning period lasts 6 to 9 weeks, from early-June to mid-August each year, Buxton et al. argue here that only a small number of vessels are involved, for only a few weeks each year. Surprisingly however, Buxton et al. find that reducing orange roughy fishing would have very significant social and economic effects: *“[T]he proposed system of MPAs will decimate Australia’s orange roughy fishery and the many fishing and processing industries that depend on it”* (Buxton et al. 2006:136).



Source: Vieira et al. (2007:180)

The real gross value of production (GVP) for the sector in 2005-06 was just under \$44 million, 54 per cent less than in 1992-93. This is mainly the result of a steep decline in the total catch of orange roughy over this period (figure E). In 2005-06, blue grenadier, tiger flathead, orange roughy, silver warehou and ling accounted for 60 per cent of total gross value of production.

Figure 12.14: By 2005, it was clear that the value of the orange fishery was declining.

At this time (2006) the total Australian orange roughy catch amounted to approximately 1300 tonne, on a declining time trend (see Figure 12.14 above from Vieira et al. 2007). Assuming a landed value of \$3.30 per kilogram, this would be worth \$m 4.3¹⁶⁶. By comparison, according to the Larcombe 2006 fishery status report, total catch from the AFMA-managed Southern and Eastern Scalefish and Shark Fishery was 35,000 tonne, valued at around \$m 100 – shared between ports in Tasmania, South Australia, Victoria and New South Wales (no breakdown by State is available). The gross value of production from Tasmanian State fisheries in 2006 was \$m 417 (ABARE 2007:6). Assuming 25% of the SESSF value was landed in Tasmania, and assuming all the orange roughy catch was landed in Tasmania (predominantly Hobart) *then the value of the orange roughy catch amounted to only 1% of the harvest passing through Tasmanian businesses*¹⁶⁷.

In their conclusions, Buxton et al. (2006:140) find:

- Flow on effects would need to be assessed on a case-by-case basis, noting that the closure of the orange roughy fishery would have significant impacts on the existing infrastructure, particularly in Tasmania.
- Marketers and processors will suffer significantly with the loss of orange roughy, export markets will be lost as will the ability to generate a surplus through land-based processing of whole, fresh orange roughy into skinless fillets for the US market, and associated export synergies.
- Jobs will be lost onshore as well as on deepwater vessels:
 - a. There are specific businesses based in Hobart, which would become uneconomic without the activity of the orange roughy fleet out of Hobart. These include electronics, chandlery and gear businesses;
 - b. Transporters would be severely impacted, as orange roughy requires substantial transport services from Tasmania to the mainland.

These surprising claims¹⁶⁸ remain entirely unsubstantiated in the Buxton report.

In the Commonwealth Government's final decision regarding southeastern marine protected areas, the proposed areas of protection overlapping the Cascade Plateau orange roughy fishing grounds did not proceed.

12.13 AFMA's response to the Ministerial Direction

The Ministerial Direction (December 2005) instructed AFMA to:

- take action to cease overfishing;
- better manage the broader environmental aspects of fishing;
- take a more strategic, science-based approach to setting catch limits;
- develop a *harvest strategy policy* to manage fish stocks sustainably and profitably;
- include in the *harvest strategy policy* defaults of 40% Bo for target and 20% Bo for limit reference points;
- subject the draft *harvest strategy policy* to an expert-based review (foreshadowing the likelihood of using, for vulnerable stocks, defaults of 50% Bo for target and 30% Bo for limit reference points);
- attempt to introduce ITQs as a key management control into all Commonwealth-managed fisheries by 2010;
- minimise incentives for discarding; and
- implement a structural adjustment package to reduce over-capacity in the fishing fleet.

In May 2006 AFMA published their first report on their response to the Direction (AFMA 2006b). In terms of the instruction to cease overfishing, AFMA relied heavily on their developing *harvest strategy framework* (see previous references to Anon (2005) and Wayte (2005) . AFMA stated that this framework would result in management reductions to catch limits when stocks declined below 40% Bo, and instructions to cease targeted fishing when stocks declined below 20% Bo. Similar commitments had been a feature of AFMA's management regimes for many years, as outlined above, but not implemented. If the past can be used to predict the future, AMFA will leave many important commitments without serious attempts at implementation.

AFMA (2006:3) also stated that “the harvest strategy framework will automatically determine more precautionary catch limits for tier 4 stocks” (stocks with poor data or high level uncertainties). Clearly some refinement of the rules is foreshadowed, as Wayte (2005) had already found instances of the tier rules producing the opposite result.

AFMA (2006:4) placed orange roughy at the head of the queue for the planned *stock recovery plans*: “In 2006 stock recovery plans will be developed for orange roughy (all overfished stocks), eastern gemfish and school shark. Regulations may be implemented to give effect to some aspects of these recovery plans.”

AFMA were directed to improve their management of the “broader environmental impacts of fishing” (Macdonald 2005:1). As already discussed, orange roughy fisheries on New Zealand (and in other areas where comprehensive observer data is available) have had extremely damaging impacts on deepsea benthic environments, particularly seamounts and areas of coral. Limited data (Koslow et al. 2001) suggest the impacts of Australian fishing operations have been equally severe. Some nations, such as Palau, have banned deepsea trawling from their entire fishing zones. Others, like Norway, have mapped areas of deepsea vulnerable habitat, and have controls in place to exclude trawling from these areas. AFMA took a much weaker approach, nevertheless welcome, in temporarily excluding trawling operations from large areas of the SESSF below 700m:

Scientific advice on deepwater species generally supports the view that in order for fishing to be ecologically sustainable, the catch limits for these species will need to be set at very low or very precautionary levels. AFMA therefore expects that sustainable catch levels for these species will be so low that fishing is unlikely to be economically viable, particularly when the full cost of management (including research) is taken into account.

Therefore until sustainable catch limits for deepwater sharks and oreos can be determined, fishing below 700m will not be permitted by any method in all zones of the SESSF except in the areas defined above to target orange roughy and alfonsino.

In future, operators who wish to trial fishing in deepwater may be permitted to do so, in accordance with the processes (yet to be defined) (AFMA 2006c:7).

Notably, the orange roughy fishing grounds on the Cascade Plateau – where severe damage probably occurred in the past – were left open to trawling operations. AFMA also remained silent on the techniques it intended to use to police this trawling ban, or the resources necessary to do this. The temporary nature of the ban on deepsea trawling is also a matter of some concern.

12.14 Orange roughy listed as a threatened species:

This section discusses the legal and administrative background behind the listing of orange roughy as a threatened species under Commonwealth legislation, and draws attention to serious inadequacies in the orange roughy conservation programme, developed by AFMA in response to the proposed listing.

The Commonwealth Government, as well as most Australian States, have enacted legislation designed to protect threatened species and threatened ecological communities.

Once listed, governments have certain responsibilities – generally to plan for the amelioration of threats facing those species or communities. In most cases they have no detailed responsibilities to fund or implement those plans, however.

In the case of the Commonwealth, the relevant statute is the *Environment Protection and Biodiversity Conservation Act 1999*. The EPBC Act also provides for the listing of “key threatening processes”, which again require some planning action. The threatened species provisions of the EPBC Act have to date been most influential when identified “critical habitat” is the subject of a proposed development – either by government or by companies or individuals. In these circumstances the Act has resulted in some proposed developments either not going ahead, or going ahead under stringent conditions. Under the EPBC Act, species listed as *extinct in the wild*, *critically endangered*, *endangered*, or *vulnerable* become “matters of national environmental significance” – protected matters under the Act. The first and sixth classifications, *extinct* and *conservation dependent* are not classified ‘matters’ and are not protected by the provisions of the EPBC Act. However the minister may proclaim *critical habitat* for all listed categories, and in this case protective provisions of the Act do apply.

Persons or organisations can nominate a species for listing. It is then up to the responsible minister to decide whether it should be listed, and if so in what category it should be listed, after seeking advice from the Threatened Species Scientific Committee (TSSC). The Act provides for a decision to be made on a nomination with 15 months, except in special circumstances where additional information must be obtained. In making his/her decision, the minister and the committee are only allowed (under the provisions of the Act) to take into account the species’ conservation status. They are not allowed – obviously – to take into account the social or economic impacts of listing on, for example, a fishing fleet.

The Humane Society International (HSI) nominated the orange roughy as ‘vulnerable’ in June 2003, on the basis of steep declines in stock, and continued overfishing. The Commonwealth Minister for the Environment at the time was Ian Campbell. He had the authority to delay the listing by requesting the TSSC examine matters more thoroughly, and providing them with extensions of time.

Prior to the minister’s decision, AFMA wrote to the Department of Environment and Heritage (DEH) (McLoughlin 2006) expressing the view that using an assessment criteria of a steep decline in population numbers was inappropriate for marine fishes in general. AFMA argued that such steep declines were a natural feature of the marine environment, and that in general populations of marine fish could tolerate such declines without risk of extinction. AFMA agreed that fishing can cause steep declines in fish populations. AFMA’s letter to DEH was critical of DEH’s “unsupported views” – yet itself failed to cite even one scientific reference to support its own arguments. AFMA, while opposing listing at any level, implied that it would not be particularly concerned if the species was listed in the ‘lowest’ category: conservation dependent.

Three extensions and 40 months after the initial nomination, on 10 November 2006, the minister announced that orange roughy would be listed as “conservation dependent” (Darby 2006) – a listing which became effective on 5 December 2006. Since listing, critical habitat for the species has not been considered.

Although the Act does not require a *conservation plan* to be prepared for a species listed as conservation dependent, this is implicit in the Act, and AFMA prepared and submitted an orange roughy conservation plan to DEH for approval on 26 October 2006. DEH approved the plan without modification or even comment, although it had several serious failings.

Important aspects of the plan were:

- temporary bans on bottom trawling across the SESSF, with a limit of 750 m in the Great Australian Bight, and 700 m elsewhere (discussed above);
- “targeted commercial fishing for orange roughy will only be permitted in the Cascade Plateau Zone” (Rundle 2006:2);

- a commitment that AFMA's Cascade fishing management program will "maintain the spawning biomass of orange roughy on the Cascade Plateau at or above B_{60} with a probability of 50% so as not to impact on any potential role it may play in the recovery of depleted populations." (Rundle 2006:2);
- the establishment of a performance criteria "management measures are in place to enable a maximum rate of recovery of orange roughy." (Rundle 2006:3); and
- a "biologically reasonable timeframe" for recovery was set at 40-45 years (Rundle 2006:4).

The plan's important failings included:

- a complete absence of discussion about the need to protect the species' habitat, and how Australia's responsibilities to protect fragile marine habitats (for example, under the provisions of the UN Convention on the Law of the Sea – see Chapter 5) might relate to habitat monitoring and mapping programs, and the use of scientific observers in recording bycatch data;
- absence of a discussion of how the TAC which AFMA set for the following year of 450 t could be justified against scientific recommendations that the RBC was likely to lie in the range 124 – 408 tonne (DAG 2005) – again in the context of the precautionary principle, and the fact that the 2005 B_0 had been estimated at 33 – 44% of B_0 (well below the plan's target of 60% of B_0);
- absence of a discussion of how any TAC above zero is compatible with the plan's performance criteria of *maximizing* the rate of population recovery – again in the context of the precautionary principle;
- absence of a discussion of why such a low probability (50%) was chosen in the performance criteria, and how it should be calculated (again in the context of the precautionary principle);
- absence of a discussion of the need to investigate the relationship between orange roughy and its deepsea habitats, over its life-cycle¹⁶⁹;
- absence of a discussion of the need to investigate the place of orange roughy in the marine food chain, and
- absence of discussion of the need for stock monitoring programs of sufficient (and appropriate) statistical power within a precautionary framework (Hilborn 1996, Peterman 1990);

The fact that DEH approved a conservation plan which entirely ignores the need to protect the species' habitat, and contains recovery targets in apparent major contradiction to AFMA's management program, raises serious questions about DEH's ability to act as an environmental watchdog over AFMA's operations. Given AFMA's track record of failure to adhere to its own stated management strategies, the trust placed by DEH in AFMA's management abilities is even more surprising. Shortages of appropriately skilled staff in DEH, as well as management priorities, perhaps provide a partial explanation.

12.15 The integrity of the Commonwealth's environmental assessment process:

The Australian Government was one of the first worldwide to introduce a comprehensive system of fishery assessment and accreditation. In fact, according to Government of Australia (2006) it was the first.

Under the provisions of a Commonwealth statute, the *Environment Protection and Biodiversity Conservation Act 1999*, any Australian fishery wishing to export product must undergo a five-yearly review, assessed against benchmarks which are intended to measure aspects of the fishery's performance related to sustainability. These benchmarks (often referred to as the sustainability guidelines) were developed after an industry and public consultation program.

The process for each fishery involves the development of a review paper which provides background on the particular fishery in question, and addresses the benchmarks (guidelines) developed by the Commonwealth. This review paper is generally written by staff within the relevant fisheries management agency – which may be a State agency, or in the case of the Commonwealth it will be AFMA (all AFMA-managed fisheries undergo assessment, whether they export product or not). This review is made available to the public, who are invited to comment on it, or on any matter which they believe is relevant to the process. The review, together with comments received from the public, is subsequently assessed by officers from the Sustainable Fisheries Section of the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA). They advise the minister responsible for the EPBC Act (and this department) who then writes to the minister responsible for the fisheries management agency (or in the case of AFMA, directly to the Chairman of the Board). The assessment report is subsequently published.

In theory the Commonwealth Minister for the Environment could refuse accreditation, but in practice DEWHA appears to have adopted an unwritten policy of encouraging 'continuous improvement' rather than using a more heavy-handed approach. Every fishery which the Commonwealth has assessed has been approved, usually in the context of a number of recommendations for actions to improve the environmental performance of the fishery.

The form the approval takes is the accreditation of the fishery's management plan, which is, in the case of the Commonwealth, a statutory instrument in its own right (within the framework of the *Fisheries Management Act 1991*). Once the management plan is accredited, actions taken by fishers (under the conditions of permits issued under the plan) are legally exempt from prosecution (in fact scrutiny) under the EPBC Act.

This section briefly examines issues relating to the integrity of this process (using the orange roughy fishery as a case study) and asks a number of questions:

- are the Commonwealth benchmarks (guidelines) adequate?
- do the review reports provide sufficient information to (a) inform the public who might wish to comment on the process, and (b) adequately inform the DEWHA departmental staff charged with preparing the assessment?
- if not, does the process allow for a supplementary review report?
- are the timeframes of the process reasonable?
- do the approval recommendations issued by the minister adequately address the fishery's environmental problems?
- is there evidence that fishery management agencies address the recommendations promptly and fully? and most importantly
- do the ultimate assessment outcomes match the information made available to the public during the review process?

Adequate benchmarks:

The Commonwealth's assessment benchmarks (*Guidelines for the ecologically sustainable management of fisheries*) first appeared in public view in draft form in July 1999, and in final form in June 2000. An examination of the evolution of the benchmarks from draft to final form is contained in Appendix Three. The main findings are summarized below:

The evolution of the guidelines (after close of public comment) indicates that both gains and losses have occurred from a sustainable management regime perspective. Gains are generally in matters of clarification of detail. Losses on the other hand, are far more substantial, and three issues in particular are of considerable concern:

- A loss of auditability brought about by the replacement of *measurable* conservation targets by *general* commitments: eg: to 'minimise' harm;
- A loss of specific requirements for reference points designed to signal a situation so serious as to warrant temporary halts to fishing effort - these have been replaced by

requirements simply to 'reduce fishing effort' as the critical reference point is reached; and

- The replacement of demonstrable management aspects, such as the *existence* of effective compliance and enforcement programs, with 'paper' commitments to the development of *proposals* which are likely to produce the desired effect – ie: proposals which, in this example, *could* result in effective compliance and enforcement programs. It is important to note that there is a major difference between a good idea and an on-ground reality (see 3.1.9 above).

The precautionary principle is one of a small number of principles fundamental to ocean management. Dilution of the precautionary approach is apparent in comparing the original and final guideline texts. The original wording of draft Objective 3.1 required that “*the fishery shall be subject to ... arrangements ... which give effect to ... the precautionary approach to management.*” This requirement has been removed in the final text, and replaced with vague references to the use of the precautionary approach which move well clear of establishing a requirement.

This change in wording between draft and final versions appears to contradict the apparently strong commitments made by the Australian government to the precautionary principle in international agreements, national policy statements, and in legislation (Appendix Two). The change appears to substantially diminishes the ability of the Commonwealth Government to promote the use of the precautionary principle as an operational concept.

A comparison between the discussion draft and final versions of the guidelines indicates substantial weakening of the ability of the guidelines to promote sustainable approaches to fishery management between the two versions.

Requirements for auditable and meaningful performance criteria are an essential aspect of strategic governance systems: without them the intent of the original strategy or commitment is easily diluted, or lost entirely. The loss of such measurable criteria appears as a serious, even critical, weakness in the adopted guidelines.

Comprehensive documentation:

Australia's orange roughy fishery is concentrated within the Southern and Eastern Scalefish and Shark Fishery (SESSF). This fishery has been reviewed under Commonwealth procedures twice, in 2003 and again in 2006. The review documents prepared by AFMA (AFMA 2002a, 2006) are examined below for the extent and relevance of detail relating to the orange roughy fishery, noting that the SESSF comprises a number of fisheries, some grouped by gear, others by target. The detailed review is contained in Table 12.2 below.

The first of AFMA's two reports contains a substantial amount of information, while the second report is a much shorter update on the first. Neither report indicates that peer review was undertaken in the interests of quality control. The first report contains numerous spelling and grammatical errors, suggesting that it was not even proof-read. This seems surprising for a major public report, and may indicate the existence of a culture within the organisation placing a casual value on quality and professionalism. However the major failings of this report have nothing to do with spelling or grammar. The report contains false and misleading information, which would have the effect, on a reader unfamiliar with the details of the fishery, of diverting attention from key management failures (see Table 12.2). A striking example is where AFMA (2002a) describe management decisions as '*using the best available scientific advice*' which are in fact in direct contradiction to their own commissioned scientific reports. Of equal concern is simply lack of information. In most cases, discussions of the benchmarks either contain little or no information relating to the orange roughy fishery, or where information is presented, sources are not acknowledged or cited, leaving the reader in a position where follow-up is difficult or impossible.

A key question is *how many of the benchmarks are met by the orange roughy fishery in its current form?* Of the 28 guidelines, information in the first report is sufficient to demonstrate compliance with only two.

A major failing in the report is that it does not adequately present information on benthic damage caused by deepwater trawling. As indicated above, orange roughy are often found in association with coldwater coral habitats – which can be extremely bio-diverse. The dependence of orange roughy on coral habitat, in juvenile and adult form, is not understood – the species certainly occupies other habitats. However there is sufficient information available to show that deepwater trawling causes extensive damage to deepwater coral habitats, and it is known that these habitats recover extremely slowly (Koslow et al. 2001; Koslow 2007). The habitats destroyed by trawling could be critical to the orange roughy in one or more of its life stages – at this stage there is not enough information available to know.

The failure of AFMA to arrange comprehensive scientific observer sampling of orange roughy bycatch, and to present the results in the major assessment review (AFMA 2002a) needs explanation. In the absence of an explanation, the reader is left to assume the material has not been presented in the interests of sweeping incriminating evidence under the carpet. Although AFMA (2002a) discusses the need for habitat mapping, and foreshadows action in this area, no commitments are made to identify and protect deepsea vulnerable habitat, particularly coral habitat – one of the most vulnerable and probably one of the most biodiverse (Koslow 2007).

Table 12.2: Examination of referenced information in the two AFMA accreditation review reports relating specifically to the orange roughy fishery component of the SESSF.

Code: full = information is presented covering most aspects of the guideline
 part = information is presented covering an aspect of the guideline
 none = information is not presented covering any aspect of the guideline
 X = incorrect information is presented

GUIDELINE COMPONENT(2000)	Does the AFMA 2002a review contain referenced information relevant to the guideline?	Does the AFMA 2002a review report demonstrate that the guideline has been met?	Does the AFMA 2002a review report demonstrate that the guideline is likely to be met in the near future?	Does the AFMA 2006b review contain referenced information relevant to the guideline?	Does the AFMA 2006b review report demonstrate that the guideline has been met?	Does the AFMA 2006b review report demonstrate that the guideline is likely to be met in the near future?
Principle 1 objective 1. The fishery shall be conducted at catch levels that maintain ecologically viable stock levels at an agreed point or range, with acceptable levels of probability.		no	no		no	no
1.1.1 There is a reliable information collection system in place appropriate to the scale of the fishery. The level of data collection should be based upon an appropriate mix of fishery independent and dependent research and monitoring.	part	no	no	none	no	no
1.1.2 There is a robust assessment of the dynamics and status of the species/fishery and periodic review of the process and the data collected. Assessment should include a process to identify any reduction in biological diversity and /or reproductive capacity. Reviews should take place at regular intervals but at least every three years.	part ¹⁰ X ¹¹	no	no	none	no	no
1.1.3 The distribution and spatial structure of the stock(s) has been established and factored into management responses.	part ¹²	part	part	none	no	no

¹⁰ Independent reviews were commissioned in 1994, and eight years later in 2002. The 2002 review highlighted the lack of consideration of biodiversity impacts, and recommended that this be addressed in all future stock assessments. AFMA did not act on this important – in fact critical recommendation.

¹¹ AFMA (2002a): “four management units [zones] have quantitative assessments”. At the time of writing quantitative assessments had been prepared for the eastern, southern and western zones. A survey but no assessment had been conducted for the South Tasman Rise (Prince & Diver 2001).

1.1.4 There are reliable estimates of all removals, including commercial (landings and discards), recreational and indigenous, from the fished stock. These estimates have been factored into stock assessments and target species catch levels.	part ¹³	yes	yes	part	yes	yes
1.1.5 There is a sound estimate of the potential productivity of the fished stock/s and the proportion that could be harvested.	part X ¹⁴	no	no	none	no	no
1.1.6 There are reference points (target and/or limit), that trigger management actions including a biological bottom line and/or a catch or effort upper limit beyond which the stock should not be taken.	part X ¹⁵	no	no	none	no	no
1.1.7 There are management strategies in place capable of controlling the level of take.	yes	yes	yes	yes	yes	yes
1.1.8 Fishing is conducted in a manner that does not threaten stocks of by-product species. (Guidelines 1.1.1 to 1.1.7 should be applied to by-product species to an appropriate level).	none	no	no	none	no	no
1.1.9 The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.	none	no	no	none	no	no
Principle 1 objective 2. Where the fished stock(s) are below a defined reference point, the fishery will be managed to promote recovery to ecologically viable stock levels within nominated timeframes.	part	no	no	none	no	no
1.2.1 A precautionary recovery strategy is in place specifying management actions, or staged management responses, which are linked to reference points. The recovery strategy should apply until the stock recovers, and should aim for recovery within a specific time period appropriate to the biology of the	part X ¹⁶	no	no	none ¹⁷	no	no

¹² AFMA (2002a): [Stock structure] “remains uncertain despite considerable research.” – with no citations to research reports. Assumptions are made that the different management zones have different stocks, and TACs are set according to this assumption.

¹³ AFMA (2002a) make no mention of major breaches of TACs which occurred in 1990 and 1992 (see discussion elsewhere in this section) or any discussion of how compliance arrangements have been tightened over the preceding decade.

¹⁴ Tilzey (1994) is quoted as a source for an orange roughy natural mortality figure of 0.04. AFMA (2002a:165) advise the reader: “The long and relatively stable history of this fishery [the SESSF] indicates that current catches are taking a sustainable portion of each stock. Overfishing of some species has occurred in the past and strategies are in place for rebuilding to occur.” No mention was made of the fact that sustained catches can be maintained for some time by serial overfishing of distinct stocks, or that orange roughy stocks in the eastern, southern and western zones were below the original management strategy limit point in 2002. No mention was made of information indicating decadal variation in recruitment, or uncertainties surrounding mortality estimates and biomass estimates.

¹⁵ AFMA’s original management strategy for the orange roughy stocks included a limit reference point of 20% Bo, below which fishing would cease (Bax 1996). However by the time AFMA wrote the 2002 accreditation review, three orange roughy stocks has dropped below the limit point and AFMA had not acted to cease fishing. In the accreditation report AFMA do not acknowledge this situation, and merely refer to the target reference point alone (discussed elsewhere in this section). AFMA (2002a:169) incorrectly state that egg production data exist for “several orange roughy stocks” (without citing a reference). In fact, egg production data were (in 2002) only available for the southern and eastern zones.

stock.						
1.2.2 If the stock is estimated as being at or below the biological and / or effort bottom line, management responses such as a zero targeted catch, temporary fishery closure or a 'whole of fishery' effort or quota reduction are implemented.	X ¹⁸	no	no	part ¹⁹	no	no
Principle 2 objective 1: the fishery is conducted in a manner that does not threaten bycatch species.	none ²⁰	no	no	none	no	no
2.1.1 Reliable information, appropriate to the scale of the fishery, is collected on the composition and abundance of bycatch.	none	no	no	none	no	no
2.1.2 There is a risk analysis of the bycatch with respect to its vulnerability to fishing.	none	no	no	none ²¹	no	no
2.1.3 Measures are in place to avoid capture and mortality of bycatch species unless it is determined that the level of catch is sustainable (except in relation to endangered, threatened or protected species). Steps must be taken to develop suitable technology if none is available.	none	no	no	none	no	no
2.1.4 An indicator group of bycatch species is monitored.	none	no	no	none	no	no

¹⁶ According to AFMA (2002a:181): "reference points for all stocks ... explicitly take into account uncertainty..." – however AFMA does not explain this statement or cite supporting references. See footnote regarding guideline 1.1.6 – which applies to this guideline. AFMA cite only the part of the original management strategy relating only to the target reference point, implying that overfished stocks are expected to rebuild to the target reference point by 2004. Papers by Wayte and Bax in 2000 and 2002, which AFMA would be well aware of (seeing they commissioned them) had pointed out that this objective was not achievable. AFMA also state, incorrectly, that "there are quantitative models for all stocks in this [orange roughy] fishery. According to Bruce et. al. (2002) no stock assessment had been carried out for the Cascade fishery. Neither the South Tasman Rise, or the Great Australian Bight fishing zones (assumed to correspond to stocks) had quantitative stock assessments in 2002.

¹⁷ AFMA (2006b:27) refer to an orange roughy recovery plan, but do not provide a citation or URL.

¹⁸ This section of AFMA (2002a) contains blatantly false information, and provides an insight into AFMA's view of precaution and the use of best available science. Once again, AFMA do not mention the (now apparently abandoned) limit reference point, already breached for three stocks. AFMA (2002a:183) make the erroneous statement that: "[The Orange Roughy Advisory Group and the South East Fishery Advisory Group] have undertaken to continue reductions in TACs until models predict a higher than 50% chance of recovery to virgin biomass." First, the advisory groups do not set TACs – AFMA does. Secondly, ORAG and SEFAG never made such a recommendation in any publically available document. Wayte & Bax (2002) had recommended that the eastern zone TAC be reduced to zero (these authors had been expressing concern over the depletion of the stock since 1996). AFMA (2002a:184) stated "Current TACs for the southern and eastern sectors are considered precautionary, using the best available scientific advice, and have a good chance of meeting the recovery strategy". In fact, Wayte & Bax's analysis makes it clear that that best available science was being ignored, and that the current TACs made achievement of the recovery strategy impossible.

¹⁹ AFMA (2006a:31) discusses proposals (a) to temporarily close waters below 700 m to trawling other than existing orange roughy fishing grounds, and (b) temporarily close 20% of orange roughy aggregation sites in the Great Australian Bight to trawling. A small area at St Helens Hill was temporarily closed on 1/1/03 to protect the aggregation site from trawling (AFMA 2006b:13). Closures at the Tasmanian Seamounts Marine Protected Area, and in a 'trawl exclusion box' around some seamounts in the east coast deepwater trawl sector are mentioned but without detail, citations or URL (AFMA 2006b:18).

²⁰ In spite of the fact that AFMA had scientific observers collecting bycatch data on a proportion of orange roughy fishing vessels, no information is presented by AFMA (2002a) providing any bycatch data, or any summary or overview of this bycatch data.

²¹ An ecological risk assessment for the SESSF is mentioned, without a citation or URL (AFMA 2006b:27). Its relevance to the orange roughy fishery is not discussed.

2.1.5 There are decision rules that trigger additional management measures when there are significant perturbations in the indicator species numbers.	none	no	no	none	no	no
2.1.6 The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.	none	no	no	none	no	no
Principle 2 objective 2. The fishery is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species and avoids or minimises impacts on threatened ecological communities.	none ²²	no	no	none	no	no
2.2.1 Reliable information is collected on the interaction with endangered, threatened or protected species and threatened ecological communities.	none	no	no	none	no	no
2.2.2 There is an assessment of the impact of the fishery on endangered, threatened or protected species.	none	no	no	none	no	no
2.2.3 There is an assessment of the impact of the fishery on threatened ecological communities.	none	no	no	none	no	no
2.2.4 There are measures in place to avoid capture and/or mortality of endangered, threatened or protected species.	none	no	no	none	no	no
2.2.5 There are measures in place to avoid impact on threatened ecological communities.	none	no	no	none	no	no
2.2.6 The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.	none	no	no	none	no	no
Principle 2 objective 3. The fishery is conducted in a manner that minimises the impact of fishing operations on the ecosystem generally.	part ²³ X	-	-	none	-	-

²² AFMA (2002a) provide no discussion of Principle 2 Objective 2 relating to the orange roughy fishery.

²³ AFMA (2002a:188) state: "Impacts of demersal trawling on the fishery's seabed habitat do occur. The extent of the impact to bycatch species and the broader ecosystem is currently unknown... The impact of seabed modification on associated communities is unknown. The best way to assess impacts of trawling on seabed habitats is through spatial contrasts. A habitat mapping project is being conducted to do this." A logical aim of such a project in this context would be to identify habitats vulnerable to deepwater trawling, and to identify their condition and value. Such information would then allow important and vulnerable areas to be protected from trawling. Norway took this approach in the late 1990s (Koslow 2007). It can be argued that developing such a strategy should be the responsibility of the Australian Government broadly, and AFMA should not be unduly blamed for an absence of progress in this area. Nevertheless, AFMA must shoulder a portion of the responsibility – see discussion of poor progress in habitat mapping elsewhere in this section. The statement above that "the impact of seabed modification on associated communities is unknown" is misleading. Adequate information was available in 2002, from both Australian and New Zealand observations, showing that trawling vulnerable seamount habitats causes major damage. This was demonstrated for example by Koslow & Gowlett-Holmes (1998) – a paper itself cited later in AFMA's discussion. In contradiction to Koslow & Gowlett-Holmes' findings on damage to complex coral habitats, AFMA (2002a:233) state: "demersal trawl fishing methods are not likely to coincide with seabed habitats of high structural development...". AFMA correctly state that some seamounts have been protected from trawling, off the south coast of Tasmania, and off the coast of New South Wales. While AFMA (2002a:240) use the term "many" in reference to protected seamounts, it is important to understand how many are not protected, and what values might be at risk. AFMA (2002a:241) do provide some data on the southern Tasmanian seamounts: 15 of around 70 are protected from demersal trawling. In Norway's case (mentioned above) *all* vulnerable deepsea coral habitat has been protected from trawling.

2.3.1 Information appropriate for the analysis in 2.3.2 is collated and/or collected covering the fisheries impact on the ecosystem and environment generally.	part ²⁴	no	no	none	no	no
2.3.2 Information is collected and a risk analysis, appropriate to the scale of the fishery and its potential impacts, is conducted into the susceptibility of [the listed] ecosystem components to the fishery.	part ²⁵	no	no	none	no	no
2.3.3 Management actions are in place to ensure significant damage to ecosystems does not arise from the impacts described in 2.3.1.	part	no	no	none	no	no
2.3.4 There are decision rules that trigger further management responses when monitoring detects impacts on selected ecosystem indicators beyond a predetermined level, or where action is indicated by application of the precautionary approach.	none	no	no	none	no	no
2.3.5 The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.	part	no	no	none	no	no

Assessment process timeframes:

The public consultation process surrounding the first accreditation review was comprehensive, but the timeframes were tight considering the wide scope of the report, and the complex and detailed nature of many of the issues surrounding management of the fishery. The consultation process took the following steps:

- AFMA released terms of reference for the review report to the public for a period of 28 days in early 2002. Public comment was considered, and the terms of reference finalised;
- the terms of reference were used to develop a draft report which was released to the public for comment between 30 July 2002 and 31 August 2002;
- public comment was considered in finalizing the report, which was released for a two-month public comment period in November 2002;
- the Department of the Environment and Heritage took public comment into account in preparing their assessment report, released in September 2003.
- on 30 September 2003, the Minister for the Environment, David Kemp, wrote to Wendy Craik, Chair of the AFMA Board, announcing his decision to accredit the fishery, attaching a list of 18 recommendations.

Approval process: reports, letters and recommendations:

The two assessment reports prepared by the Department of the Environment and Heritage (DEH 2003, 2006) are summary reports which do not assess the AFMA material in depth. They do not address the important information gaps note above. The first report made 18 recommendations, mostly of an administrative nature suggesting changes to the fishery's

²⁴ AFMA has collected bycatch data through the use of scientific observers which would provide some indication of the impacts of orange roughy trawling on benthic habitats, however none of this information is presented, referenced or summarised. For example, under the Australia-New Zealand bilateral memorandum of understanding 1998 dealing with orange roughy fishing at the South Tasman Rise, AFMA was obliged to place scientific observers on vessels, and collect bycatch and benthic damage data.

²⁵ AFMA (2002a) indicate that program funding has been provided for an ecological risk assessment of the SESSF fishery (principal investigator or program identifier not cited) which is presumed in the text to address orange roughy trawling benthic impacts.

statutory management plan. These appeared relatively easy to comply with, and AFMA acted promptly to make the necessary changes to the wording of the plan.

The minister responsible for the EPBC Act, David Kemp, in his letter to the AFMA Board of 30 September 2003, made a number of statements which are interesting to compare with the findings above related to the deficiencies of the AFMA review. This comparison almost certainly reflects on the integrity of the Commonwealth fisheries assessment process well beyond the example of the SESSF.

I am satisfied that AFMA has provided a report that adequately addresses the current and likely impacts of activities taken in accordance with the management plan for the SESSF (Kemp 2003).

With respect to orange roughy, the report contained major examples of false and misleading information. It also contained major gaps in information on critical issues. Where information was presented, it was usually un-referenced.

I am satisfied that actions taken in accordance with the management plan are unlikely to have unacceptable or unsustainable impacts on the environment in a Commonwealth marine area (Kemp 2003).

I am also satisfied that, for the purposes of the wildlife trade provisions of Part 13A of the Act, the plan of management for the SESSF provides for the fishery to be managed in an ecologically sustainable way. I am also satisfied that it is unlikely to be detrimental to the survival or conservation status of any taxon, or threaten any relevant ecosystem, to which the fishery relates (Kemp 2003).

Actions taken under the management plan continued the unsustainable harvesting of orange roughy target stocks. The TAC for eastern zone orange roughy was set at 820 tonne for 2004, compared with a scientific recommendation for zero TAC (Wayte & Bax 2002). Koslow & Gowlett-Holmes (1998) had documented unsustainable bycatch damage caused by the industry, but AFMA had taken no steps to stop this damage continuing, or even to monitor its extent. Koslow & Gowlett-Holmes had documented the entire destruction of local ecosystems on heavily-fished seamounts.

A small group of southern Tasmanian seamounts had been included in a relatively small protected area. The Tasmanian Seamounts Marine Reserve was established to protect some seamounts from trawling (Koslow et al. 2001). However this does not justify the lack of monitoring or conservation in other areas, such as the Tasman Rise or Cascade Plateau. It should also be noted that fishing is permitted above the protected seamounts, even though the dependence of orange roughy on food sources in this area is not well understood. Again, a precautionary approach would see all harvesting activities excluded from all seamount marine reserves.

Three years later, the 2006 assessment documentation and decision followed the same path as the earlier decision.

The ultimate assessment outcomes do not match the reality behind the fishery, largely hidden from the general public by a superficial assessment and review process. If the example of the orange roughy fishery is indicative of other fisheries, Australia's fishery assessment process can fairly be accused of a lack of integrity and a lack of effectiveness, in spite of an appearance of transparency and accountability.

12.16 Benchmark assessment: precautionary, ecosystem and adaptive approaches:

The benchmarks used below are derived from chapters 7, 8 and 9 above.

Each benchmark is scored as follows:

- 0 – no evidence of policy or implementation;
- 1 – policy in place or partially in place; no significant implementation at this stage;
- 2 – policy in place; evidence of partial implementation;
- 3 – policy in place; evidence of substantial implementation.

Table 12.4: the precautionary approach:

	Benchmark	Assessment
A1	Management strategies and plans contain clear objectives, indicators and performance targets relating to the protection of: target stocks, populations of dependent and associated species, and habitat.	Score 1. Clear management strategies are in place with respect to the target species. In the past these strategies have not been implemented. No strategies are in place with respect to dependent species, other than fisheries closures in large part the result of stock collapse. Strategies to protect habitat have not been developed..
A2	Fishery management plans use pre-agreed decision rules based partly on limit reference points equivalent to, or more conservative than, both target stock MSY and bycatch population MSY for the most vulnerable species of bycatch.	Score 0. Fishery management plans and strategies have for many years used a limit reference point of 20% of original biomass – however this has been poorly implemented in the past. Bycatch limit reference points have not been established, and are now to some extent irrelevant do to the near-complete destruction of fragile coral habitat in heavily trawled areas. Expansion of the fishery into new sites, although in practice improbably, is currently banned under the orange roughy conservation program.
A3	Undesirable outcomes which could result from excessive fishing pressures are identified, and monitoring programs are in place with sufficient power to rapidly detect these changes should they occur.	Score 0.5 Undesirable outcomes were identified many years ago, and in fact have eventuated in all but the Cascade stock. Effective action was not taken to prevent stock collapse. Benthic damage was not identified as a management issue until very recently, and no effective action has been taken over the last remaining orange roughy trawling ground (Cascade).
A4	The risks to ecosystem health and integrity are assessed for each major fishery, and additional caution applied to management programs for high-risk fisheries	Score 0.5 In spite of the likelihood of major damage to benthic habitats, no effective action was taken to monitor or control these impacts as the fishery developed. Current restrictions on the expansion of new deepsea fisheries, if adequately enforced, will limit further damage (see above).
A5	Independent peer review is used as quality assurance for major management policies, strategies and plans.	Score 1.0 Independent peer reviews of stock assessments were undertaken in 1994 and 2002. However, key recommendations for studies from the later review were not funded. The reviews were however made public. Peer reviews were not undertaken in preparation of AFMA's accreditation reports in 2002 and 2006. AFMA has itself been the subject of independent management performance review on at least two occasions in recent years.

The precautionary approach continued.

A6	Management procedures provide for rapid response in the light of unexpected declines in target stocks, bycatch populations, or habitat value. Such provisions provide for fisher compensation where necessary.	Score 0.5 As described above, management was unable to respond rapidly in the face of unexpected declines in the target stocks. No effective action was taken to protect bycatch populations or habitats until major damage had taken place.
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Table 12.5: the ecosystem approach:

	Benchmark	Assessment
B1	There is formal periodic assessment of the impacts of particular fisheries against agreed objectives, including ecosystem-based objectives.	Score 2.5 The five-yearly assessment and review processes under the provisions of the EPBC Act meet this criteria. The criteria used, however, are open to criticism (Nevill 2004), as is the review's effectiveness (see discussion).
B2	There is monitoring and reporting of agreed ecosystem indicators based on stated ecosystem objectives.	Score 0.5 No ecosystem indicators have been agreed specifically in relation to the orange roughy fishery within the SESSF. However, ecosystem objectives are stated within AFMA's corporate vision, and discussed with AFMA's SESSF accreditation reports.
B3	There is a substantial program in mapping, protecting and monitoring critical and vulnerable habitats, funded by the fishery agency or responsible government.	Score 1.0 The Australian Government, through CSIRO and Geosciences Australia, undertake mapping of benthic habitats, partly in association with the government's regional marine planning program. This program broadly aims to identify and protect critical habitat of all endangered species. However, in relation to orange roughy habitat, protection of the habitat of the Cascade stock was recommended in the draft regional plan for the Southeast Region, but removed from the final protected areas plan. During the public discussion period, arguments of dubious logic and veracity were mounted by scientists opposed to the creation of protected areas over orange roughy habitat (see discussion of Buxton et al. (2006) elsewhere in this review).
B4	There are effective programs in place to monitor and maintain old-growth age structure in specific fisheries.	Score 0. No such programs are in place, other than the closures of orange roughy stocks/grounds resulting from stock collapse and the listing of the fish as endangered (conservation dependent) under the EPBC Act. Considerable information is available on orange roughy age structure (see for example Smith et al. 1998)
B5	The agency has a substantial program to account for evolutionary change caused by fishing.	Score 0. No such programs are in place, other than the closures of orange roughy stocks/grounds resulting from stock collapse and the listing of the fish as endangered (conservation dependent) under the EPBC Act.

The ecosystem approach continued.

B6	There are effective programs in place to maintain the spatial extent of all major sub-populations (both target and bycatch) affected by specific fisheries, and maintain and monitor population genetic diversity.	Score 0. No such programs are in place, other than the closures of orange roughy stocks/grounds resulting from stock collapse and the listing of the fish as endangered (conservation dependent) under the EPBC Act.
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Table 12.6: active adaptive management:

	Benchmark	Assessment
C1	The performance of the fishery management agency itself is subject to independent periodic review against stated objectives, and quantifiable indicators and performance targets.	Score 3. AFMA, while not under independent periodic review, has been the subject of several reviews ¹⁷⁰ including a one-off independent review, and is under scrutiny from its 'parent' department (Agriculture Fisheries and Forestry) as well as through the reports of other agencies, such as the Australian Bureau of Agriculture and Resource Economics (ABARE).
C2	The management program uses mathematical modelling to pinpoint uncertainties and generate alternative hypotheses.	Score 1. There is little evidence of this activity other than the models used by Bax, Wayte and Smith to investigate sensitivities to variation in assumptions on natural mortality and stock recruitment relationships. Note that Bax et al. (2005:266) describe an "adaptive management experiment" in the southern zone in 1994, which allowed "pulse fishing". This 'experiment' reads more like an excuse to allow mining of the stock, and was soon discredited.
C3	The assumptions behind the models are clearly set out and evaluated.	Score 0. There is no evidence of this activity.
C4	Reports incorporating the use of active adaptive management set out the bounding of management problems in terms of explicit and hidden objectives, and practical constraints on actions.	Score 0. There is no evidence of this activity.
C5	There are changes in management controls, designed to test clearly stated hypotheses, which are sufficiently large to reasonably produce detectable effects; the size of these effects is estimated in advance, and sufficiently powerful field surveys undertaken, and statistically examined to deduce the probabilities of both Type I and Type II errors.	Score 0. There is no evidence of this activity.
C6	Formal organizational requirements are established for evaluating and reporting the results of the experimental management strategies, both to managers and stakeholders.	Score 0. There is no evidence of this activity.

12.17 Concluding comments:

Pursuing ecological sustainable fisheries while enabling profitable fishing is the most important challenge in managing Commonwealth fisheries.

AFMA Corporate Plan 2008-2011.

AFMA (and its predecessor the Australian Fishing Service) has had a history over the last two or three decades of committing to broad management objectives incorporating sustainability, and these corporate objectives have led to more detailed management strategies and plans with what appear to be laudable goals¹⁷¹. In addition, AFMA must, under its enabling legislation, apply the precautionary principle to fisheries management. Such a charter would seem to lay a good foundation both for the sustainable management of fish stocks, and for the protection of marine ecosystems from the effects of fishing. However, in many cases outcomes have been less successful than expected, with most Commonwealth stocks reduced below the level that would produce maximum economic yield, and many unresolved issues surrounding the health of ecosystems (and the survival of populations) impacted by commercial fishing.

The rapid expansion of the early fishery in the late 1980s, and the accompanying neglect of the fishery's damage to benthic habitats, were in direct conflict with the principal management objectives articulated by the Australian Fisheries Service in 1984 (Bax et al. 2005), and were in direct conflict with commitments to protect marine ecosystems inherent in the *UN Convention on the Law of the Sea 1982*²⁶. This comment holds noting the creation of the small marine protected areas around the southern Tasmanian seamounts¹⁷². As the fishery developed in the mid-1990s, management's disregard of scientific advice (in allowing the expansion of catch rates on poorly understood stocks) was in direct conflict with responsibilities to apply precaution stemming from the *FAO Code of Conduct 1995*. Continued disregard of the fishery's benthic impacts was in direct conflict with responsibilities inherent in the *UN Fish Stocks Agreement 1995*, as well as earlier commitments made in 'softer' agreements such as the *UN Stockholm Agreement 1972*, and the *UNGA World Charter for Nature 1982*. During the early 2000s, AFMA neglected its responsibilities under the *Commonwealth Policy on Fisheries Bycatch 2000*. After orange roughy was listed as a threatened species, continued fishing on the Cascade Plateau was in direct conflict with the approved *Orange Roughy Conservation Plan 2006* (read in conjunction with AFMA's statutory duty to apply precaution) which required action to maximize the rate of stock recovery.

The current examination of Australia's orange roughy fishery indicates that, in practice, broad management goals are sometimes (perhaps often) corrupted in the process of implementation, and to understand how this happens, a good deal of the fine detail of the management of individual fish stocks must be carefully examined. I have tried to look carefully and critically at the detail lying behind the recent management of orange roughy. This examination has shown that, in practice, explicit management objectives have been abandoned in the face of pressure from the fishing industry. It has also shown that both managers and scientists appear to have a superficial understanding of the importance of the precautionary and ecosystem approaches, and a cavalier attitude to their implementation. Commitments relating to the protection of benthic ecosystems, and the reporting of bycatch trends over time, have not been kept.

The small marine reserves over orange roughy habitat are too little too late. By the time the South Tasman Seamounts Reserve was established, all south east Australian seamounts at orange roughy preferential depth (800 – 1000 m) had been trawled (A. Williams pers. comm. 23/3/09) and almost certainly severely damaged. No significant spawning aggregation sites have been protected by permanent reserves.

²⁶ The fact that several international agreements did not come into force for some years does not remove Australia's responsibilities to comply with the spirit and intent of those agreements immediately following registration of support.

In many cases, over a period of many years, the words of policy do not match the reality of management. There are no indications that the organisational cultures, which support fishing in direct conflict with strategic national and international agreements, have changed. There are no indications that these cultures pay any more attention to the precautionary and ecosystem approaches now than they did when these approaches were first adopted as strategic national goals many years ago.

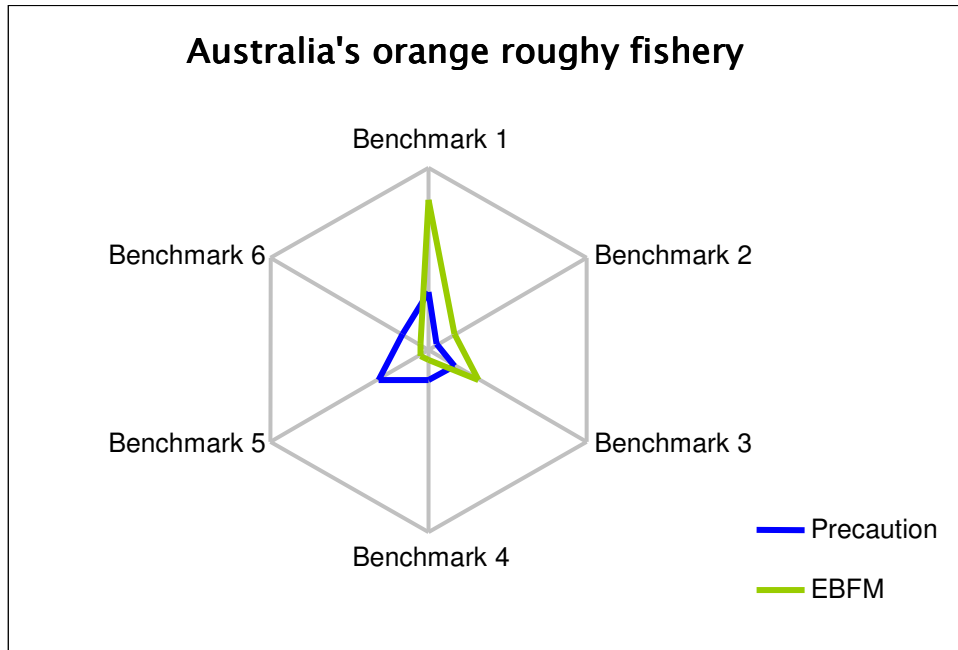


Figure 12.14. Kite diagram showing benchmark performance on precaution and ecosystem based management for the orange roughy fishery.

This chapter has examined the extent to which the precautionary and ecosystem approaches, and active adaptive management, have been applied in the Australian orange roughy fishery. The results of the benchmark assessment, contained in the detailed table above, are summarised for the precautionary and ecosystem approaches in Figure 12.14. Active adaptive management is not displayed in the above kite diagram, but is broadly ignored within the fishery – although it must be said that this is not unusual, in the Australian or global contexts. Figure 12.14 could be summarised by saying that implementation of the two former approaches is minimal in the orange roughy fishery – indicating little more than a token commitment to either approach on the part of the fishery managers – AFMA.

Other issues have been examined in this review. Briefly, the conclusions are:

- 1) AFMA failed to apply basic elements of the precautionary approach to the management of the orange roughy fishery. In this respect AFMA's actions appear to be in breach of the *Fisheries Management Act 1991*, as well as the United Nations *Fish Stocks Agreement 1995*;
- 2) AFMA failed to apply basic elements of the ecosystem approach to the management of the Tasman Rise fishery, breaching obligations under the United Nations *Fish Stocks Agreement 1995*;
- 3) AFMA, in preparing the first accreditation review for the Commonwealth fisheries assessment process under the *Environment Protection and Biodiversity Conservation Act 1999* (AFMA 2000a) supplied false and misleading information which had the effect of underplaying previous management failures, and the precarious situation of the orange roughy stocks;

- 4) The outcomes of the Commonwealth's review and accreditation process in relation to orange roughy cast serious doubt over the integrity of the process – and this shadow may lie over the accreditation of all fisheries which have been assessed;
- 5) Although AFMA widely ignored the recommendations of fishery assessment scientists for substantial reductions in catch, even the assessment reports prepared by these scientists appear to underplay the importance of precaution in both stock assessment and management;
- 6) AFMA appear to have been extraordinarily slow in acting on responsibilities contained in the *Commonwealth Policy on Fisheries Bycatch 2000*.
- 7) AFMA have not acted on important recommendations contained in the two independent reviews of orange roughy stock assessment (1994 and 2002); and
- 8) In response to the listing of orange roughy as a threatened species, AFMA prepared a conservation plan for the recovery of orange roughy which contained such a serious omission (see above) as to call into question the competence of both the plan and AFMA's management, yet the plan was approved by the minister responsible for the EPBC Act, at the advice of his department, without comment or modification.

Epilogue:

When forecasting the outcomes of risky projects, executives all too easily fall victim to what psychologists call the planning fallacy. In its grip, managers make decisions based on delusional optimism rather than on a rational weighting of gains, losses, and probabilities. They overestimate benefits and underestimate costs. They spin scenarios of success while overlooking the potential for mistakes and miscalculations. As a result, managers pursue initiatives that are unlikely to ... ever deliver the expected returns.

Lovallo & Kahneman (2003) quoted in Bax et al (2005).

Endnotes:

¹³⁶ Due to extensive citation of Koslow (2007), endnotes are used for some referencing in this section to enhance readability of the text. See Koslow (2007:207).

¹³⁷ Koslow (2007:208)

¹³⁸ Koslow (2007:208).

¹³⁹ Koslow (2007:208).

¹⁴⁰ Bax et al. (2005) – note quote from Lovallo & Kahneman (2003).

¹⁴¹ Bax et al. (2005) outline the administrative arrangements for managing the offshore fisheries around southeastern Australia: Up until the mid-1980s fisheries were managed by the States. In 1985 the Australian Fisheries Service (a division of the Commonwealth Department of Primary Industries) took over management of the fisheries on behalf of the Commonwealth Government. The AFS was later transformed in 1992 into a statutory authority at arm's length from the Commonwealth minister responsible for primary industries: the Australian Fisheries Management Authority (AFMA).

¹⁴² Bulman & Elliot (1994:1) found length at first maturity in the St Helen's Hill population was 30 cm for males and 32 cm for females.

¹⁴³ Bulman et al. (1994:B11-12) in a survey of St Helens Hill found that a proportion of females (40-46%) do not appear to spawn each year. Koslow et al. (1995) found that the proportion of non-spawning females declined from 46% to 29% between 1990 and 1992 for the St Helens spawners based on surveys carried out prior to the spawning season away from the spawning ground. The authors urged conservative management (Bulman & Elliot 1994:1).

¹⁴⁴ Due to extensive citation of Koslow (2007), endnotes are used for some referencing in this section to enhance readability of the text. Citation for this sentence is Koslow (2007:209). Bruce et al. (2002:35-36) also comments on the episodic nature of recruitment.

¹⁴⁵ Koslow (2007:204).

¹⁴⁶ Koslow (2007:204).

¹⁴⁷ Koslow (2007:204).

¹⁴⁸ Koslow (2007:206); Scientists involved in assessing the sustainability of deep-sea fisheries in the New Zealand and Australian regions and in the Southwest Indian Ocean have come to similar conclusions. For example, Clark (1999) stated that an analysis of commercial catch and effort data in fisheries for orange roughy on seamounts in New Zealand waters, one of the largest deep-sea bottom trawl fisheries in the southern hemisphere, “show strong declines in catch rates over time, and a pattern of serial depletion of seamount populations, with the fishery moving progressively...to unfished seamounts.”

¹⁴⁹ Koslow (2007:206).

¹⁵⁰ Koslow (2007:205).

¹⁵¹ Koslow (2007:206).

¹⁵² AFMA (2006:5) did not disagree with Koslow’s view: “The expansion of fishing within the area of the SESSF, from its early years as a shark fishery to its evolution into a multi-species, multi-method fishery, occurred in large part with very few controls over how quickly or into what areas the fishery expanded before the expansion actually occurred.”

¹⁵³ Koslow (2007:208).

¹⁵⁴ According to Bax et al. (2005:269): “TACs were set an order of magnitude higher [than scientists’ recommendations] and were either not enforced or failed to take into account lost and discarded fish, so catches were considerably higher.”

¹⁵⁵ Acoustically imaged.

¹⁵⁶ Note the discussion about orange roughy survey accuracy in Bulman et al. (1994:15-16) emphasising substantial uncertainties. Bruce et al. (2002:36) emphasised that “assessment results are highly dependent on the rate of natural mortality used.” McDonald et al. (1998:68) also discussed uncertainties in stock estimation, and found that the unfished biomass in the eastern zone “is most likely to be within the range 75,000 to 160,000 tonne and [for the southern zone] is most likely to be between 30,000 and 135,000 tonne.” Kloser et al. (2001:4) reported survey estimates of stock size from the St Helens Hill population (from the one set of 1999 survey measurements) between 1100 to 5200 tonne. Honkalehto & Ryan (2003:2) reported estimates of the spawning biomass at the Cascade Plateau in 2003 in the range 5000 to 53,400 tonne, with a most likely figure of 9650 tonne. Wayte (2004:1) estimated B_0 at the Cascade Plateau lying in the range 20,000 – 38,000 tonne, and later in the same report (p.22) gave the estimated B_0 range as 23,000 – 44,000 tonne. These are substantial range bands, and immediately raise the issue of how the estimates should be treated within a precautionary decision-making framework. Uncertainty in other model parameters increases the uncertainty of stock projections (Punt et al. 2002).

¹⁵⁷ In the case of very high profile stock collapses, fishers do blame the government. A good example is the collapse of the Canadian cod fishery. This collapse was so large and dramatic that fishers, and the industries attached to the fishery, had nowhere to go (Harris 1998).

¹⁵⁸ Unless there were serious concerns about its veracity: no such concerns were raised in the above report.

¹⁵⁹ See reference to this guidelines elsewhere in this paper.

¹⁶⁰ The UN Fish Stocks Agreement 1995 full title: “AGREEMENT FOR THE IMPLEMENTATION OF THE PROVISIONS OF THE UNITED NATIONS CONVENTION ON THE LAW OF THE SEA OF 10 DECEMBER

¹⁶¹ Koslow & Gowlett-Holmes (1998): “Fauna are extensively damaged by normal trawl operations...”

¹⁶² Anderson and Clark quoted a report from G. Diver giving an upper catch figure of 50 tonne of coral in one tow.

¹⁶³ See for example AFMA’s vision statement in their Annual Report 2007/08, which highlight’s AFMA’s commitment to accountability.

¹⁶⁴ According to Smith & Wayte 2003:181: “Additional 2003/04 funding to initiate the MSE approach was rejected by the ARC in February 2003.”

¹⁶⁵ It should be noted that, even assuming the bycatch level of 30% was not often approached, such a figure appears quite high, particularly for a fishery targeting aggregations. If much of the bycatch was coral and other benthic organisms (see Appendix 4) this would signal grave concerns about impacts on benthic ecosystems.

¹⁶⁶ ABARE 2007 does not provide the gross value of production for orange roughy fisheries. The most recent available estimate is from the ABARE 2005 report, which puts the value at \$m 8.6 for 2595 tonne, or \$3.30 per kg.

¹⁶⁷ If only the wild harvest is considered, this figure is 3% - still very small when it is noted that businesses mentioned by the Buxton report, electronic retailers for example, have a substantial customer basis outside the commercial fishing sector.

¹⁶⁸ While the claims made in Buxton et al. (2006) of the closure of support businesses (resulting from orange roughy fishing closure) appeared surprising at the time they were written, on account of the relatively small stature of the fishery in overall terms, they appear even more surprising in hindsight. In 2006 and 2007 support businesses were in fact affected by the contraction of the local wild fishery resulting from the Commonwealth Government’s industry restructure program. The overall program removed nearly 40% of the SESSF effort, and although the specific impact on the Tasmanian sector of the SESSF is not available, it is apparent that it would have been around an order of magnitude greater than the impact which would have resulted from complete closure of the orange roughy fishery.

To examine the impact on supporting businesses of this substantial contraction of the SESSF fleet, take the case of ships chandlers, a line of business closely tied with shipping (more so than electronics retailers, also named in the Buxton report). In 2006 Hobart had four substantial ships chandler businesses located near the Hobart fishing harbour: CH Smith Marine, Peter Johnston Marine, Purdon & Featherstone, and Tasmanian Shipping Supplies. The latter two business were not noticeably affected by the 2006 restructure, as they cater for larger vessels (pers.comm. Edward Fader, P&F manager, 18/3/09). However CH Smith is a small ‘working chandlery’ and was significantly affected. In 2006 their business was oriented towards the commercial fishing fleet, unlike Peter Johnston, which is oriented towards the yachting sector. In 2005 CH Smith’s turnover was 70-80% commercial fishing vessel supplies; this moved to 30-40% in 2008 (pers.comm Tony Rice, manager, CH Smith, 19/3/09). Over this period CH Smith applied for financial assistance from the Commonwealth Government’s onshore business assistance package, but this application was refused. Neither CH Smith Marine nor Peter Johnston Marine laid off staff over the 2005-08 period – in spite of a fishing fleet contraction around ten times larger than that which might have been created if the orange roughy fishery had been completely shut down in 2006. Although Peter Johnston Marine noticed a reduction in sales to the commercial fishing fleet after the 2006 restructure, this amounted to considerably less than 1% of their gross turnover (Andrew Johnston, manager, 24/3/09).

¹⁶⁹ The link between orange roughy and its benthic habitat remains in urgent need of investigation, decades after targeted fishing for orange roughy commenced. It is known that orange roughy feed primarily on midwater fishes, prawns & squids that either vertically migrate or drift in deep scattering layers past the seamounts. Orange roughy adults

presumably depend on benthic habitat for refuge, but little is known on this issue. The reproductive biology of the fish is also not understood, including the dependence of juveniles on benthic habitats.

¹⁷⁰ According to AFMA (2002:5): "In addition to specific legislative accountability provisions, AFMA has been subject to a number of external reviews and audits. AFMA's management effectiveness has been reviewed by the Australian National Audit Office (twice), a Senate Standing Committee (1993 and 2000) and a House of Representatives Standing Committee (1997). In response to these reviews, and as part of good corporate governance, AFMA has strengthened its planning, performance assessment and reporting arrangements. The strategic assessment process under the EPBC Act is also a process of review and audit."

"Independent reviewer ACIL Pty Ltd reviewed AFMA's management advisory committees (MACs) in late 2000. The ACIL report highlighted concerns over a number of MAC and AFMA processes and practices, although strongly supporting the MAC concept and the contribution of MACs to Commonwealth fisheries management. These concerns were dealt with in a series of 31 recommendations, the majority of which have been adopted by the AFMA Board. The Board noted that actions had already been initiated to address some of the issues covered in the report but that further action will be required to implement the remaining agreed recommendations. AFMA is currently developing a timetable and plan for implementing these recommendations."

¹⁷¹ Compare the above statement from the current AFMA Corporate Plan with the principal objectives from the management plan for the southeastern trawl fishery (Australian Fisheries Service 1984, quoted in Bax et al. 2005): "(a) ensuring through proper conservation and management measures that the living resources of the Australian fishing zone are not endangered by over-exploitation, and (b) achieving the optimum utilization of the living resources of the Australian fishing zone."

¹⁷² The creation of the small MPA protecting 15 seamounts south of Tasmania was certainly welcome, but as noted above does not excuse or justify the lack of protection (or even bycatch monitoring) over other areas of the fishery.

13. Benchmark appraisal: South Australia's abalone fishery

The purpose of this appraisal is to compare the SA abalone fishery management regime to benchmarks representing key aspects of three broad 'modern' management approaches: active adaptive management, and the precautionary and ecosystem approaches.

13.1 Background:

The South Australian *Fisheries Management Act 2007* explicitly incorporates the precautionary principle. Section 7 (Objects of the Act) emphasizes "proper conservation" and the need for actions to be "consistent with ecologically sustainable development" – defined as "taking into account" the precautionary principle. In addition South Australia endorsed the *National Strategy for Ecologically Sustainable Development* (Commonwealth of Australia 1992) which embodies the precautionary principle. It appears, at least on paper, that precaution must be applied within activities sanctioned under the Fisheries Management Act.

South Australia has not explicitly endorsed use of the ecosystem approach or adaptive management within management of State fisheries, although the ecosystem approach is implicit within the objects of the *Fisheries Management Act 2007*. The Act requires (s.7) "aquatic habitats are to be protected and conserved, and aquatic ecosystems and genetic diversity are to be maintained and enhanced." In addition (s.7) states "proper conservation and management measures are to be implemented to protect the aquatic resources of the State from over-exploitation and ensure that those resources are not endangered."

The Act requires that fishery management plans must be consistent with the objects of the Act (s.43), and requires that management plans must assess and address ecosystem risks associated with the fishery (s.43(2)). The Department uses the approach set out in Fletcher et al. (2004) in conducting risk assessments¹⁷³.

The ecosystem approach is endorsed by (in fact central to) *Australia's Oceans Policy 1998*; however the South Australian Government does not formally support this document. The ecosystem approach is also central to the FAO Code of Conduct for Responsible Fisheries 1995, which the Australian Government endorsed through the Rome Declaration in 1999 (Chapter 5).

The SA abalone fishery is managed by the Department of Primary Industries and Resources (PIRSA) under the guidance of the minister to which the Department reports. PIRSA has not developed guidelines or training courses for its staff specifically targeting its responsibilities under the Act to apply precaution or to maintain and enhance aquatic ecosystems and genetic diversity. PIRSA's minister has not issued directives on these matters.

Over the last century most global abalone fisheries have collapsed, driven primarily through overfishing. California's white abalone is on the brink of extinction, and Alaska's abalone fishery has shown little sign of recovery decades after closure. Abalone fisheries in South Australia and Tasmania are amongst the few relatively healthy abalone fisheries worldwide. The SA industry uses ITQs to limit catch for the commercial fishery, which accounts for about 90-95% of the total catch (the illegal catch being subject to some uncertainty). Entry to the recreational fishery is by licence, with attendant size and bag limits. Otherwise entry to the recreational fishery is unlimited, there being no cap on licence numbers in place or proposed. The commercial take is valued at over \$million 100 per year.

The small number of fishers involved, the regional scale of permits, and the quota system provide fishers with fishing 'rights' which to some extent provide 'ownership' over the resource, and should in theory provide incentives for sustainable management. The separation of licence holders from working fishers, however, weakens this link.

13.2 Benchmarks:

The benchmarks used below are derived from chapters 7, 8 and 9 above. The detailed discussion of the Commonwealth's assessment of the SA abalone fishery, referenced in the table below, is available as Appendix Five below.

Each benchmark is scored as follows:

- 0 – no evidence of policy or implementation;
- 1 – policy in place or partially in place; no significant implementation at this stage;
- 2 – policy in place; evidence of partial implementation;
- 3 – policy in place; evidence of substantial implementation;

Table 13.1 The precautionary approach in the SA abalone fishery:

	Benchmark	Assessment
A1	Management strategies and plans contain clear objectives, indicators and performance targets relating to the protection of: target stocks, populations of dependent and associated species, and habitat.	Score 1.5 The 2004 management plan (Nobes et al. 2004) establishes a number of objectives linked to performance indicators, and indicator trigger points. Some of the target species indicators are clear, however in some cases they are not at all clear. For example (p.16) a performance indicator is “appropriate levels of information available to consider the establishment of MPAs”, with a trigger point defined as “insufficient information is available to consider the establishment of MPAs”. No method of assessing this indicator is proposed, and the performance indicator is not reported in fishery status reports (eg Chick et al. 2007). No indicators relating to dependent species exist ¹⁷⁴ . The linked “management responses” are likewise vague: “report to Director of Fisheries” is typical.
A2	Fishery management plans use pre-agreed decision rules based partly on limit reference points equivalent to, or more conservative than, both target stock MSY and bycatch population MSY for the most vulnerable species of bycatch.	Score 0. Target or limit reference points are not used; instead a performance indicator has a trigger point. Pre-agreed decision rules relating to target species are not used; instead a ‘management response’ is required if a performance indicator is triggered. “Report to Director of Fisheries” is a typical response. These reports are not readily accessible to the public. As abalone are hand-picked, no significant bycatch exists.
A3	Undesirable outcomes which could result from excessive fishing pressures are identified, and monitoring programs are in place with sufficient power to rapidly detect these changes should they occur.	Score 0. The 1997 management plan contained an objective to “maintain metapopulations at sustainable levels”. This objective was dropped from the current (2004) management plan, which does however identify overfishing as a possible undesirable outcome. Stock assessment reports are published; however these reports contain no discussion of the power of fisheries-independent monitoring programs. Reports relate to fishing zones: no reports are provided on the status of individual metapopulations or populations.

Table 13.1 The precautionary approach (continued)

	Benchmark	Assessment
A4	The risks to ecosystem health and integrity are assessed for each major fishery, and additional caution applied to management programs for high-risk fisheries	Score 0. The fishery is described as 'low ecosystem risk', however no thorough assessment was undertaken ¹⁷⁵ – for example no literature review was reported by Government of South Australia (2003). There is no credible attempt at developing a future research program to address uncertainties, although Waterloo Bay is mentioned as a possible MPA suitable for such a study (McGarvey et al. 2005).
A5	Independent peer review is used as quality assurance for major management policies, strategies and plans.	Score 0.5 The 2004 management plan makes no reference to peer review. Independent peer reviews are not valid or useful if hidden from public scrutiny ¹⁷⁶ . The new management plan now under preparation will be tabled in State parliament, allowing review by parliamentarians.
A6	Management procedures provide for rapid response in the light of unexpected declines in target stocks, bycatch populations, or habitat value. Such provisions provide for fisher compensation where necessary.	Score 0. No provisions, such as clear decision rules, are made for rapid response. Scientific findings of severe decline in local populations have not been addressed, with many local populations at very low abundance levels still open for fishing (Shepherd & Rodda 2001, Shepherd et al. 2001, Shepherd 2008). Proposals by scientists for the use of harvest refugia (Baker et al. 1996, Shepherd & Brown 1993) have not been referenced in management papers..

Table 13.2 The ecosystem approach in the SA abalone fishery:

	Benchmark	Assessment
B1	There is formal periodic assessment of the impacts of particular fisheries against agreed objectives, including ecosystem-based objectives.	Score 2.5 The assessment process required by Commonwealth accreditation under the <i>Environment Protection and Biodiversity Conservation Act 1999</i> meets this benchmark, noting difficulties with the assessment criteria and process (see detailed assessment, and the discussion in Nevill 2004).
B2	There is monitoring and reporting of agreed ecosystem indicators based on stated ecosystem objectives.	Score 0. The 2004 management plan does not establish credible measurable ecosystem indicators – resting on the assumption that no significant effect is likely. No moves to establish experimental areas have been taken (noting comments above regarding Waterloo Bay). No research programs have been developed.
B3	There is a substantial program in mapping, protecting and monitoring critical and vulnerable habitats, funded by the fishery agency or responsible government.	Score 2. The South Australian Government has put in place a substantial planning framework which includes mapping and protecting critical and vulnerable habitat. Not yet fully implemented. See Day et al. (2008), and Edyvane (1998).

Table 13.2 The ecosystem approach (continued)

	Benchmark	Assessment
B4	There are effective programs in place to monitor and maintain old-growth age structure in specific fisheries.	Score 0. The 2004 abalone management plan does not consider the need to maintain, or even the existence of, old-growth age structure. Old-growth structure is assumed to be irrelevant. No significant harvest refugia have been created. No maximum size limits apply. Large old abalone are still found around Kangaroo Island.
B5	The agency has a substantial program to account for evolutionary change caused by fishing.	Score 0. The 2004 abalone management plan does not consider evolutionary change caused by fishing, nor is a research program proposed to address this issue.
B6	There are effective programs in place to maintain the spatial extent of all major sub-populations (both target and bycatch) affected by specific fisheries, and maintain and monitor population genetic diversity.	Score 1. The management plan 2004 and associated monitoring procedures do provide for the collection of fairly fine scale catch data, and for limited local fishery-independent surveys. However, in some cases where major declines of local populations have been identified (Shepherd & Rodda 2001, Shepherd et al. 2001) no effective remedial action has been taken. In some places (eg Tiparra Reef) voluntary catch caps are in place, responding to population decline. Waterloo Bay has been closed twice in response to population declines – with the current closure still in place.

Table 13.3 Adaptive management in the SA abalone fishery:

	Benchmark	Assessment
C1	The performance of the fishery management agency itself is subject to independent periodic review against stated objectives, and quantifiable indicators and performance targets.	Score 1. Annual reports for the responsible agency (Primary Industries and Resources South Australia) do not indicate that independent performance reviews of fishery management operations are undertaken (refer www.pir.sa.gov.au). However the <i>Performance Assessment System</i> (DEH-SA 2006) may be effective at encouraging passive adaptive management within all State marine agencies.
C2	The management program uses mathematical modelling to pinpoint uncertainties and generate alternative hypotheses.	Score 0. Not used in abalone management – see the 2004 abalone management plan. Opportunities to apply modelling in an active adaptive management context are readily available if management wished to investigate the metapopulation structure of stocks. Scientists have argued that an understanding of metapopulation structure would allow precautionary approaches to maintaining the long-term health of local populations (Morgan & Shepherd 2006).

Table 13.3 Adaptive management in the SA abalone fishery (continued):

	Benchmark	Assessment
C3	The assumptions behind the models are clearly set out and evaluated.	Score 0. Not used in abalone management – see the 2004 abalone management plan, and comments above.
C4	Reports incorporating the use of adaptive management set out the bounding of management problems in terms of explicit and hidden objectives, and practical constraints on actions.	Score 0. Not used in abalone management – see the 2004 abalone management plan, and comments above.
C5	There are changes in management controls, designed to test clearly stated hypotheses, which are sufficiently large to reasonably produce detectable effects; the size of these effects is estimated in advance, and sufficiently powerful field surveys undertaken, and statistically examined to deduce the probabilities of both Type I and Type II errors.	Score 0. Not used in abalone management – see the 2004 abalone management plan, and comments above.
C6	Formal organizational requirements are established for evaluating and reporting the results of the experimental management strategies, both to managers and stakeholders.	Score 0. Not used in abalone management – see the 2004 abalone management plan, and comments above.

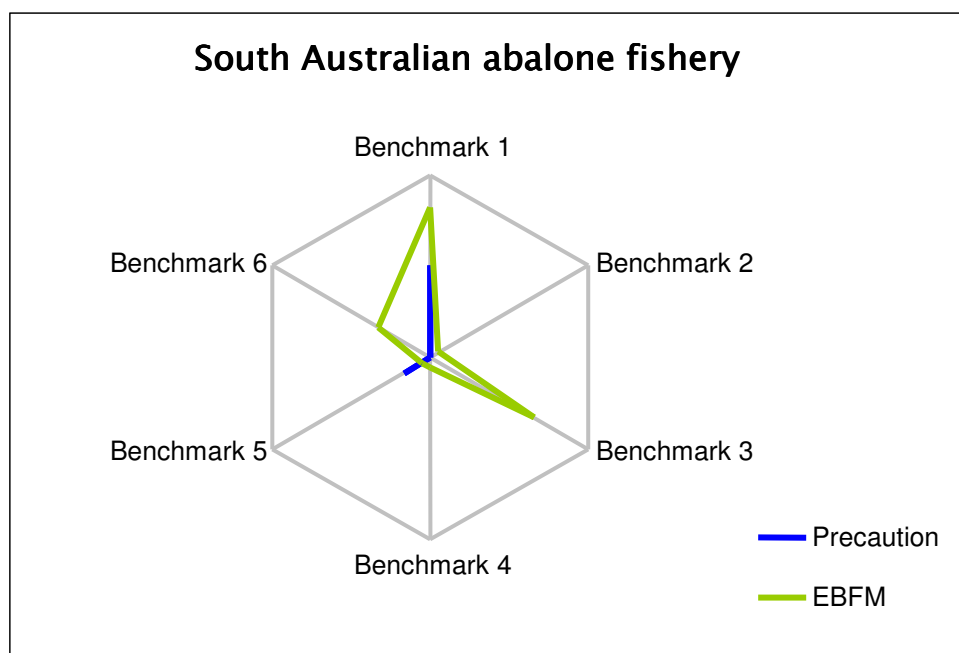


Figure 13.1: Kite diagram for precaution and EBFM in the SA abalone fishery

13.3 Commonwealth accreditation of the SA abalone fishery:

Appendix 5 provides a detailed examination of the SA abalone fishery in the context of the Commonwealth of Australia's export accreditation procedures under the (Commonwealth) *Environment Protection and Biodiversity Conservation Act 1999*. This accreditation assessment was based on compliance of the fishery with the Commonwealth guideline.

Of the guideline's 28 components, the SA abalone fishery failed 11, partially met 6, and fully met 11. The above-mentioned examination reveals major flaws in the management of the fishery, as well as clear areas of guideline compliance.

If the analysis conducted in this chapter and in Appendix 5 is accepted as a valid measurement of fishery compliance with the three management approaches under discussion, it may be concluded that the SA abalone fishery:

- demonstrates almost no attempt to incorporate either the precautionary approach or active adaptive management (scoring only 2/18 in precaution, and 1/18 in active adaptive management); and
- demonstrates little incorporation of the ecosystem approach (scoring 6 from a possible 18).

It is of interest to compare these findings with the text of the letter of accreditation, written by the Commonwealth Minister's delegate to the South Australian Minister for Fisheries, on June 10, 2004¹⁷⁷:

I am satisfied that for the purposes of the wildlife trade provisions in part 13A of the *Environment Protection and Biodiversity Conservation Act*, the management arrangements provide the basis for the fishery to be managed in an ecologically sustainable way. ...

The [South Australian government's] management arrangements for the fishery meet the Australian Government's *Guidelines for the Ecologically Sustainable Management of Fisheries*. The fishery is well managed under a comprehensive, adaptable, precautionary and ecologically based regime capable of controlling, monitoring and enforcing the level of take from the fishery.

13.4 Perceptions of fishery management:

A senior fisheries management officer from PIRSA was interviewed on 3 October 2008. The interview questions revolved around benefits and costs of the precautionary, ecosystem and adaptive management approaches. In this context benchmark assessment issues were discussed. A view was expressed that my scoring of benchmark values took insufficient account of several factors, the most important being: (a) the fishery has essentially no bycatch, and causes no direct damage to habitat or to other shallow reef biota, (b) no evidence is available indicating that a significant ecosystem effect might ensue from fishing activities, and (c) the track record of the fishery, since the imposition of quotas, has been one of generally stable catches and profits.

Management perceptions on the application of the three approaches is straightforward. Where a component has been applied (or partially applied): for example with respect to benchmarks A1, B1 and B3, this is perceived as simply standard practice. Here particular benefits are difficult to articulate, as there is no other practical approach by way of comparison. A view was expressed that clear indicators and trigger points assist in negotiations with fishers, and the external overview which occurs via the Commonwealth accreditation process also assists in government-fisher negotiations aimed at responsible management.

In cases where a component has not been applied, for example within the precautionary and active adaptive benchmark sets, management's perception is that these approaches are simply not necessary in this case. Why undertake unnecessary and possibly expensive activities when the fishery appears to be stable, and with little or no environmental impact?

13.5 Discussion and summary:

The evidence found in this review indicates that the South Australian abalone fishery is characterised by management essentially devoid of precautionary or active adaptive provisions. Although the broad management regime incorporates some aspects characteristic of ecosystem based management, these largely stem from the programs of agencies beyond the State fishery agency.

As noted above, the fisheries management agency, PIRSA, is obliged under statute to take account of the precautionary principle, and is obliged to ensure that “proper conservation and management measures are to be implemented to protect the aquatic resources of the State from over-exploitation and ensure that those resources are not endangered.” Local abalone populations have, however, been over-exploited, and resources at this scale have been (and remain) endangered over many years (various papers by Shepherd et al.). The failure of PIRSA to take decisive precautionary remedial action appears to be a serious contravention of the Department’s enabling legislation.

Abalone fisheries around the world have crashed, with many failing to recover after long periods of fishery closure. Prior to fishing, abalone were a conspicuous herbivore within many temperate rocky reef areas worldwide. A sedentary benthic broadcast spawner, abalone are highly vulnerable to fishing pressures, and successful spawning is subject to the Allee effect at low adult densities. A cause of abalone fishery failures worldwide is likely to be the serial overfishing of local populations – in such cases overall CPUE can be maintained (at least for some years) as local populations crash. Where more than one species of abalone are harvested from the same habitat, with differing species vulnerability to fishing, the most vulnerable species can be fished to extremely low levels (including local extinction) by the fishing pressures resting on the economics of the least vulnerable population. This is the case in South Australia, with greenlip in many situations having increased vulnerability.

The abalone fishery is one of South Australia’s most important in terms of its overall economic value, noting however that the public – the owners of the abalone resource – receive no direct resource rent. Abalone metapopulation structure implies the need for considerable resources for adequate stock assessment – resources which the South Australian Government appears unwilling to allocate. Obvious questions, central to effective long-term management, remain un-answered after many years. For example, what is the relationship of the detailed fishery area codes to metapopulation structure? Although the original area coding was undertaken with metapopulations in mind, how successful are the codes in practice in identifying metapopulations? How many local populations have fallen below a egg production trigger point of half virgin levels? Information presented in several papers by Shepherd et al. indicate many local populations are likely to be below 10% of virgin spawning biomass, with some populations nearing or at local extinction.

Morgan & Shepherd (2006) have argued for application of fine-scale management to species exhibiting metapopulation structure. Temporary and permanent harvest refugia can also play important roles in fishery management. The current fishery management regime uses both permanent and temporary closures, but with relatively little effect. A small permanent closure at West Island saw the resident abalone population collapse, possibly from recruitment failure or poaching (or both). It has been suggested that the temporary closure at Waterloo Bay could be made permanent, both to obtain fishery-independent data on key life-cycle parameters, and to investigate possible ecosystem effects. Both these ideas should be supported, providing a sufficiently large no-take reserve could be created to facilitate ecosystem functioning of some of the larger animals, such as rays and rock lobsters.

South Australia’s abalone fishery has maintained catch stability over a considerable period. However, this has occurred, in my view, more by good luck than good management. The current fishery management regime is not precautionary, and does not apply active adaptive management. Although it applies some elements of an ecosystem approach, other critical elements are lacking.

The current management regime appears to be in contravention of the *Fisheries Management Act 2007*, specifically regarding lack of precautionary action to address local

population decline. The current fishery management regime offers little or no precautionary protection against the ecosystem impacts of abalone fishing – which remain largely unknown. The SA abalone fishery, under the current management regime, is not secure from collapse in the medium or long term. In my view the industry is currently sailing too close to the wind.

Recommendations:

Precautionary management would, amongst other effects, produce larger abalone populations which would provide a buffer against environmental variation. Larger populations would underpin stability of profits for the industry over coming decades, as well as providing for unknown ecosystem effects, particularly to abalone predators. More consideration of fine-scale metapopulation issues should also enhance stability of the fishery. Key elements which appear to warrant implementation are:

- the identification of all major metapopulations, and if necessary the re-organization of area codes boundaries to better align with metapopulations and populations;
- the use of fine-scale rolling area closures, on (say) a 5-year basis¹⁷⁸, complemented by increased fisheries-independent population surveys conducted 12 months before re-opening – extent of aggregation may be a useful indicator of population resilience¹⁷⁹;
- prohibitions on greenlip harvesting when greenlip population indicators either decline sharply, or drop below the existing egg production trigger point. The practice of allowing divers to take greenlip from depleted populations while harvesting undepleted blacklip populations should cease;
- where population indicators show declines over two successive years, a decision rule should mandate immediate seasonal closures over the spawning period as a precautionary measure;
- at least four large fishery refugia areas (in Western A, B, Central and Southern zones) should be created. These areas should be permanently closed to all harvesting activities to investigate ecosystem effects, to provide for unknown ecosystem effects, and to enable scientific study and experimentation;
- all populations with a probability of over 80% that spawning biomass has fallen below 20% of pristine levels should be identified and closed pending recovery to >50% spawning biomass;
- there should be decreased reliance on industry CPUE data¹⁸⁰ in fisheries status reports;
- where metapopulation source/sink dynamics are likely, such as the Cape Jervis – Normanville area, additional protection should be provided to the source population (Shepherd et al. 2001)¹⁸¹;
- fisheries status reports should report on *all* performance indicators, and should report management actions taken in the previous year to address indicators triggered in the last status report; and
- PIRSA should honour long-standing commitments to the use of independent peer review in its preparation of (a) methods dealing with stock assessment, (b) fishery status and fishery assessment reports, and (c) fishery management plans. Peer review reports should be made public.

Endnotes:

¹⁷³ Michelle Besley, pers.comm. 3/10/08.

¹⁷⁴ At pristine abundances, abalone are a conspicuous herbivore in shallow rocky reef environments. Mayfield et al. (2002:11) identify abalone predators including fish, crabs, starfish, octopus, rays and rock lobster. While no predator has been identified as depending

solely or heavily on abalone, studies necessary for such identification have not been undertaken.

¹⁷⁵ Risk assessment protocols (eg Fletcher et al. 2004) are based on a sliding scale of investigation intensity depending on risk. Typically the first stage includes a thorough literature review (eg: Fletcher et al. 2004:5). Government of South Australia (2003) contains no evidence that such a literature review was undertaken. Available literature appears to be ignored – for example Thomas & Day 1995, and Gorfine & Dixon 2000 both discuss abalone/ecosystem interactions, but are not mentioned.

¹⁷⁶ PIRSA and SARDI made commitments to independent peer review in 2003: “Primary Industries and Resources South Australia (PIRSA) has moved to implement a review process every three years that will assess current fishery assessment tools and include an independent peer review. SARDI Aquatic Sciences, as part of their annual stock assessment process, seek independent reviews of assessment methods and their annual reports (Government of South Australia 2003). Subsequent stock assessment reports, available to the public via the PIRSA website, state that an *internal* review has been undertaken, but supply no further details. This type of review does not qualify as “independent peer review” – such a review must be carried out by a scientist of appropriate experience and stature, employed outside the Department or its associated agencies, and in full public view. Examples of such peer review can be routinely found, for example, in any Marine Stewardship Council assessment report.

¹⁷⁷ (<http://www.deh.gov.au/coasts/fisheries/assessment/sa/abablone/decision.html> accessed 11/11/2004).

¹⁷⁸ Rolling closures were recommended by a SARDI fisheries scientist (Sluczanowski 1984).

¹⁷⁹ See Dowling et al. (2004).

¹⁸⁰ Due to inadequate funding on fisheries-independent surveys, stock assessments rely heavily on fisheries CPUE data. CPUE data is subject to uncertainties due to changes in diver behaviour over time, and differences between individual divers. Another problem is that in places where blacklip and greenlip are taken together, overall CPUE cannot be separated into species-specific CPUEs – which is necessary for stock assessment. This confounding is a serious problem for interpreting changes in CPUE – yet attempts continue to be made to interpret what is in fact a highly flawed statistic.

¹⁸¹ In the case of Cape Jervis, where the source population is particularly accessible and thus vulnerable, a permanent no-take reserve would be necessary. In other less vulnerable situations, temporary closures (5-10 years) or seasonal closures in the spawning season might be effective.

14. Benchmark appraisal: Western Rock Lobster fishery, WA.

The purpose of this appraisal is to compare Western Australia's western rock lobster fishery management regime to benchmarks representing key aspects of three broad 'modern' management approaches: active adaptive management, and the precautionary and ecosystem approaches.

14.1 Background:

The WA western rock lobster (*Panulirus cygnus*) fishery is generally considered one of Australia's best managed fisheries¹⁸². Although it includes waters beyond the State (3 nautical mile) limit, it falls under the jurisdiction of the WA Government, via the WA Department of Fisheries (DoFWA), under an agreement with the Australian (Commonwealth) Government – the Offshore Constitutional Settlement agreement. It is also one of Australia's most economically valuable single-species fisheries (with a landed catch value of ~\$m280 pa) – noting that Australian waters are relatively unproductive compared with those of most other continents.

The fishery is divided into three large zones (called A, B and C), and is managed by effort restriction¹⁸³. It harvests an average of around 10,000¹⁸⁴ (8000 to 14,500¹⁸⁵) tonnes of lobster per year – the annual catch being strongly related to coastal settlement of post-larvae lobsters (pueruli) 4 years earlier (more below). The commercial fishery takes around 94-96% of the total reported harvest¹⁸⁶, and is limited primarily by pot (trap) licences, closed seasons, minimum and maximum lengths, closed areas, and gear restrictions¹⁸⁷. At present a fleet of about 460 commercial boats sets around 54,000¹⁸⁸ pots (of which 10-15% are lost or decommissioned each season). Entry to the recreational fishery is by licence, and is presently unlimited; with about 42,000 licences current (estimated 21,000 in active use¹⁸⁹). Recreational fishers face similar restrictions to the commercial fleet – except for their limit of two pots per recreational licence. The WA Government has announced an intention to introduce annual catch targets for both commercial and recreational fisheries in 2009-10 (a notional total allowable commercial catch (TACC) of 9250 tonne was introduced in 2007/08) with the commercial sector taking 95% of the total¹⁹⁰.

The fishery was the first worldwide to obtain Marine Stewardship Certification (MSC) in March 2000. In August 2002 the fishery received Commonwealth accreditation (necessary to enable export of lobsters to overseas markets – the primary destination of the catch). MSC re-accreditation was obtained in November 2006, and Commonwealth re-accreditation in August 2007. The MSC accreditations involved independent review, while the Commonwealth accreditation involved a Commonwealth assessment of a WA Department of Fisheries review.

Lobsters have a life-span > 30 years¹⁹¹, but few reach half this age, due to heavy harvest pressures on adults. Spawning mostly occurs in shelf (rather than shallow) waters, following a migration of most pre-breeding adults from shallow to deeper waters around October-November each year. These lobsters are known as 'whites' from their pale colour, and a substantial proportion are harvested prior to spawning.

Bycatch of the fishery includes octopus, crabs, and small sharks and scalefish – all of which may be retained. Moray eels are discarded. Sea lion pups (from a declining Abrolhos Islands population) can get stuck and drown in pots¹⁹², and whales and turtles occasionally get tangled in pot lines, as do (rarely) mantas. Dusky whaler sharks get caught in bait-bands (rarely)¹⁹³. The fishery has been slow to adopt strategies to remediate bycatch problems: for example sea lion exclusion devices (SLEDs) were proposed in 1999, but not included in mandatory gear requirements until 2006 (SCS 1999, DoFWA 2001, DoFWA 2007)¹⁹⁴. The reason for the delay was "lack of industry support" (SLSRG 2005). Several other important management improvements have suffered similar delays (SCS 2006)¹⁹⁵. A major flaw remains with regard to poor stakeholder consultation¹⁹⁶ - an issue unresolved over many years (more below).

Over the last decade the fishery has been a profitable one. According to the DoFWA website, a 100-pot licence, together with boat and gear, was valued at about \$4 million in 2001. Industry profitability is one valid measure of the success of the management regime, at least in the short term.

Considerable effort and expense has been devoted to understanding the biology of the lobster, which is distributed along the western coastline of Australia (Figure 14.1). Spawning takes place in spring and early summer. Female lobsters produce thousands of eggs, of which only a few survive to become breeding adults. Larvae spend up to 11 months in a pelagic phase, somewhere in the Indian Ocean. Ocean currents return them to shallow water between August and the following January, where they settle on algae or seagrass, and spend three to four years as juveniles before undertaking their first pre-spawning migration to deeper water.



Figure 14.1: *Distribution of western rock lobster* (Source: www.fish.wa.gov.au, 2/9/09)

The WA Department of Fisheries runs an annual sampling program that measures the abundance of late larval-stage lobsters (pueruli) settling on inshore reefs along the coast. This “puerulus settlement index” has been measured at one site since 1968 and has shown a strong correlation with catches of lobsters three and four years later. The index is currently measured at 10 sites (www.fish.wa.gov.au, accessed 9/9/2009).

The ability of the DoFWA to predict the abundance of adult lobsters, and thus to predict likely catch rates for a given fishing effort, does provide a key for passive adaptive management of the fishery. Under the State’s *Fish Resources Management Act 1994*, the responsible Minister has the ability to tighten or loosen effort controls each season, and in fact can make changes within a season – although such changes may not be welcomed by fishers with heavy financial commitments. Nevertheless the procedural framework is in place which could allow a rapid response to unexpected stock declines.

The puerulus monitoring program has been studied over the last three decades, and correlations between oceanic and atmospheric factors have been established. Years of high settlement accompany years with westerly wind anomalies and years where the Leeuwin Current is strong, bringing warm water from the northern part of the WA coastline.

Recent settlement measurements have been low (Figure 14.2). According to the DoFWA website (accessed 19/10/09): “The below-average 2007/08 settlement has now been followed by an even lower level of settlement in 2008/09. However, unlike the previous settlement season when environmental conditions were average for larval survival, conditions leading up to the 2008/09 settlement season were very favourable (with a strong Leeuwin Current) and were expected to lead to an improved puerulus settlement in 2008/09,

although some environmental conditions observed during this period, such as westerly winds, were not favourable.”

In 2008-09 the nominal TACC was reduced from 9200 tonne to 7800 tonne, in direct response to concerns raised by the low settlement figures¹⁹⁷. Effort restrictions in the form of pot usage limitations and “days off” were introduced to achieve a reduced catch. Subsequently the 2009-10 nominal TACC was set at 5500 tonne, with further restrictions on effort¹⁹⁸. These restrictions have been described as “precautionary” by DoFWA, and they may be successful in protecting the ability of the spawning stock to maintain sustainable and profitable populations. Only time will tell.

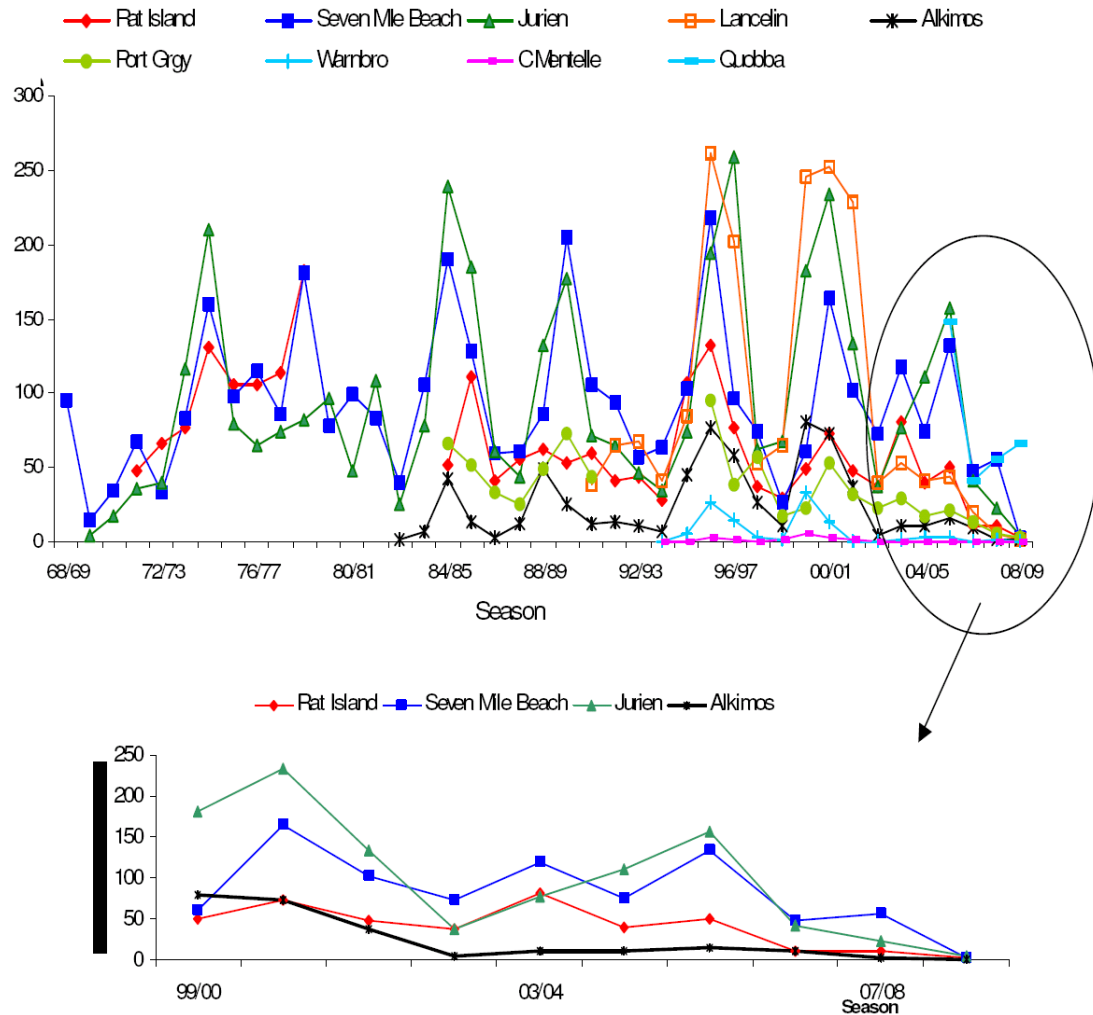


Figure 14.2 Long-term puerulus settlement. The plot contains measurements for the nine stations with extended periods of data collection. The most recently established station, at Coral Bay, is not shown. Source: Brown (2009).

Detailed settlement information for one monitoring site is provided in Figure 14.3, current to the time of writing.

The most likely explanations (according to Brown 2009) for the collapse of puerulus recruitment relate to unexplained environmental variables, or declines in breeding stocks (or both). Other less likely explanations relate to the effects of increased predation (possibly by jellyfish) or disease, or the effects of increasing ocean acidity. Returning to the most likely explanations, concerns are held that fishing pressures have impacted on spawning stocks. According to Brown (2009:10):

When annual increases in the level of effective fishing effort of about 8% (as determined from depletion analysis) are included in calculations of breeding stock levels, there is evidence that the levels have fallen to below the 1980s threshold level and to levels similar to the low levels seen in the early to mid-1990s (which raised serious concern at the time) and close to the limit reference point (i.e. 20% below the threshold level).

The decline in the breeding stock in the Big Bank, northern Abrolhos and the coastal deep water breeding stock areas in Zone B are of particular concern, as preliminary results from oceanographic modelling suggest that, under certain environmental conditions, the northern breeding stock areas could be more important in producing successful puerulus settlement. There is also concern regarding the decline in breeding stock levels in some other deepwater areas in Zone A and Zone C (only the area north of Lancelin).

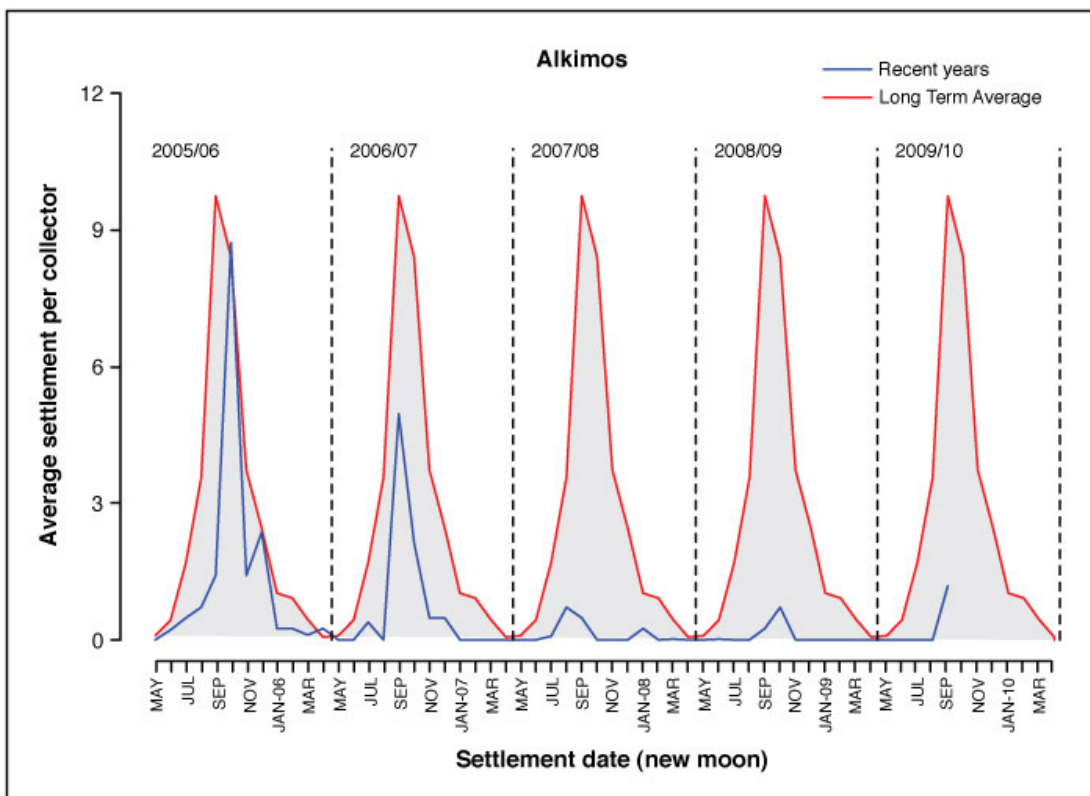


Figure 14.3 Puerulus settlement at Alkimos monitoring site.

Settlement tends to occur around the time of the new moon (i.e.: 13 times each year). Current to September 2009. Source: Brown (2009)

In overview: the 50-year old fishery is effort controlled, although discussions have been held regarding a change-over to output controls since 2004. Up until the present, the history of the fishery has generally been profitable, and it has been widely regarded as relatively well-managed by Australian standards. Stocks have fluctuated, but within bounds which have been fairly easily accommodated. The environmental impacts of the fishery have been investigated and to some extent (and with some delays) addressed, with the fishery achieving Marine Stewardship Council certification. A reasonably sophisticated form of passive adaptive management is employed in forecasting lobster abundance and in regulating effort. However the industry has opposed the creation of large permanent reserves which, amongst other values, could have protected spawning stocks, particularly in metapopulation source areas. Fishing pressures have been high, with little or no allowance for ecological food chain effects, trophic cascades, or unexpected environmental impacts on the lobster populations. More information on several of these issues is contained in the discussion and the endnotes below.

14.2 Benchmarks:

The benchmarks used below are derived from chapters 7, 8 and 9 above.

Each benchmark is scored as follows:

- 0 – no evidence of policy or implementation;
- 1 – policy in place or partially in place; no significant implementation at this stage;
- 2 – policy in place; evidence of partial implementation;
- 3 – policy in place; evidence of substantial implementation.

Table 14.1: the precautionary approach in the WA western rock lobster fishery:

	Benchmark	Assessment
A1	Management strategies and plans contain clear objectives, indicators and performance targets relating to the protection of: target stocks, populations of dependent and associated species, and habitat.	Score 1.5 A primary goal of management is to maintain the WRL population egg production index above 0.1 – one of the fishery’s two limit reference points (SCS 2007:63) ¹⁹⁹ . The second limit RP is a sea lion bycatch of zero – which is always exceeded ²⁰⁰ . Some other indicators are described in Fletcher et al. (2005:s5), however these indicators lack clarity ²⁰¹ . No credible indicators have been defined for ecosystem structure and function ²⁰² , or habitat protection ²⁰³ ,
A2	Fishery management plans use pre-agreed decision rules based partly on limit reference points equivalent to, or more conservative than, both target stock MSY and bycatch population MSY for the most vulnerable species of bycatch.	Score 1. Decision rules are used, most effectively in relation to breeding stock biomass (DoFWA 2007:63ff). However examination of rule DR1 reveals weaknesses which are mirrored in other WRL decision rules. The calculation of the indicators is not explained, and the first response triggered is “additional analysis is required” – which is not an action statement. The second trigger has a clearer response: “15% effort reduction is required” – but this, again, is not an action statement ²⁰⁴ . MSY levels are not presented for either the target or the most vulnerable bycatch (octopus) ²⁰⁵ . The sea lion limit reference point is breached each season – but perhaps the recent move to mandate SLEDs will improve this situation.
A3	Undesirable outcomes which could result from excessive fishing pressures are identified, and monitoring programs are in place with sufficient power to rapidly detect these changes should they occur.	Score 2. Overfishing ²⁰⁶ the WRL spawning stock has occurred (in the early 1990s) and is clearly identified as a possible undesirable outcome. Monitoring programs to track egg production are in place, however their power has not been examined in published literature ²⁰⁷ . Undesirable bycatch, habitat damage and pollution outcomes are identified in risk assessments (eg: Burgman 2005) and monitoring programs (of undefined power) are in place. While ecosystem impacts were identified as requiring study by SCS (1999), monitoring programs are only now being initiated (EEFSRG 2006, DoFWA 2007:8).
A4	The risks to ecosystem health and integrity are assessed for each major fishery, and additional caution applied to management programs for high-risk fisheries	Score 2. Ecological risk assessments have been carried out (eg: Burgman 2005). These assessments, however, have relied heavily on expert workshops rather than comprehensive reviews of best available information. On some issues workshop briefing notes appear either selective or inadequately researched (Babcock in Burgman 2005:99). Attending experts do not have expertise in all issues (see comment on criteria B5 below). Long delays in implementing SLEDs, for example, are not indicative of a precautionary management stance (above).

Table 14.1: the precautionary approach (continued):

	Benchmark	Assessment
A5	Independent peer review is used as quality assurance for major management policies, strategies and plans.	Score 2. MSC certification procedures provide for independent (peer-reviewed) review – noting however that the reviewers are contracted to the WRL industry council. In other areas use of peer review needs improvement. For example SCS (2006:62 & 2006:83) note problems with peer review of risk assessment (ERA) and the operational plan. The independent stock assessment review also raises issues of bias ²⁰⁸ .
A6	Management procedures provide for rapid response in the light of unexpected declines in target stocks, bycatch populations, or habitat value. Such provisions provide for fisher compensation where necessary.	Score 1.5 Decision rule DR1 (see above) is the only decision rule clearly linked with effort reduction. Other decision rule triggers invoke the general response of 're-consider management arrangements'. This sort of response subverts the essential intent of decision rules to trigger pre-agreed actions aimed at protecting stock or associated values ²⁰⁹ . A recent history of slow management responses (see above) provides little indication of an ability to respond quickly to unexpected changes ²¹⁰ .

Table 14.2: The ecosystem approach in the WA western rock lobster fishery:

	Benchmark	Assessment
B1	There is formal periodic assessment of the impacts of particular fisheries against agreed objectives, including ecosystem-based objectives.	Score 2.5 The 5-yearly MSC re-certification process provides a formal independent review of the fishery against a range of objectives, including bycatch objectives pertaining to threatened and protected species. The fishery has not yet established quantitative ecosystem objectives other than bycatch-related. The Commonwealth accreditation process provides a similar, if weaker review mechanism. However questions remain in respect to the ability (or more correctly willingness) of the WRL fishery to respond to MSC conditions and Commonwealth recommendations – see discussion in endnotes 9, 10 & 26.
B2	There is monitoring and reporting of agreed ecosystem indicators based on stated ecosystem objectives.	Score 1. Apart from bycatch indicators, no other quantifiable ecosystem indicators have been established. Comprehensive reporting of bycatch indicators is not accessible through the DoFWA website.
B3	There is a substantial program in mapping, protecting and monitoring critical and vulnerable habitats, funded by the fishery agency or responsible government.	Score 1.5 The WA State government has funded marine habitat mapping in some areas. Limited mapping has also been funded by the Commonwealth. Detailed maps are available of several areas of shallow WRL habitat. Deep water habitat mapping is neglected (SCS 2006:49) but under way (SCS 2006:50). Critical and/or vulnerable habitats have not been identified at this stage. Programs to 'protect and monitor' are yet to be developed.

Table 14.2: The ecosystem approach in the WA western rock lobster fishery (continued):

	Benchmark	Assessment
B4	There are effective programs in place to monitor and maintain old-growth age structure in specific fisheries.	Score 1. For several years a maximum length restriction has applied to female lobsters (DoFWA 2006) to protect the breeding value of large animals ²¹¹ . Large males are not protected. No large marine protected area has been established which would protect shallow water and deep water habitats, with migration pathways. Given the size of the WRL range, a number of such MPAs appear to be needed.
B5	The agency has a substantial program to account for evolutionary change caused by fishing.	Score 0. The potential for the fishery to create genetic change in the population was considered by a risk assessment expert workshop (Burgman 2005). Although no expert briefing material was prepared, and no attending experts had published in the field of fishery-induced evolution, it was concluded that the risk of significant detrimental change was low. No further action appears to have been taken, in spite of research indicating possible fishery-induced effects ²¹² .
B6	There are effective programs in place to maintain the spatial extent of all major sub-populations (both target and bycatch) affected by specific fisheries, and maintain and monitor population genetic diversity.	Score 2. Post-larval settlement is monitored routinely at six locations spanning the geographical extent of the fishery. The fishery is managed through three management zones. WRLs are believed to comprise a single population (SCS 2006:47) which seems a reasonable assumption given the extended duration (and thus dispersion) of the pelagic larval stage. The only bycatch subpopulation believed to be at risk is the sea lion ²¹³ ; however the size and viability of this population is not routinely monitored (Campbell 2005).

Table 14.3: active adaptive management in the WA western rock lobster fishery:

	Benchmark	Assessment
C1	The performance of the fishery management agency itself is subject to independent periodic review against stated objectives, and quantifiable indicators and performance targets.	Score 2. Although the Department (DoFWA) is never subject to independent review, it does report annually to the WA parliament, and the WRL fishery is reported in the State of the Fisheries Report (Fletcher & Santoro 2007). In the case of the WRL fishery, substantial compensation for the lack of independent departmental review is provided by the two independent reviews of the fishery itself – noting difficulties in relation to these reviews discussed above, and problems with the Commonwealth review criteria discussed in Appendix 5. Importantly, the MSC review includes a review of the management system (Principle 3).
C2	The management program uses mathematical modelling to pinpoint uncertainties and generate alternative hypotheses.	Score 1. Stock modelling has established a possible dependence of the population on the Abrolhos Islands spawning stock. While uncertainties have been identified, no alternative hypotheses have been prepared – as far as I can judge from published literature.

Table 14.3: active adaptive management in the WA western rock lobster fishery (continued):

	Benchmark	Assessment
C3	The assumptions behind the models are clearly set out and evaluated.	Score 0. No evidence is available indicating that assumptions are clearly set out and evaluated. .
C4	Reports incorporating the use of adaptive management set out the bounding of management problems in terms of explicit and hidden objectives, and practical constraints on actions.	Score 0. There are no reports on the use of active adaptive management within the WRL fishery.
C5	There are changes in management controls, designed to test clearly stated hypotheses, which are sufficiently large to reasonably produce detectable effects; the size of these effects is estimated in advance, and sufficiently powerful field surveys undertaken, and statistically examined to deduce the probabilities of both Type I and Type II errors.	Score 0. Although there is clearly scope for the use of active adaptive management (see criteria C2 above) no related management action has been taken.
C6	Formal organizational requirements are established for evaluating and reporting the results of the experimental management strategies, both to managers and stakeholders.	Score 0. No such requirements exist.

14.3 Summary and comment:

When the Commonwealth minister (David Kemp) accredited the WRL fishery on 20 August 2002, he wrote: “The fishery is managed under a comprehensive, adaptable, precautionary and ecologically based regime...” (Kemp 2002).

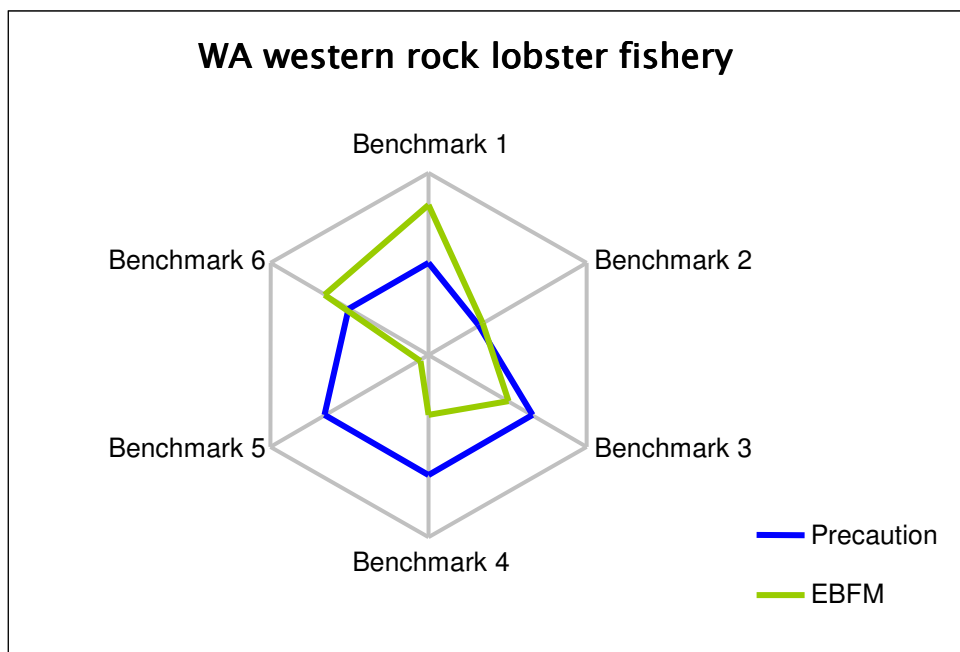


Figure 14.4 Kite diagram for the precautionary and ecosystem approaches in the WA western rock lobster fishery.

Under the current assessment, the Western Australian western rock lobster fishery scores 10.5/18 for adoption of precautionary management, 8.5/18 for adoption of the ecosystem approach, and 3/18 for adoption of active adaptive management. A low score in active adaptive management is not unusual – although the approach is often praised or advocated, enthusiastic implementation is rare worldwide. It should also be noted that the fishery has no formal commitment to the application of active adaptive management (noting however the Commonwealth minister’s comments above). The fishery does employ passive adaptive management, but this is common-place even in poorly managed fisheries globally. With respect to the precautionary and ecosystem approaches, both the Western Australian Government, and the Australian Government have formal commitments to their implementation dating back a considerable time (Chapter 5).

The fishery has its critics: for example Senator Louise Pratt accused the WA State Government fishery managers (particularly the responsible minister) of being “asleep at the wheel”²¹⁴ – no doubt a political hyperbole. The fishery is well-managed by Australian standards, and has so far escaped major output declines due to overfishing, after several decades of operation. Nevertheless a careful examination of the management of the fishery demonstrates major weaknesses, and at a practical level there is considerable room for improvement²¹⁵. There are serious questions about how an apparently increasing risk of overfishing the spawning stocks was dealt with over the last decade, and also about what constituted effective spawning stocks, and how these stock were protected within changing spatial patterns of effort, catch and depletion.

Bycatch issues, as well as the more general issues of the ecological effects of fishing, have not been adequately addressed, and some obvious precautionary strategies (large no-take reserves to protect spawning populations, for example) are not in place.

The size of mature females has declined over time (Melville-Smith & de Lestang 2006), and one explanation is that this is a genetic effect of fishing – however this has not been adequately investigated, and has not been addressed by, for example, strong measures to identify and protect the full spatial extent of spawning populations. For example, historical evidence indicates that large mature lobsters were abundant in shallow water prior to the onset of intensive fishing (Melville-Smith et al. 2009); in these circumstances certain areas of extensive shallow reef may have been important contributors to egg production. Such a hypothesis could be investigated by the creation of large no-take reserves, or by an active adaptive management approach.

Viewed from a precautionary perspective, recent harvest rates have been too high. The low spawning biomass limit reference point of 22% virgin biomass provides little if any margin or error for unexpected environmental variation, and provides virtually no ecological allowance for natural predation (or other ecological effects) of large lobsters. The Abrolhos Islands spawning stock index remains at the level it was in the early 1990s when the WRL industry was in difficulties (Fletcher & Santoro 2007:24) and is in fact only half its 1997/98 level¹⁶. According to Brown (2009:9) “breeding stocks in the far north of the fishery – Big Bank and the northern Abrolhos – have been significantly depleted.” A temporary fishing closure now protects Big Bank. Establishment of a large no-take marine protected area in the Abrolhos Islands would appear to provide both spawning stock security and ecological protection for predators of large lobsters, yet such a proposal does not appear to have been seriously examined in WRL fisheries management literature.

While the WA Government, through the DoFWA, maintains lip-service to the precautionary and ecosystem approaches, the government has given the department no directive to apply these approaches, and has provided no specific funds to develop operational guidance in applying the approaches to specific fisheries, or indeed funds to support an information base on which an ecosystem approach to managing WA fisheries could rest.

Extended delays in implementing management reforms (even those required by MSC accreditation) are a prominent feature of the fishery’s recent history (see discussion in endnotes marked *Original 9*, *Original 10* and *Original 26*). Excuses offered in respect to the delay in implementing SLEDs (see above), and the continued failure of the WRL fishery management system to provide equal input to the advisory process for non-fishery stakeholders (see endnote 10 below) creates the impression of a management regime which has been ‘captured’ by fishing industry interests. This impression is reinforced by important gaps in public reporting (discussed above and below) for example with respect to the workings and findings of the scientific reference groups.

--ooOoo--

Endnotes:

¹⁸² According to the Australian Department of Agriculture, Fisheries and Forestry: “Australia has many examples of well-managed fisheries. In particular, the western rock lobster [fishery is] internationally renowned for management which provides for biological sustainability and economic success” (<http://www.affa.gov.au/content/print.cfm?objectid=D2C48F86-BAiA-11A1-A220006.htm>) accessed 11/8/2004.

¹⁸³ Returns to government from the WRL fishery come as licence fees (to WA State Government) and taxation on profits from the wider commercial industry (to Commonwealth Government). No royalty payments apply. The State Government, after taking into account the cost of managing the fishery, obtains an annual resource rent; however this is not reported, and may be negative. Prior to 2008, the Department of Fisheries did not retain a qualified economist on staff.

¹⁸⁴ The average commercial catch (1980.81-2003/04) was 11,046 tonne, and for 2005/06 was 10,3261 t. Predicted commercial catch for 2006/07 was 9450 t, recreational 205 t. (Fletcher & Santoro 2007). C

¹⁸⁵ Stoklosa (2007).

¹⁸⁶ Total annual catch for reporting and stock control purposes is the sum of the commercial (as reported) and recreational (estimated through mail questionnaires) catches. Unreported indigenous harvesting and illegal harvesting are thought to be negligible and are not taken into account.

¹⁸⁷ In addition, both commercial and recreational fishers cannot take breeding females.

¹⁸⁸ DoFWA (2008:7).

¹⁸⁹ Fletcher & Santoro (2007:17). Stoklosa (2007) puts the 'in-use' figure at 80% not 50%, and the estimate of recreational catch at between 200 – 400 tonnes/pa (each pot catching around 10 kg of lobster pa on average).

¹⁹⁰ Norman Moore, WA Minister for Fisheries, Press Release 24/9/09.

¹⁹¹ According to UMMZ (2008) lobsters are thought to live to a maximum age of around 100 years, although animals of this age have not been documented. An aquarium specimen lived to 28 years. The maximum reported mass is 5.5 kg, or 12 pound.

¹⁹² Rates of capture of sea lion pups since the enforcement of SLEDs in 2006 have not yet been reported.

¹⁹³ A voluntary bait handling code of practice exists. Uncut bands, capable of entrapment, should not be discarded under the code. How well the code is being applied has not been reported. The WA coastal population of dusky whaler sharks is believed to be declining (Stoklosa 2007). These sharks breed slowly, and are still targeted by the WA shark and demersal gill net fisheries, in spite of lack of (published) data on population decline and status.

¹⁹⁴ And then, only under threat of withdrawal of MSC accreditation (SCS 2006).

¹⁹⁵ ORIGINAL 9. Examples of excessive delays: (a) See the delay for example mentioned in criteria A3. (b) The Environmental Management Strategy for the period 7/2002 to 6/2006, required by the first MSC assessment (SCS 1999) was finalised only in March 2005, nearly 3 years late (DoFWA 2005). (c) A condition of SCS recertification (SCS 2006:53) is that bycatch reports be published by the date of the first annual surveillance. No such reports were listed on the DoFWA website in September 2008. The date of recertification was November 2006. This appears to be a breach of SCS certification conditions. (d) The first Commonwealth accreditation recommended that a plan of action be developed in the event that reference points were triggered (Government of Australia 2002:13). In addressing this recommendation five years later, the DoFWA was only able to report that the "Decision Rules Framework is currently in draft form..." (DoFWA 2007:7). (e) Accounting for uncertainties is an important aspect of fishery management. There have been long delays (only recently addressed) in introducing information on uncertainties into scientific advice provided to stakeholders and decision-makers (SCS 2006:138-9).

¹⁹⁶ ORIGINAL 10. The first MSC certification report found major problems with the transparency of decision-making within the WRL management system. A mandatory condition of certification in 2000 was: "Within 24 months of certification, there will be increased participation of the environmental community or their representatives in the decision-making processes in the fishery. This will include consultation on impending decisions, and involvement (full participation) in decision-making committees at a range of levels in the fishery." (SCS 2000:26). Five years later, the reaccreditation report found that: "Proposals for a conservation member of RLIAC have been made for several years, but without effect. The primary stakeholder consultation mechanism established under the EMS (the WRL ESD Committee) would have solved this concern; however, the committee or some other incarnation has not yet been formally implemented. There are many complaints from stakeholders in the conservation sector regarding the failure of the management system to keep them informed, and that the management system only informs them after decisions have been taken, and not the reasons why they have been taken. Stakeholders

from the industry are greatly involved in the management system; however, stakeholders from the conservation sector have only been allowed to provide advice, but not to participate in the decision making of management.” (SCS 2006:87).

This finding demonstrates a clear breach of a mandatory MSC accreditation condition.

The 2006 reaccreditation requires that: “the management system must provide opportunity for better representation of all stakeholder views and concerns in the advisory functions associated with management of the fishery. The continued lack of representation of stakeholders in the conservation community concerned with ecological impacts from fishing have been apparent and the focus of previous conditions from the first assessment of the fishery in 1999/2000. This can be accomplished in a number of ways, including by adjusting membership on the RLIAC. WAFIC must provide evidence to SCS that this is being considered within 12 months of certification, and implemented within 24 months of certification to address the deficiencies identified by SCS under this performance indicator” (SCS 2006:87). This 24 month deadline will expire in November 2008.

¹⁹⁷ Simon O’Brien, Acting Minister for Fisheries, Press Release 23/04/09.

¹⁹⁸ Norman Moore, Minister for Fisheries, Press Release 24/09/09.

¹⁹⁹ An index value of 0.1 (SCS 2006:63) is thought to represent a population egg production of 22% of the virgin level (Fletcher et al. 2005:27).

²⁰⁰ No time-series data on sea lion bycatch is presented in DoFWA documents accessible via the DoFWA website. The limit of zero is referenced in SCS (2006:68).

²⁰¹ Lack of clarity characterises many important WRL management documents and measures. For example, Fletcher et al. (2005) identify an octopus bycatch ‘indicator’ of “recorded catch rate information for octopus by lobster fishing by independent observers”, with the associated ‘performance measure’ of “a decline in the calculated rate per pot lift more than 25% outside the range of recorded variation”. No information is provided on: (a) observer coverage of seasonal pot lifts, (b) calculation method for the ‘range of recorded variation’ – which under some methods could have a lower value of zero, or (c) historical trends in existing data.

²⁰² Fletcher et al. (2005) suggest that fishing impacts on ecosystem structure and function will be negligible, based on an estimate that fished lobster biomass remains at >80% of virgin lobster biomass. However, this argument assumes that large lobsters play no significant ecological role. The findings of Babcock et al. (2007) suggest that in unfished ecosystems, large lobsters are conspicuous consumers in shallow reef ecosystems. Babcock’s findings suggest the density of large (>8 yo) lobsters has been dramatically reduced by fishing pressures. Abundance reductions of 90-99% (depending on location) seem likely for these large lobsters. It is entirely possible that these animals perform important ecological functions in these ecosystems – and perhaps deep water ecosystems as well. Such conjecture is unsurprising (Shears & Babcock 2003); however reports available through the DoFWA website indicate that this issue did not receive serious consideration prior to recent initiatives (EEFSRG 2006).

²⁰³ For example coral damage by boats, pots and pot-ropes (SCS 2006:63,91).

²⁰⁴ A more action-focused statement would be “effort to be reduced by 15%”.

²⁰⁵ While MSY calculations are not presented, the fishery does use general benchmarks from empirical indicators and past evidence of overfishing.

²⁰⁶ The term “overfishing” here uses its meaning in a single-stock context. The stock may well be grossly overfished from an ecological perspective while remaining “fully exploited” under the single-stock definition (Jennings 2007).

²⁰⁷ The current egg production trigger is thought to correspond to a spawning biomass of 22% of the virgin level. Recent work by Babcock indicates that spawning stock is considerably below this level (pers.comm. R.Babcock 9/9/08).

²⁰⁸ In choosing Dr Norman Hall to undertake the independent review of stock assessment procedures, WRL management chose a person who had previously been an employee of the DoFWA, and had previously worked on WRL stock assessments (DoFWA 2007:9,74). Several other qualified people, free of possible bias, could have been selected. However, Dr Hall's review was itself peer-reviewed by four scientists, including Malcolm Haddon (University of Tasmania) and Jim Ianelli (US – NMFS) (DoFWA 2008).

²⁰⁹ The 2002 Commonwealth accreditation recommended (amongst other matters) that triggers and decision rules be developed within the management plan, and that a trigger point "should require that action must be taken to return the fishery to a stage where it will satisfy the management objectives" (DoFWA 2007:7).

²¹⁰ Pers.comm Dr Tony Smith 18/9/08: "The fishery is currently facing one of its most severe challenges with a major collapse in perulus settlement. The key will be to see how rapid and effective the management response is to this situation."

²¹¹ The maximum size restriction on female lobsters was relaxed in 2004/05 to compensate for what was seen as a temporary downturn in legal-sized stock. The restriction was re-established in the following season. This relaxation creates an impression that fishery managers see the older lobsters as a 'harvest reserve' rather than a critical part of the population from a spawning or ecological perspective.

²¹² Melville-Smith & de Lestang (2006).

²¹³ Sea lions have a breeding population centred on the Abrolhos Islands, however most sea lion bycatch occurs in the Jurien Bay area, southeast of the Abrolhos. A marine protected area has been established in Jurien Bay.

²¹⁴ Senator Louise Pratt, Commonwealth, Speech to the Senate, Hansard 18/03/09, p.1979.

²¹⁵ ORIGINAL 26. Room for improvement is apparent with respect to delays in addressing MSC conditions and Commonwealth recommendations. These are important issues and one would expect them to receive a high priority and adequate resourcing. Issues relating to delays are listed in endnote 9 above.

There are good arguments, partly on precautionary grounds, for the extension of marine protected areas across WRL habitat. Australia (and thus WA) through its ratification of the Convention on Biological Diversity 1992, is committed to protect at least 10% of each marine ecoregion by 2012. What percentage of WRL habitat is currently under no-take protection? How much highly protected habitat spans both shallow and deep water, including migratory pathways? These questions should be addressed in WRL ecological risk assessments. It is noteworthy that initial proposals for the Jurien Bay MPA included shelf waters, but the final boundaries (much smaller than the first proposal) do not include significant deep water habitat. Given the possibly substantial dietary reliance of sea lion pups on medium-to-large rock lobsters under virgin conditions, to what extent is the WRL fishery to blame for the uncertain status of the Abrolhos Islands sea lion population? A large marine reserve in the Abrolhos Islands could protect threatened sea lions, as well as protecting the WRL spawning population in an area which could benefit downstream WRL populations through the effects of the Leeuwin current. A marine reserve in this area could have other substantial scientific, fishery-related, biodiversity and tourism benefits. Such a proposal would need to be tempered by the fact that about one third of the total WRL catch comes from the Abrolhos Islands fishing zone, and the WA government has a policy of full compensation for fishers affected by MPA creation.

In addition, the issue of whale entanglements warrants attention. Humpback whales migrate northwards along the western Australian coastline, mainly from June to September each year. The whales travel through coastal waters used by the lobster industry: June is the final month of the fishing season. Each year whales are entangled in pot ropes. DoFWA requests fishers to notify fishery inspectors of these events, and a name and phone number (currently Doug Coughran 0419 947 708) is provided. In 2006, six entanglements were reported, with five of these released alive. The reporting rate could be as low as 3% (SCS 2006:51). It is

surprising that the issue has not received more careful coverage in risk assessment reports. The timing and location of entanglements has not been reported, nor the factors (like rope slack, or water depth) which could contribute. It has been reported that most (~60%) of entanglements occur in June. Would there be reason to investigate the viability of a partial closure of 'risk' areas in June? A total closure in June would have marketing implications, and these too need discussion – lobsters can be stored (DoFWA 1998). Given that the industry exhibits an effort creep of about 1% a year, closures for whale protection purposes could serve a dual purpose (SCS 2006:161). Further detailed discussion is warranted.

The issue of ghost fishing also warrants more attention than it appears to have received. Pots do trap some fish, although small fish and most lobsters appear to be able to exit pots without too much difficulty, given enough time. At an annual loss rate of 10-15% (perhaps higher in the recreational fishery) (SCS 2006:60) if each lost pot continues to fish for three years (taking 're-baiting' into account) ghost fishing could have a significant fishing effect. Ghost fishing in the Norway lobster fishery has been reported (Adey et al. 2008) and appears to be minimal, however the approach used in this study should nevertheless be applied in WA. Experimental studies with video surveillance seem another obvious option to investigate the issue more thoroughly. Decay times for steel and wood pots also appear to need methodical study.

The issue of the use of pots near coral would also seem to warrant better attention and discussion. Given that pots near coral can damage coral by rope movement or entanglement, where and when, and at what level, does most damage occur? In the absence of information, a precautionary approach would ban pot setting near coral. What would be the cost to the industry of such regulation?

Another issue relates to the effectiveness of codes of practice – pertaining, for example, to bait handling and whale entanglements. After several years in operation the SCS (2006:61) noted "there has been no systematic assessment of the effectiveness of the [bait handling] code of practice".

Important scientific committees established to provide advice with respect to management issues have not been operating effectively. According to SCS (2006:64) the Sea Lion Scientific Reference Group had "limited capacity" to provide the required advice. With respect to the Ecological Impacts SRG, "meetings are poorly organized, outcomes do not properly address the committee's terms of reference, the members do not reach agreement, and organizational aspects are inadequate" (SCS 2006:64). There appears to be no evidence that findings of the EcoSRG have substantially altered research funding priorities.

The Ecologically Sustainable Development SRG "appears to have never met, or if it has there are no documented outcomes." (SCS 2006:65). The SCS recommended that these groups provide minutes "for public review" (SCS 2006:65). The DoFWA WRL webpage, accessed in September 2008 (two years later) provided no such minutes, and no indication that such minutes existed.

²¹⁶ Fletcher & Santoro (2007) did not report the 2002/06 Abrolhos spawning stock index value, even though it was available at the time they finalised their report.

15. Benchmark appraisal: Victorian recreational spearfishing

The purpose of this appraisal is to compare the Victorian Government's management regime for recreational spearfishing against benchmarks representing key aspects of three broad 'modern' management approaches: active adaptive management, and the precautionary and ecosystem approaches.

15.1 Background:

The Victorian *Fisheries Act 1995* does not incorporate direct reference to the use of adaptive management, or the precautionary or ecosystem approaches. However s.3 (Objects of the Act) states that the Act should "provide for the management, development and use" of resources in an "ecologically sustainable manner". S3(b) includes an objective "to protect and conserve fisheries resources, habitats and ecosystems including the maintenance of aquatic ecological processes and genetic diversity". As Victoria endorsed the *National Strategy for Ecologically Sustainable Development* (Commonwealth of Australia 1992) which embodies the precautionary principle, it appears implicit that precaution must be applied within activities sanctioned under the Fisheries Act;

Victoria, through its endorsement of the *National Strategy for the Conservation of Australia's Biological Diversity 1996*, committed itself (amongst other matters) to:

- reviewing the appropriateness of current management strategies, techniques, standards, jurisdictions and legislation;
- developing and adopting practical and acceptable codes of practice for the management and monitoring of commercial and recreational fishing, for the harvesting of invertebrates, for the rehabilitation of depleted stocks, and for key habitat and spawning areas; and
- developing through the Australian and New Zealand Fisheries and Aquaculture Council, in consultation with relevant ministerial councils, a national strategy and guidelines for managing recreational fishing on an ecologically sustainable basis.

An examination of material available from the Department of Primary Industries indicates that, for the State of Victoria:

- no review has been undertaken of the appropriateness of management strategies, techniques, standards or legislation specifically applicable or relevant to recreational spearfishing;
- no code of practice has been developed specific or relevant to the management and monitoring of recreational spearfishing; and
- no guidelines are in place specific to the management of recreational spearfishing on an ecologically sustainable basis.

It appears that the commitments made in 1996, listed above, have not been kept.

Recreational spearfishing, globally, has had little systematic study. Few papers have been published in peer-reviewed or grey literature dealing with the ecological impacts of spearfishing. In a review presented to the 2006 conference of the Australian Marine Science Association, Nevill (2006) suggested that spearfishing, while having the potential for low ecological impact in certain situations, has in fact had major impacts on accessible shallow reef ecosystems around Australia. This review is presented below in Appendix 6. There is adequate evidence (largely anecdotal but nevertheless persuasive) that recreational spearfishing has resulted in the extirpation of some reef species, and has played an important role in an imminent regional extinction – the east coast population of grey nurse

shark *Carcharias taurus*. Amongst a number of recommendations, Nevill advises broad prohibition of spearfishing on SCUBA, and of night-time spearfishing.

15.2 Benchmarks:

The derivation of the benchmarks used below is described in chapters 7, 8 and 9 above.

Each benchmark is scored as follows:

- 0 – no evidence of policy or implementation;
- 1 – policy in place or partially in place; no significant implementation at this stage;
- 2 – policy in place; evidence of partial implementation;
- 3 – policy in place; evidence of substantial implementation.

Table 15.1 The precautionary approach in the Victorian recreational spearfishery:

	Benchmark	Assessment
A1	Management strategies and plans contain clear objectives, indicators and performance targets relating to the protection of: target stocks, populations of dependent and associated species, and habitat.	Score 0. Recreational spearfishers in Victoria must carry a current recreational licence, and are subject to minor local restrictions, as well as recreational catch limits, as are other recreational fishers. Past these controls, the sport is essentially unrestricted.
A2	Fishery management plans use pre-agreed decision rules based partly on limit reference points equivalent to, or more conservative than, both target stock MSY and bycatch population MSY for the most vulnerable species of bycatch.	Score 0. The Victorian Government has not undertaken research on the ecological impacts of recreational spearfishing. No codes of practice or conduct have been developed, and no management plans specific to the sport exist. No accurate information is available on the number participating in the sport, or the size, mix or location of the catch.
A3	Undesirable outcomes which could result from excessive fishing pressures are identified, and monitoring programs are in place with sufficient power to rapidly detect these changes should they occur.	Score 0. See comments above.
A4	The risks to ecosystem health and integrity are assessed for each major fishery, and additional caution applied to management programs for high-risk fisheries	Score 0. See comments above.
A5	Independent peer review is used as quality assurance for major management policies, strategies and plans.	Score 0. See comments above.
A6	Management procedures provide for rapid response in the light of unexpected declines in target stocks, bycatch populations, or habitat value. Such provisions provide for fisher compensation where necessary.	Score 0. See comments above.

Table 15.2 The ecosystem approach in the Victorian recreational spearfishery:

	Benchmark	Assessment
B1	There is formal periodic assessment of the impacts of particular fisheries against agreed objectives, including ecosystem-based objectives.	Score 0. See comments above.
B2	There is monitoring and reporting of agreed ecosystem indicators based on stated ecosystem objectives.	Score 0. See comments above.
B3	There is a substantial program in mapping, protecting and monitoring critical and vulnerable habitats, funded by the fishery agency or responsible government.	Score 2. The Victorian Government has mapped marine habitats at a broad scale, and provided some protection to critical and vulnerable habitats through a network of no-take areas covering slightly in excess of 5% of Victorian waters (coastal to 3 nm.).
B4	There are effective programs in place to monitor and maintain old-growth age structure in specific fisheries.	Score 0. See comments above.
B5	The agency has a substantial program to account for evolutionary change caused by fishing.	Score 0. See comments above.
B6	There are effective programs in place to maintain the spatial extent of all major sub-populations (both target and bycatch) affected by specific fisheries, and maintain and monitor population genetic diversity.	Score 0. See comments above.

Table 15.3 Active adaptive management in the Victorian recreational spearfishery:

	Benchmark	Assessment
C1	The performance of the fishery management agency itself is subject to independent periodic review against stated objectives, and quantifiable indicators and performance targets.	Score 0. See comments above.
C2	The management program uses mathematical modelling to pinpoint uncertainties and generate alternative hypotheses.	Score 0. See comments above.
C3	The assumptions behind the models are clearly set out and evaluated.	Score 0. See comments above.

Table 15.2 Active adaptive management in the Victorian recreational spearfishery (cont.).

	Benchmark	Assessment
C4	Reports incorporating the use of adaptive management set out the bounding of management problems in terms of explicit and hidden objectives, and practical constraints on actions.	Score 0. See comments above.
C5	There are changes in management controls, designed to test clearly stated hypotheses, which are sufficiently large to reasonably produce detectable effects; the size of these effects is estimated in advance, and sufficiently powerful field surveys undertaken, and statistically examined to deduce the probabilities of both Type I and Type II errors.	Score 0. See comments above.
C6	Formal organizational requirements are established for evaluating and reporting the results of the experimental management strategies, both to managers and stakeholders.	Score 0. See comments above.

15.3 Summary:

While the Victorian Government is committed on paper “to protect and conserve fisheries resources, habitats and ecosystems” partly through precautionary management, there appears little or no evidence that this commitment has any expression with respect to the Government’s management of recreational spearfishing. The Government’s management regime in this case appears virtually devoid of any evidence of the application of adaptive, precautionary or ecosystem-based management approaches. In essence, the sport is unstudied and unmanaged.

The studies, guidelines and codes of practice for recreational fisheries, planned in 1996, have not been funded, undertaken or prepared. Notably the 1996 commitments contained no timeframes. The Government could argue that these commitments will be undertaken at some point in the future, although such an argument would not be persuasive.

There is ample evidence that spearfishing can cause serious damage not only to fish stocks, but to entire reef ecosystems where shallow reefs are readily accessible to recreational fishers (Appendix 6). This evidence appears to have been entirely ignored by the Victorian Government, not for years but for decades.

Although the Victorian Government has protected around 5% of its marine and estuarine habitats, this falls well short of the target of 10% “effectively conserved” by 2010 which the Australian Government has endorsed through its ratification and participation in the *Convention on Biological Diversity 1992* (Chapter 5). The Victorian Government does not have a program in place to meet this commitment. The Victorian Government’s marine protected area framework is largely based on the recommendations of the Victorian Environment Conservation Council; however these recommendations left many important shallow water habitats without protection (Nevill 2000).

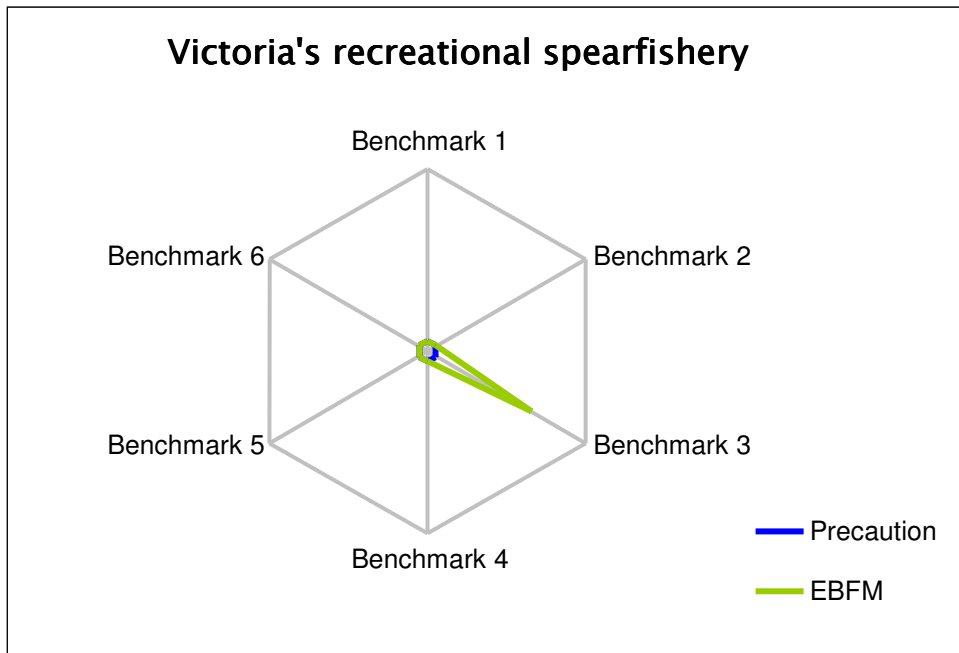


Figure 15.1 Kite diagram for the precautionary and ecosystem approaches within the Victorian recreational spear fishery.

These findings support comments made by Cooke & Cowx (2004:857):

[B]oth recreational and commercial fishing sectors deserve consideration as contributors to the exploitation of fish in marine and inland waters. The lack of global monitoring and compiling of statistics on recreational fishing participation, harvest, and catch-and-release has retarded our ability to understand the magnitude of this fishing sector. Using data from Canada, we estimate that the potential contribution of recreational fish harvest around the world may represent approximately 12 percent of the global fish harvest. Failure to recognize the potential contribution of recreational fishing to fishery declines, environmental degradation, and ecosystem alterations places ecologically and economically important resources at risk. Elevating recreational fishing to a global conservation concern would facilitate the development of strategies to increase the sustainability of this activity.

There is to date no evidence that these concerns are shared by the Victorian Government. There is no evidence that the Victorian Government is aware of, or understands, these concerns.

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16. Benchmark appraisal: Tasmanian recreational gillnetting

The purpose of this appraisal is to compare the Tasmanian Government's management regime for recreational gillnetting against benchmarks representing key aspects of three broad 'modern' management approaches: active adaptive management, and the precautionary and ecosystem approaches.

16.1 Background:

The Tasmanian *Living Marine Resources Management Act 1995* does not explicitly incorporate a need to apply the precautionary principle. However s.310 of the Act references the "objectives of the resource management and planning system of Tasmania" which include: "to promote the sustainable development of natural and physical resources and the maintenance of ecological processes and genetic diversity". As Tasmania endorsed the *National Strategy for Ecologically Sustainable Development* (Commonwealth of Australia 1992) which embodies the precautionary principle, it appears implicit that precaution must be applied within activities sanctioned under the *Living Marine Resources Management Act*;

Tasmania, through its endorsement of the *National Strategy for the Conservation of Australia's Biological Diversity 1996*, committed itself (amongst other matters) to:

- reviewing the appropriateness of current management strategies, techniques, standards, jurisdictions and legislation;
- developing and adopting practical and acceptable codes of practice for the management and monitoring of commercial and recreational fishing, for the harvesting of invertebrates, for the rehabilitation of depleted stocks, and for key habitat and spawning areas; and
- developing through the Australian and New Zealand Fisheries and Aquaculture Council, in consultation with relevant ministerial councils, a national strategy and guidelines for managing recreational fishing on an ecologically sustainable basis.

An examination of material available from the Department of Primary Industries indicates that, for the State of Tasmania:

- no review has been undertaken of the appropriateness of management strategies, techniques, standards or legislation specifically applicable, or relevant to recreational gillnetting;
- no code of practice has been developed specific or relevant to the management and monitoring of recreational gillnetting; and
- no guidelines are in place specific to the management of recreational gillnetting on an ecologically sustainable basis.

It appears that the commitments made in 1996, listed above, have not been kept.

Recreational gillnetting undoubtedly has had, and continues to have, major effects on the fish populations of accessible Tasmanian reefs, in addition to significant bycatch impacts on dolphins and seabirds (Bryan 2008; Baker et al. 2002:83-84; Brothers et al. 1996). Amongst Australia's States, Western Australian and Tasmania alone allow recreational gillnetting.

16.2 Benchmarks:

The derivation of the benchmarks used below is described in chapters 7, 8 and 9 above.

Each benchmark is scored as follows:

- 0 – no evidence of policy or implementation;
- 1 – policy in place or partially in place; no significant implementation at this stage;
- 2 – policy in place; evidence of partial implementation;
- 3 – policy in place; evidence of substantial implementation.

Table 16.1 The precautionary approach in the Tasmanian recreational gillnet fishery:

	Benchmark	Assessment
A1	Management strategies and plans contain clear objectives, indicators and performance targets relating to the protection of: target stocks, populations of dependent and associated species, and habitat.	Score 0. Recreational gillnetters in Tasmania must carry a current recreational graball net licence, and are subject to minor local restrictions, as well as recreational catch limits, as are other recreational fishers. Past these controls, the sport is essentially unrestricted.
A2	Fishery management plans use pre-agreed decision rules based partly on limit reference points equivalent to, or more conservative than, both target stock MSY and bycatch population MSY for the most vulnerable species of bycatch.	Score 0. The Tasmanian Government has not undertaken research on the ecological impacts of recreational gillnetting. No codes of practice or conduct have been developed, and no management plans specific to the sport exist. No accurate information is available on the number active in the sport (although the number of licences is around 7000), or the size, mix or location of the catch.
A3	Undesirable outcomes which could result from excessive fishing pressures are identified, and monitoring programs are in place with sufficient power to rapidly detect these changes should they occur.	Score 0. See comments above.
A4	The risks to ecosystem health and integrity are assessed for each major fishery, and additional caution applied to management programs for high-risk fisheries	Score 0. See comments above.
A5	Independent peer review is used as quality assurance for major management policies, strategies and plans.	Score 0. See comments above.
A6	Management procedures provide for rapid response in the light of unexpected declines in target stocks, bycatch populations, or habitat value. Such provisions provide for fisher compensation where necessary.	Score 0. See comments above.

Table 16.2 The ecosystem approach in the Tasmanian recreational gillnet fishery:

	Benchmark	Assessment
B1	There is formal periodic assessment of the impacts of particular fisheries against agreed objectives, including ecosystem-based objectives.	Score 0. See comments above.
	Benchmark	Assessment
B2	There is monitoring and reporting of agreed ecosystem indicators based on stated ecosystem objectives.	Score 0. See comments above.
B3	There is a substantial program in mapping, protecting and monitoring critical and vulnerable habitats, funded by the fishery agency or responsible government.	Score 1.5. The Tasmanian Government has mapped some marine habitats at a broad scale, and provided minor protection to critical and vulnerable habitats through a network of marine protected areas. However the effectiveness of this network is severely compromised by the small area covered and poor protection from threatening processes, particularly fishing.
B4	There are effective programs in place to monitor and maintain old-growth age structure in specific fisheries.	Score 0. See comments above.
B5	The agency has a substantial program to account for evolutionary change caused by fishing.	Score 0. See comments above.
B6	There are effective programs in place to maintain the spatial extent of all major sub-populations (both target and bycatch) affected by specific fisheries, and maintain and monitor population genetic diversity.	Score 0. See comments above.

Table 16.3 Active adaptive management in the Tasmanian recreational gillnet fishery:

	Benchmark	Assessment
C1	The performance of the fishery management agency itself is subject to independent periodic review against stated objectives, and quantifiable indicators and performance targets.	Score 0. See comments above.
C2	The management program uses mathematical modelling to pinpoint uncertainties and generate alternative hypotheses.	Score 0. See comments above.

Table 16.3 Active adaptive management in the Tasmanian recreational gillnet fishery (cont.)

	Benchmark	Assessment
C3	The assumptions behind the models are clearly set out and evaluated.	Score 0. See comments above.
C4	Reports incorporating the use of adaptive management set out the bounding of management problems in terms of explicit and hidden objectives, and practical constraints on actions.	Score 0. See comments above.
C5	There are changes in management controls, designed to test clearly stated hypotheses, which are sufficiently large to reasonably produce detectable effects; the size of these effects is estimated in advance, and sufficiently powerful field surveys undertaken, and statistically examined to deduce the probabilities of both Type I and Type II errors.	Score 0. See comments above.
C6	Formal organizational requirements are established for evaluating and reporting the results of the experimental management strategies, both to managers and stakeholders.	Score 0. See comments above.

16.3 Summary:

While the Tasmanian Government is committed on paper “to promote the sustainable development of natural and physical resources and the maintenance of ecological processes and genetic diversity” partly through precautionary management, there appears little or no evidence that this commitment has any expression with respect to the Government’s management of recreational gillnetting. The Government’s management regime in this case appears virtually devoid of any evidence of the application of adaptive, precautionary or ecosystem-based management approaches. In essence, the sport is unstudied and almost unmanaged.

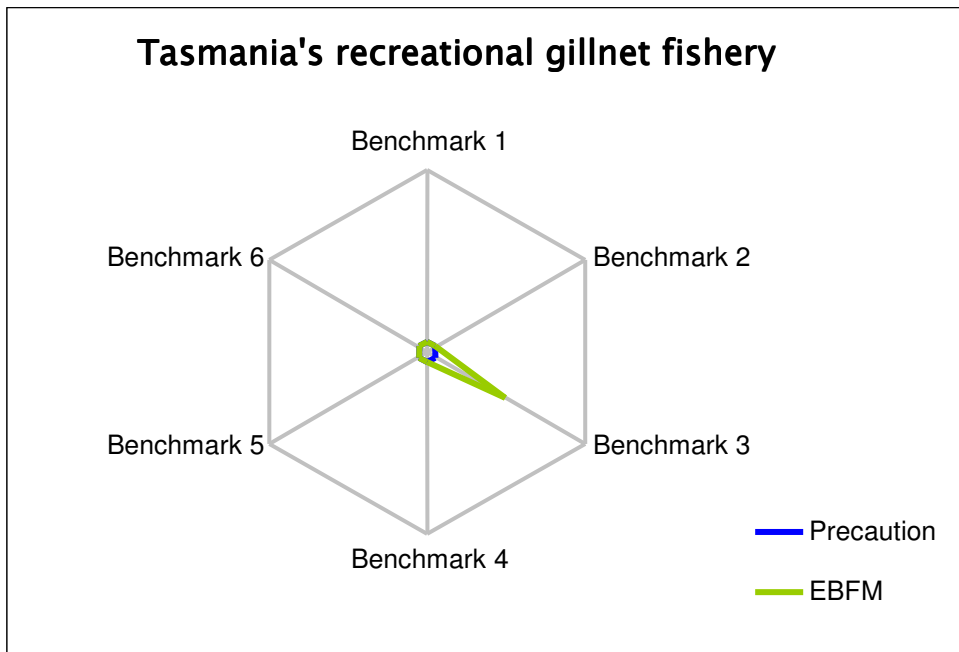


Figure 16.1 Kite diagram for the precautionary and ecosystem approaches within Tasmania’s recreational gillnet fishery.

The studies, guidelines and codes of practice for recreational fisheries, planned in 1996, have not been funded, undertaken or prepared. Notably the 1996 commitments contained no timeframes. The Government could argue that these commitments will be undertaken at some point in the future, although such an argument would not be persuasive.

There is ample evidence that gillnetting can cause serious damage not only to fish stocks, but to entire reef ecosystems where shallow reefs are accessible to recreational fishers. This evidence appears to have been entirely ignored by the Tasmanian Government.

Although the Tasmanian Government has protected around 2% of its marine and estuarine habitats, this falls well short of the target of 10% “effectively conserved” by 2010 which the Australian Government has endorsed through its ratification and participation in the *Convention on Biological Diversity 1992*. The Tasmanian Government does not have a program in place to meet this commitment.

These findings support comments made by Cooke & Cowx (2004:857):

[B]oth recreational and commercial fishing sectors deserve consideration as contributors to the exploitation of fish in marine and inland waters. The lack of global monitoring and compiling of statistics on recreational fishing participation, harvest, and catch-and-release has retarded our ability to understand the magnitude of this fishing sector. Using data from Canada, we estimate that the potential contribution of recreational fish harvest around the world may represent approximately 12 percent of the global fish harvest. Failure to

recognize the potential contribution of recreational fishing to fishery declines, environmental degradation, and ecosystem alterations places ecologically and economically important resources at risk. Elevating recreational fishing to a global conservation concern would facilitate the development of strategies to increase the sustainability of this activity.

There is to date no evidence that these concerns are shared by the Tasmanian Government. There is no evidence that the Tasmanian Government is aware of, or understands, these concerns.

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Part Three: discussion, conclusions and recommendations

17. Case studies discussion

17.1 Introduction:

This chapter reviews the results of the case studies, in order to gain an overview of the results, particularly with respect to similarities and differences between the case studies. Seven fisheries were analysed against benchmarks representing the precautionary and ecosystem approaches, and active adaptive management. These benchmarks were derived from mainstream fisheries literature (in Chapters 7, 8 and 9). The case studies covered fisheries of different scale, from the regional CCAMLR krill fishery, to the small Tasmanian recreational gillnet fishery. The Australian examples included both Commonwealth-managed fisheries (through the Australian Fisheries Management Authority) and those managed by State fishery agencies. More detail on the rationale for case study selection is provided in Chapter 1. A problem which came to light immediately was the lack of documentation regarding the management of recreational fisheries (Chapters 15 & 16). This contrasts sharply with the Commonwealth fisheries, where there is considerable documentation – though not always of high quality.

The benchmarks used in the case studies are listed below:

Table 7.2 Benchmarks for the precautionary approach:

A1	Management strategies and plans contain clear objectives, indicators and performance targets relating to the protection of: target stocks, populations of dependent and associated species, and habitat.
A2	Fishery management plans use pre-agreed decision rules based partly on limit reference points equivalent to, or more conservative than, both target stock MSY and bycatch population MSY for the most vulnerable species of bycatch.
A3	Undesirable outcomes which could result from excessive fishing pressures are identified, and monitoring programs are in place with sufficient power to rapidly detect these changes should they occur.
A4	The risks to ecosystem health and integrity are assessed for each major fishery, and additional caution applied to management programs for high-risk fisheries
A5	Independent peer review is used as quality assurance for major management policies, strategies and plans.
A6	Management procedures provide for rapid response in the light of unexpected declines in target stocks, bycatch populations, or habitat value. Such provisions provide for fisher compensation where necessary.

Table 8.4 Benchmarks for the ecosystem approach:

B1	There is formal periodic assessment of the impacts of particular fisheries against agreed objectives, including ecosystem-based objectives.
B2	There is monitoring and reporting of agreed ecosystem indicators based on stated ecosystem objectives.
B3	There is a substantial program in mapping, protecting and monitoring critical and vulnerable habitats, funded by the fishery agency or responsible government.
B4	There are effective programs in place to monitor and maintain old-growth age structure in specific fisheries.
B5	The agency has a substantial program to account for evolutionary change caused by fishing.
B6	There are effective programs in place to maintain the spatial extent of all major sub-populations (both target and bycatch) affected by specific fisheries, and maintain and monitor population genetic diversity.

Table 9.1 Benchmarks for active adaptive management:

C1	The performance of the fishery management agency itself is subject to independent periodic review against stated objectives, and quantifiable indicators and performance targets.
C2	The management program uses mathematical modelling to pinpoint uncertainties and generate alternative hypotheses.
C3	The assumptions behind the models are clearly set out and evaluated.
C4	Reports incorporating the use of adaptive management set out the bounding of management problems in terms of explicit and hidden objectives, and practical constraints on actions.
C5	There are changes in management controls, designed to test clearly stated hypotheses, which are sufficiently large to reasonably produce detectable effects; the size of these effects is estimated in advance, and sufficiently powerful field surveys undertaken, and statistically examined to deduce the probabilities of both Type I and Type II errors.
C6	Formal organizational requirements are established for evaluating and reporting the results of the experimental management strategies, both to managers and stakeholders.

Each benchmark was scored as follows:

- 0 – no evidence of the approach in policy or program implementation;
- 1 – policy incorporating the approach in place; no significant implementation at this stage;
- 2 – policy incorporating the approach in place; evidence of partial implementation;
- 3 – policy incorporating the approach in place; evidence of substantial implementation.

In each case study the fishery was introduced, and the analysis then presented in tabular format. The results for the precautionary and ecosystem approaches were summarized by kite diagram; however the results for active adaptive management were, with the exception of CCAMLR, generally very low scores, so summary by kite diagram is not particularly informative, and was not undertaken.

17.2 Case studies: CCAMLR

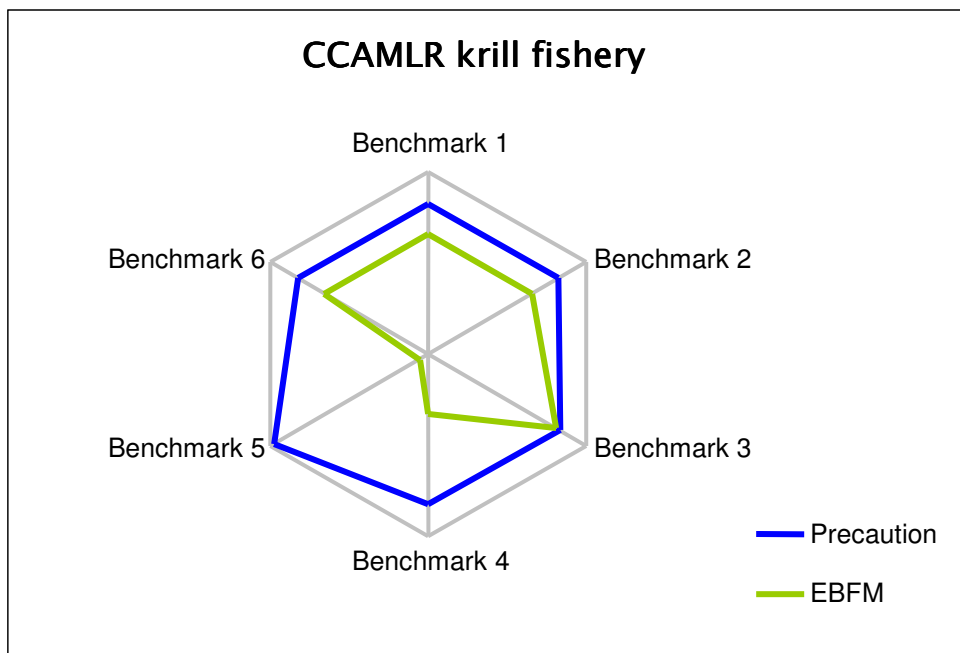


Figure 10.1: Kite diagram for CCAMLR precautionary and ecosystem approaches.

An immediate point of note is that CCAMLR's name has the word "conservation" in the agency title. In this respect it is singular amongst the case studies – all remaining fisheries being managed by traditional agencies operating primarily under fisheries-specific legislation (see Chapter 7 for the names of the Australian fisheries statutes).

CCAMLR's enabling statute (the Convention) requires the use of an ecosystem approach to fisheries management, and has been interpreted to require the application of the precautionary approach. While in these respects it is not very different from the Australian agencies studied, it is immediately noticeable that CCAMLR scores very well on the precautionary benchmarks, and scores very well on all but two of the ecosystem approach benchmarks. These two benchmarks use concepts which are relatively 'new' to fisheries management – the protection of the genetic diversity of fish stocks, and the protection of age structure (particularly older fish) within targeted stocks.

It is noteworthy that the two CCAMLR scientific staff interviewed held positive and almost identical views on the ecosystem and precautionary approaches, and these are worth repeating here (taken from Chapter 10):

- The precautionary and ecosystem approaches may be different in theory, but in practice they are interwoven. In some respects the precautionary approach can be seen as an element of the practical implementation of the ecosystem approach.
- Erring on the side of caution, and adopting 'safe' harvest levels rather than economically 'optimal' levels (i.e.: using different safety margins or likelihoods when choosing harvest levels) must reduce harvest targets – so leaving an added margin of species productivity within the natural food web of the ecosystem.
- Application of the precautionary principle to ocean environments rests partly on careful consideration of the statistical power of monitoring programs designed to detect the ecological effects of harvesting – taking a precautionary approach will involve choosing increased probabilities of making Type I errors, while reducing Type II errors. No guidelines for these probabilities exist, and each case will be different.
- The direct costs of both the precautionary and ecosystem approaches to fisheries are lower short term harvests – and thus in some cases profits. The direct benefits are greater stability of catches in the long term – which is likely to support future fishery profits.
- Although to some fishery scientists the ecosystem approach seems complex and daunting, it is important to start with simpler aspects which can be managed – predator/prey relationships being a good example. Although CCAMLR's krill fishery is 'lucky' in that key predators have land-based breeding colonies, making monitoring simpler, management options which allow for predator needs can be made in any fishery. Minimization of bycatch, and prevention of long-term damage to benthic habitats, are also basic elements of the ecosystem approach. Once a start has been made, a path of gradual incremental improvement can be followed to ultimately expand the scope of ecosystem based management within a particular fishery.

17.3 Case studies: Australia's northern prawn fishery

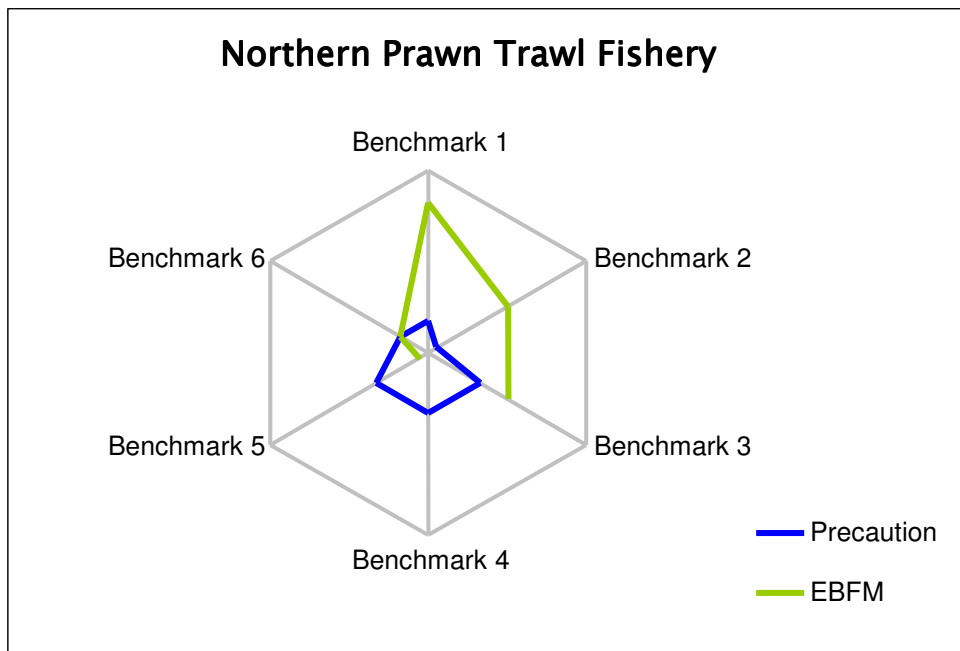


Figure 11.4. Kite diagram showing benchmark performance of the NPTF on precaution and ecosystem based management.

Prawn trawling is a destructive fishery, with high bycatch ratios (in spite of some commendable progress), and very considerable areas subject to benthic damage by the demersal trawls (Chapter 11).

The northern prawn fishery is managed by AFMA, and AFMA's enabling legislation requires application of the precautionary principle to fisheries management. Australian Government policy also requires AFMA to similarly apply an ecosystem approach. The fishery has a progressive management advisory committee, and has a generally good reputation for a fishery successfully using co-management arrangements. However, the fishery does not score well on the precautionary benchmarks – suggesting, in reality, little more than lip-service to the precautionary approach. Benchmark 2, concerning the application of pre-agreed decision rules, scores zero, in spite of important government commitments, for example, to the use of bycatch reference points in making management decisions.

The fishery scores somewhat better on the ecosystem benchmarks. It should be noted, however, that the relatively good scores on benchmarks 1 and 2 could be disputed. Although the fishery undergoes a formal periodic review (benchmark 1) my analysis of the quality of this review (Chapter 11) shows that the review process itself has serious problems. With respect to benchmark 2, dealing with ecosystem indicators, some of the most important indicators (eg: temporal and spatial reporting of bycatch ratios) are not even attempted by the fishery or its regulator, and important commitments to reduce bycatch have not been followed through (Chapter 11).

Benchmark 4, relating to protection of stock age structure, hardly applies to the fishery, so it was not scored (see Figure 11.4).

17.4 Case studies: Australia's orange roughy fishery

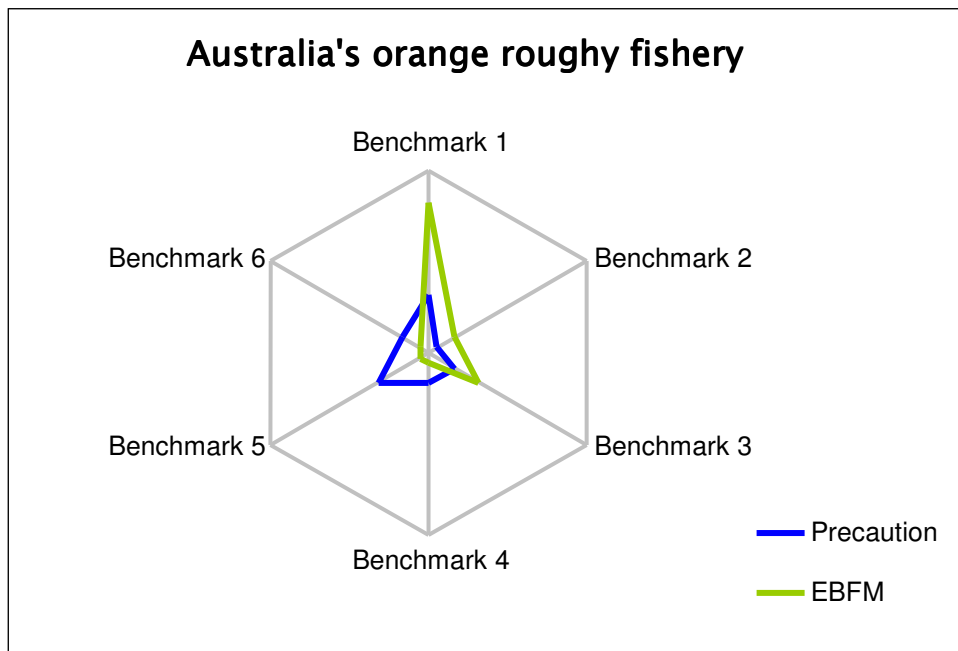


Figure 12.14. Kite diagram showing benchmark performance on precaution and ecosystem based management for the orange roughy fishery.

The story of Australia's orange roughy fishery is a classic story of overfishing under regulation. The fishery is also a destructive fishery, associated with a substantial but un-quantified amount of benthic damage to ancient and diverse coral ecosystems.

The role of fishers and the management agency are examined in Chapter 12 in some detail. In particular, many fishers showed that they were quite prepared to breach their legal responsibilities regarding catch limits when they perceived licence compliance was not being enforced – also in the knowledge that the productivity of the stock was very low. Koslow (2007) has argued that there was an un-written understanding amongst fishers that the stock should be 'mined out' – which in fact is exactly what occurred.

Although AFMA had clear responsibilities to apply the precautionary and ecosystem approaches in management of the fishery, and in spite of statements that precautionary catch limits would be set, the reality showed that AFMA either promoted the 'mining' of the stock, or were too weak to resist the pressures of their vocal clients.

The kite diagram summary (Figure 12.14) shows that nothing more than token efforts were made to apply either the precautionary or the ecosystem approach.

As with the northern prawn fishery, the one high score on the ecosystem benchmarks is largely an artefact. This benchmark relates to the fact that the fishery (in this case assessed as part of the Southern and Eastern Scalefish and Shark Fishery) is subject to a formal periodic assessment (required by the EPBC Act's strategic assessment procedures). Unfortunately, Chapter 12 shows that this assessment is seriously compromised on several fronts, not least of which is the inadequate information supplied by AFMA to the accreditation review (and accepted by the minister responsible for the EPBC Act).

17.5 Case studies: South Australia's abalone fishery

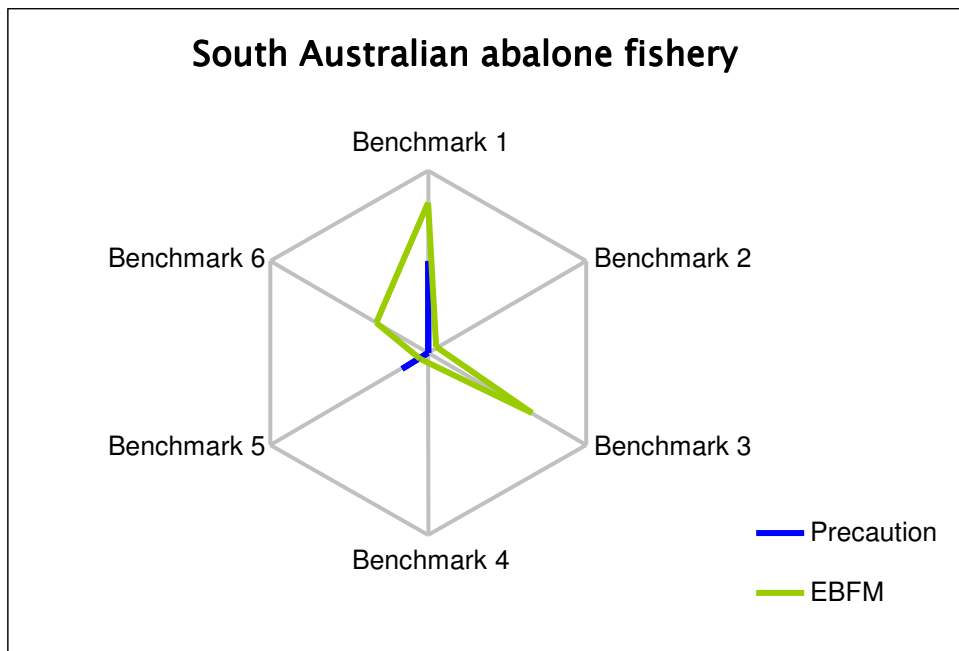


Figure 13.1: Kite diagram for precaution and EBFM in the SA abalone fishery

Like Australia's northern prawn fishery, South Australia's abalone fishery has something of a reputation for good management, and it has maintained relatively stable catch levels over decades which have seen the collapse of abalone stocks in other nations. Unlike the prawn fishery, it is not destructive: it has almost no bycatch, and causes little benthic damage. It has, however, greatly reduced the abundance of a once-dominant reef herbivore – with unknown effects on predators and competitors.

The analysis in Chapter 13 of the fishery's application of the precautionary and ecosystem approaches shows effectively no application of the precautionary approach, and almost no action initiated by the South Australia fishery management agency (PIRSA) relating to the ecosystem approach.

With respect to precaution, the score of 1.5 on benchmark 1 (relating to the establishment of objectives, indicators and performance targets) is perhaps over-generous, given the imprecise wording of several of the key indicators (Chapter 13). With respect to the ecosystem approach, the high scores on benchmark 1 (formal periodic assessment) and benchmark 3 (habitat mapping and protection) are the result of programs initiated by other agencies, not by PIRSA.

The analysis in Chapter 13 concludes that the fishery is a good deal more precarious than a superficial examination of catch statistics would suggest. If implemented, precautionary management would, amongst other effects, produce larger abalone populations which would provide a buffer against environmental variation. Larger populations would underpin stability of profits for the industry over coming decades, as well as providing for unknown ecosystem effects, particularly to abalone predators. More consideration of fine-scale metapopulation issues should also enhance stability of the fishery.

Several recommendations are made, including the establishment of substantial precautionary fishery-based marine protected areas, the rebuilding of depleted local populations, and fine-scale management of metapopulations, including the use of rolling closures using spatial units carefully defined by their distinct metapopulations.

17.6 Case studies: the western rock lobster fishery, WA

When the Commonwealth minister (David Kemp) accredited the WRL fishery on 20 August 2002, he wrote: “The fishery is managed under a comprehensive, adaptable, precautionary and ecologically based regime...” (Kemp 2002).

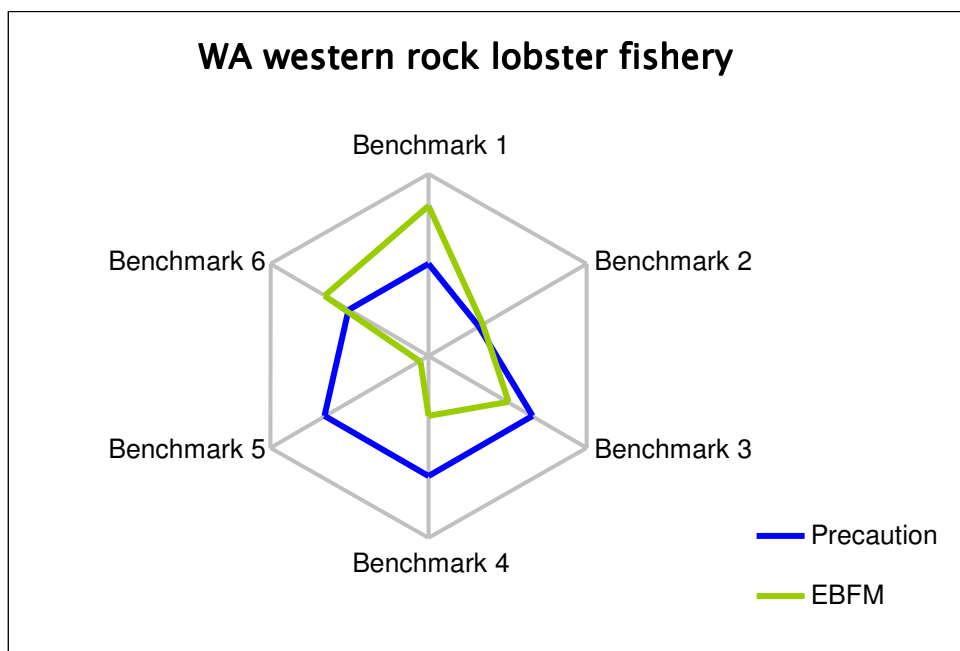


Figure 14.4 Kite diagram for the precautionary and ecosystem approaches in the WA western rock lobster fishery.

The fishery is well-managed by Australian standards, and has so far escaped major output declines due to overfishing, after several decades of operation – however the shadow of a collapse in puerulus settlement now hangs over the fishery (see above). A careful examination of the management of the fishery demonstrates major weaknesses, and at a practical level there is considerable room for improvement. Bycatch issues, as well as the more general issues of the ecological effects of fishing, have not been adequately addressed, and effective precautionary strategies (large no-take reserves for example) are not in place to provide long-term security for the breeding stock, ecologically dependent species, or the lobster’s within-species genetic diversity.

Viewed from a precautionary perspective, the harvest rate is too high. The low spawning biomass limit reference point of 22% virgin biomass provides little if any margin or error for unexpected environmental variation, and provides virtually no ecological allowance for natural predation (or other ecological effects) of large lobsters. The Abrolhos Islands spawning stock index remains at the level it was in the early 1990s when the WRL industry was in difficulties (Fletcher & Santoro 2007:24) and is in fact only half its 1997/98 level. Establishment of a large no-take marine protected area in the Abrolhos Islands would appear to provide both spawning stock security and ecological protection for predators of large lobsters, yet such a proposal has not been seriously examined in WRL fisheries management literature.

Extended delays in implementing management reforms (even those required by MSC accreditation) are a prominent feature of the fishery’s recent history (Chapter 14). Excuses offered in respect to the delay in implementing SLEDs, and the continued failure of the WRL fishery management system to provide equal input to the advisory process for non-fishery stakeholders creates the impression of a management regime which has been ‘captured’ by fishing industry interests. This impression is reinforced

by important gaps in public reporting (Chapter 14) for example with respect to the workings and findings of the scientific reference groups.

17.7 Case studies: Victoria's recreational spearfishery

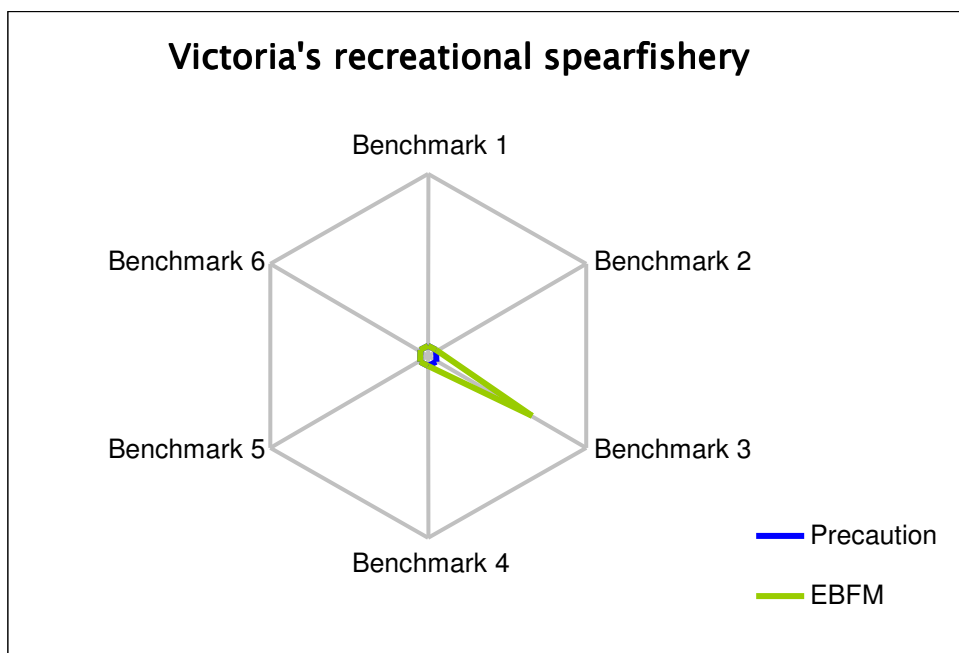


Figure 15.1 Kite diagram for the precautionary and ecosystem approaches within the Victorian recreational spear fishery.

While the Victorian Government is committed on paper “to protect and conserve fisheries resources, habitats and ecosystems” partly through precautionary management, there appears little or no evidence that this commitment has any expression with respect to the Government’s management of recreational spearfishing. The Government’s management regime in this case appears virtually devoid of any evidence of the application of adaptive, precautionary or ecosystem-based management approaches. In essence, the sport is unstudied and unmanaged.

The studies, guidelines and codes of practice for recreational fisheries, planned in 1996 as part of the commitments made by States in the *National Strategy for the Conservation of Australia’s Biological Diversity*, have not been funded, undertaken or prepared. Notably the 1996 commitments contained no timeframes. The Government could argue that these commitments will be undertaken at some point in the future, although such an argument would not be persuasive.

There is ample evidence that spearfishing can cause serious damage not only to fish stocks, but to entire reef ecosystems where shallow reefs are readily accessible to recreational fishers (Appendix 6). This evidence appears to have been entirely ignored by the Victorian Government, not for years but for decades.

Although the Victorian Government has protected around 5% of its marine and estuarine habitats, this falls well short of the target of 10% “effectively conserved” which the Australian Government has endorsed through its ratification and participation in the *Convention on Biological Diversity 1992* (Chapter 5). The Victorian Government does not have a program in place to meet this commitment. The Victorian Government’s marine protected area framework is largely based on the recommendations of the Victorian Environment Conservation Council; however these recommendations left many important shallow water habitats without protection (Nevill 2000).

17.8 Case studies: Tasmania's recreational gillnet fishery

While the Tasmanian Government is committed on paper “to promote the sustainable development of natural and physical resources and the maintenance of ecological processes and genetic diversity” partly through precautionary management, there appears little or no evidence that this commitment has any expression with respect to the Government's management of recreational gillnetting. The Government's management regime in this case appears virtually devoid of any evidence of the application of adaptive, precautionary or ecosystem-based management approaches. In essence, the sport is unstudied and almost unmanaged.

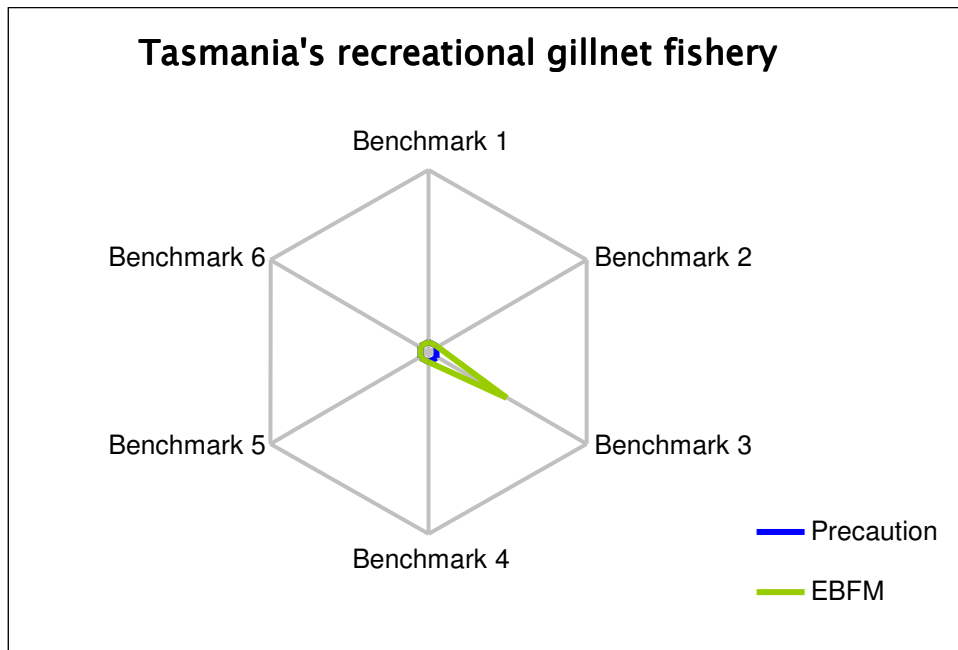


Figure 16.1 Kite diagram for the precautionary and ecosystem approaches within Tasmania's recreational gillnet fishery.

As is the case in Victoria, the studies, guidelines and codes of practice for recreational fisheries, planned in 1996 (see above), have not been funded, undertaken or prepared.

There is ample evidence that gillnetting can cause serious damage not only to fish stocks, but to entire reef ecosystems where shallow reefs are accessible to recreational fishers. This evidence appears to have been entirely ignored by the Tasmanian Government.

Although the Tasmanian Government has protected around 2% of its marine and estuarine habitats, this falls well short of the target of 10% “effectively conserved” which the Australian Government has endorsed through its ratification and participation in the *Convention on Biological Diversity 1992*. The Tasmanian Government does not have a program in place to meet this commitment.

These findings support comments made by Cooke & Cowx (2004:857):

[B]oth recreational and commercial fishing sectors deserve consideration as contributors to the exploitation of fish in marine and inland waters. The lack of global monitoring and compiling of statistics on recreational fishing participation, harvest, and catch-and-release has retarded our ability to understand the magnitude of this fishing sector. Using data from Canada, we estimate that the potential contribution of recreational fish harvest around the world may represent approximately 12 percent of the global fish harvest. Failure to recognize the potential contribution of recreational fishing to fishery declines, environmental degradation, and ecosystem alterations places ecologically and

economically important resources at risk. Elevating recreational fishing to a global conservation concern would facilitate the development of strategies to increase the sustainability of this activity.

There is to date no evidence that these concerns are shared by the Victorian or Tasmania Governments. Indeed, there is no evidence that the Victorian or Tasmanian Governments are aware of, or understand, these concerns.

17.9 Case studies: overview

A few notable points emerge from the above comparison:

- a) the one agency which has a primary mandate for ecosystem conservation (CCAMLR) generally scores well with its application of the ecosystem and precautionary approaches, and in regard to its application of active adaptive management;
- b) none of the case studies indicate that Australian fishery management agencies are making any serious attempt to apply active adaptive management;
- c) the two Commonwealth case studies show little more than lip-service to the precautionary and ecosystem approaches, in spite of rhetoric to the contrary;
- d) the South Australian case study also indicates little more than lip-service to the precautionary and ecosystem approaches, in spite of rhetoric to the contrary;
- e) the Western Australian case study shows some substantial progress with respect to the precautionary and ecosystem approaches; this case study is the only one of a fishery accredited by the Marine Stewardship Council; and
- f) the case studies of recreational fisheries in Victoria and Tasmania suggest that these fisheries are effectively unmanaged – at least as far as any element of the precautionary or ecosystem approaches is concerned. The single high score for the ecosystem approach relates to habitat mapping – not an initiative of the fishery management agency in either case.

Although it is clearly risky to draw inferences on the basis of single case studies, this is in fact what I do in the thesis conclusion (Chapter 19). I believe that part of the explanation for CCAMLR's success in implementing modern management approaches lies with its charter as a conservation organization. I also believe that part of the explanation for the success of the western rock lobster fishery in applying the precautionary and ecosystem approaches lies with the desire of the fishery for MSC accreditation, and the subsequent adoption of several aspects of these modern management approaches by the fishery (assisted, of course, by pressure from the WA Department of Fisheries).

18. Policy implementation failure in Australian marine resource management:

This chapter looks back at some of the key findings of the thesis, and briefly introduces a topic not so far discussed: Australia's progress in developing a national network of marine protected areas – representative of ecoregions, ecosystems and habitats. The chapter contains some repetition from earlier chapters, with the intention of making it comprehensible as an overview for those without the time to read the entire thesis.

18.1 Chapter overview:

Australia is sometimes seen at the forefront of ocean management in a global context. This chapter examines implementation 'failures' in four important elements of Australian marine policy. In brief, the chapter finds that: (a) Australia's developing national marine protected area network is failing to meet important national and international commitments; (b) the Commonwealth's strategic fishery accreditation program's integrity is seriously compromised on a number of fronts; (c) fisheries management agencies generally display lip-service to the precautionary principle, but avoid applying it in an effective way; and (d) destructive fishing practices in Australia are not being effectively addressed, in spite of an impending international phase-out deadline. The root cause of the identified failures probably lies primarily with the organizational cultures of fisheries management agencies; cultures essentially focused on harvesting. Such cultures could be changed if fisheries agencies could follow the path already trodden by terrestrial government agencies which, a century ago, focused on the promotion of hunting and the management of game. The *Commission for the Conservation of Antarctic Living Marine Resources* (CCAMLR) arguably provides a model for such a metamorphosis.

18.2 Management of the marine environment: Australian policy:

Australia has espoused several progressive policies relating to management of the marine environment. For example:

- Australia was one of the first nations to adopt bioregional ocean planning (Commonwealth of Australia 1998);
- Australia is committed, at least on paper, to the establishment of a comprehensive, adequate and representative national network of marine protected areas;
- All export fisheries undergo periodic reviews under the provisions of Commonwealth legislation, using a process which appears to be transparent and accountable;
- Australian fisheries legislation *requires* application of the precautionary principle;
- Australia is committed to phasing-out destructive fishing practices by 2012.
- An Australian fishery was the first world-wide to achieve Marine Stewardship Council certification (the western rock lobster fishery in Western Australia);
- The Great Barrier Reef Marine Park is an international icon of conservation;

On paper, Australia's strategic marine management indeed appears impressive. Australia's scientific capability in marine matters is also highly regarded internationally: the work that the CSIRO is currently doing in areas such as ecosystem-based modelling, and the ecological risk assessment of fisheries, is leading-edge in a global sense. However, in day-to-day fisheries management, the studies undertaken during this thesis demonstrate disturbing failures in program implementation.

This chapter provides important examples of implementation failures related to four of the above policies:

1. the national marine protected area network;
2. the Commonwealth's strategic fishery assessment program;
3. application of the precautionary principle; and
4. the scheduled phase-out of destructive fishing practices.

In order to provide a short and readable account, the examples presented below are discussed only in overview. Details on the examples used in issues 2 and 3 above, as well as a discussion of many related examples, are provided in the body of this thesis.

18.3 Australia's national network of marine protected areas:

Australia, like other nations supporting the *Convention on Biological Diversity 1992* (the CBD) is committed to the establishment of a national network of marine protected areas. This commitment was expressed through an important national strategy (ANZECC 1999) now ten years old. A core goal of the national strategy is to develop a MPA network which is comprehensive, adequate and representative.

Over the last decade many new protected areas have been declared, in both State and Commonwealth waters. Effective implementation of the 1999 strategy is, however, undermined in two important ways:

1. by the creation of 'paper' parks – parks providing little or no effective protection from important threats; and
2. inadequate extent of protection – in many instances the area covered by individual parks, and in fact by the network as a whole, is simply too small to provide effective and long-lasting protection for many important ecosystems and habitats.

Taking the first issue: paper parks – consider two examples discussed by Nevill & Ward (in press):

As part of its regional ocean planning program, the Commonwealth created a MPA network in the Southeast Region – Commonwealth (offshore) waters adjacent to Tasmania, Victoria, and parts of South Australia and New South Wales. Here MPAs of all IUCN categories cover only 5.5% of the region (by "categories" I refer to the widely-accepted categories of the International Union for the Conservation of Nature – IUCN). To make matters worse, most MPA areas are zoned to allow fishing (IUCN category 6) – a critical threat to local ecosystems. The dangers posed by fishing activities to marine biodiversity have been well documented (Chapter 2 above) both in Australia and globally.

In the absence of detailed habitat information, geomorphic province may be used as a biodiversity surrogate. The continental shelf contains many important habitats not found elsewhere. However, only 0.75% of the region's continental shelf is zoned in no-take areas. The continental shelf does contain several large MPAs, but these areas (with minor exceptions) do not restrict fishing activities (<http://www.environment.gov.au/coasts/mpa/index.html>, accessed 20/9/2009).

A second example is provided by the Tasmanian State Government, which has been using a bioregional approach in planning its MPA network – as required by the national strategy. Tasmanian State waters are those generally within three nautical miles of the coast. However the most recently announced section of the State network, the Bruny Bioregion (announced in late 2008) is comprised essentially of 'paper' parks, with all the new MPAs to allow fishing with no new restrictions (IUCN category 6) (<http://www.parks.tas.gov.au/index.aspx?base=397> accessed 20/9/2009).

These examples deal with inadequate controls over important threats. Consider now the issue of inadequate extent of protection.

Through its participation in the CBD Council of the Parties (CoP) process, Australia is committed to

- (a) establish a national network of marine protected areas by 2012, and
- (b) protect at least 10% of every marine ecoregion.

This last commitment is often interpreted to include ecosystems and habitats, with vulnerable and/or rare habitats needing much greater levels of protection (Nevill 2007). However,

Australia is falling far short of a goal of at least 10% of habitats or major marine ecosystems adequately protected.

In the Southeast Region, as already discussed, only 5.5% of the region is included in MPAs of all categories – with a much smaller proportion covered by no-take areas (mostly deep slope and abyssal plain). The Commonwealth has no plans to expand this part of the national MPA network, in spite of the fact that it does not meet (or even approach) the CBD target to which Australia is (at least on paper) committed.

In Victoria only 5.3% of Victorian marine waters are included within the State's MPA network, however almost all of these areas are no-take. Again, although Victoria's coverage falls far short of the CBD target, the State has no plans to expand the network, or even review its adequacy.

In Tasmania, the State government does not publish information on the extent of no-take protected areas within the State MPA network, but it appears to be very small, in the order of 1% of the total State coastal marine jurisdiction.

The situation is better in Queensland, whose offshore waters house the Great Barrier Reef Marine Park. The GBRMP has a total area of 345,000 km², of which 33.4% is no-take (<http://www.gbrmpa.gov.au> accessed 20/9/2009). Within the park coral habitats are reasonably well protected, but elsewhere on the continental shelf off Queensland they are not well protected. Overall about 10% of shelf coral habitats off the Queensland coast are within no-take zones – inadequate for a vulnerable habitat type.

In summary, although Australia has a sound national MPA strategy, and on paper Australia is committed to widely accepted international targets (Commonwealth of Australia 1998), in fact the development of the national MPA network is falling far short of these targets, and the rhetoric of Australian policy (Nevill & Ward in press).

18.4 The Commonwealth's strategic fishery accreditation program

Under the provisions of the *Environment Protection and Biodiversity Conservation Act 1999*, (the EPBC Act) every export fishery, and every Commonwealth fishery, must be assessed against designated 'sustainability guidelines'. Fisheries are accredited for a period of 5 years, usually on conditions aimed at promoting continual improvement (see the Chapters on the orange roughy fishery and the northern prawn fishery).

This section examines three questions:

1. Are the guidelines adequate?
2. Is the level of documentation contained in the accreditation reports adequate?
3. Does the accreditation result adequately reflect the environmental issues of the fishery?

Are the guidelines adequate?

The Commonwealth's 28 guidelines were published for stakeholder comment in 1999, and finalised in 2000. While there were some improvements in the 2000 version, mostly related to minor points of definition, the final guidelines lost extremely important features relating to auditability – in other words the final version was vague and general where the draft version had been clear and definite. Consider one example:

Draft guideline 3.1 (1999)

The fishery *shall* be subject to institutional arrangements that are in accordance with Australian laws and standards and *which give effect to the principles of international agreements relating to the conservation and sustainable use of marine living resources, including the precautionary approach to management* [emphasis added].

This draft guideline has two clear elements: (a) rules must be obeyed, and (b) the principles of international agreements must be applied.

Final guideline 3.1 (2000)

The management regime must comply with any relevant international or regional management regime to which Australia is a party. Compliance with the international or regional regime does not mean Australia cannot place upon the management of the Australian component of the fishery management controls that are more stringent than those required through the international or regional regime [emphasis added].

This guideline has only one clear element: rules must be obeyed. The rest of the guideline re-states the obvious.

Both versions basically state that 'rules must be obeyed' – which really should go without saying. However the first version quite precisely *requires* the application of the precautionary principle – and other important principles. This requirement is entirely lost in the final version.

An examination of the other 27 guidelines provides several other important examples of the removal of critical elements, and the removal of clarity on which auditability depends (see Appendix 3 below).

Is the level of documentation adequate?

Consider the example of information provided by the *South East Scalefish and Shark Fishery (SESSF)* re-accreditation report on the deepwater trawl fishery for orange roughy (AFMA 2006b). Although Australia was required (under an Australian / New Zealand Memorandum of Understanding) to send observers on each vessel operating on the South Tasman Rise in 1998-99, and these observers were required to collect information on trawl bycatch, the AFMA report contains *no* information on their bycatch results. Coral bycatch was a critical issue for the fishery at the time. *In fact, no orange roughy bycatch reports are referenced or summarised in the AFMA report.* In other words, no information was provided on an issue critical to the focus of the assessment (Chapter 12).

Consider the example of the Northern Prawn Fishery re-accreditation report (AFMA 2008a). Although bycatch impacts are a critical issue for the fishery, the AFMA report entirely failed to reference or summarise reports detailing *temporal and spatial variation in bycatch/catch ratios* – vital information in relation to developing bycatch reduction strategies (Chapter 11 above).

Does the accreditation result adequately reflect the environmental issues of the fishery?

Consider the example of the SESSF accreditation report (AFMA 2002a) particularly as it related to the orange roughy component of that fishery.

At the time the AFMA report was prepared, all but one of Australia's orange roughy stocks were in severe decline. However, AFMA provided false and misleading information in the report which had the effect of under-playing this crisis (see below). Moreover, the information which was presented in the report demonstrated that the orange roughy fishery met only 3 of the 28 Commonwealth sustainability guidelines. Many of the 'missing' guidelines were simply not addressed. Turning to another important issue, AFMA failed to produce information on the extent of trawler damage to orange roughy habitats in this report. Much of this damage was severe and effectively irreparable. The trawl fishery presented a major threat to deepsea coral habitats, and in fact to the ecological viability of orange roughy populations (Chapter 12 above).

However, in accrediting the fishery, the minister responsible for the EPBC Act (at that time David Kemp) provided a brief statement which had no foundation within the information provided by the AFMA report:

"I am satisfied that AFMA has provided a report that adequately addresses the current and likely impacts of activities taken in accordance with the management plan...

I am satisfied that actions taken in accordance with the management plan are unlikely to have unacceptable or unsustainable impacts on the environment in a Commonwealth marine area.

I am also satisfied that [the fishery] is unlikely to be detrimental to the survival or conservation status of any taxon, or threaten any relevant ecosystem, to which the fishery relates." (Kemp, 2003)

Three years later, the orange roughy became the first commercial fish listed under Australian threatened species legislation (Chapter 12 above).

In summary, the Commonwealth's fishery assessment guidelines are, in several cases, weak and vague. In the case studies examined, the level of documentation in accreditation reports was inadequate, and the results of the accreditation process did not adequately reflect the key issues facing the fisheries.

18.5 Application of the precautionary principle

Many definitions of the precautionary principle exist. A general statement of the principle is:

Where there is the threat of serious or irreversible harm, lack of scientific certainty should not deter action by decision-makers to prevent or mitigate such harm.

The principle contains two key elements: the possibility of serious harm, and the existence of uncertainty. Both these elements are common-place in fisheries management. The principle also reverses the onus of proof. Where formerly decision makers assumed that no action need be taken until the probability of damage was clearly identified or demonstrated, under the precautionary principle an activity proponent needs to demonstrate that harm will not occur, or is very unlikely to occur (Preston 2006).

Australia committed itself to apply the precautionary approach to natural resource management in 1982 through endorsement of an important resolution of the United Nations General Assembly, the *World Charter for Nature*. This commitment was later reinforced by Australia's support for the *FAO Code of Conduct for Responsible Fisheries*, as well as the *UN Fish Stocks Agreement*, both documents dating from 1995 (see Chapter 5 above).

Commonwealth fisheries legislation was amended in 1997 – fifteen years after the initial commitment – to require application of the precautionary principle to Commonwealth fisheries.

Annex II of the UN Fish Stocks Agreement (UNFSA) provides guidelines on the application of the precautionary approach. According to the Annex, the fishing mortality equivalent to that which would produce maximum sustainable yield (F_{msy}) should be used as a limit reference point not as a target reference point – thus departing from traditional fisheries management practice over much of the twentieth century.

The UNFSA is widely viewed as providing appropriate advice for the management of single stocks, in addition to migratory or straddling stocks, and this view is shared by the Government of Australia (Commonwealth of Australia 2006).

At the South Tasman Rise, AFMA initially used 20%B₀ (B₀: unfished biomass) as a limit reference point for the orange roughy fishery – in apparent violation of responsibilities under the UNFSA. AFMA made no attempt to demonstrate that this limit reference point complied with the UNFSA guideline. When this limit point was breached, AFMA abandoned the reference point, and allowed fishing to continue (Chapter 12) – in clear violation of the precautionary principle.

In AFMA policy statements it is not uncommon to find endorsement of the precautionary principle (as perhaps should be expected, given the statutory background). However evidence, such as the South Tasman Rise example above, indicates that this commitment does not go beyond lip-service. Another striking example of such evidence is provided by the following:

AFMA, in an accreditation report provided to the minister responsible for the *Environmental Protection and Biodiversity Conservation Act 1999* (AFMA 2002a:184), in discussing setting orange roughy total allowable catch (TAC) limits, stated that:

..“current TACs for the southern and eastern sectors are considered precautionary using the best available scientific advice and have a good chance of meeting the recovery strategy.”

The TACs referred to were 1600 tonne for the eastern stock and 420 tonne for the southern stock.

The relevant CSIRO stock assessment (Wayte & Bax 2002) had been commissioned by AFMA, and had recommended a total allowable catch of zero for the eastern stock and zero for the southern stock. The stock assessment report had also pointed out that *there was no chance* of either stock meeting the recovery strategy.

Arguments based on incompetence or dishonesty could be used to explain AFMA's statement. Whatever the explanation, AFMA's statement, in a such critical document, is false and misleading. Other examples can be found indicating that AFMA has little, if any, sincere commitment to the precautionary principle (see Chapters 11 and 12).

18.6 Destructive fishing practices in Australia

In 1995, on endorsement of the *FAO Code of Conduct for Responsible Fisheries*, Australia committed itself to phase out destructive fishing practices. Many destructive fishing practices existed at that time within Australian jurisdictions – and today destructive fishing practices continue under both Commonwealth and State regulation.

Australia has been slow to act on the commitment to phase-out destructive fishing practices. For example, after endorsing the Code of Conduct, no action was taken to halt the practice of shark finning until 2000, and it was not until 2005 (ten years after the policy commitment) that this practice was prohibited within all Australian fisheries.

AFMA took no action until late 2006 to protect deepsea ecosystems from the effects of bottom trawling, other than the establishment of small exclusion areas, such as the Tasman Seamounts Reserve (1999), or the St Helens Hill exclusion zone. Even when a temporary ban on bottom trawling below 700 m was put in place, the orange roughy fishery was exempted. Orange roughy frequent deepsea coral habitats, and the fishery for this species has a well-documented history of the destruction of corals and associated habitats (Gianni 2004, Koslow 2007, Appendix 4 below).

In 2002, through the United Nations *Johannesburg Implementation Statement*, Australia committed itself to a deadline – 2012 – to phase out destructive fishing practices.

Destructive fishing practices which continue under regulation in Australia include (in my view):

1. Commercial fisheries with excessive bycatch, such as prawn trawling and gillnetting;
2. Bottom trawling over vulnerable habitats – *a precautionary approach would see a blanket ban on bottom trawling except in areas which had been studied and assessed as suitable (following the European Union example)*;
3. Serial overfishing of stocks and substocks (Shaw 2008), with attendant ecosystem effects and likely lost of biodiversity at the genetic level (Allendorf et al. 2008, Hauser et al. 2002);

4. Beach seining – due to the high mortality rate of juveniles;
5. Recreational activities such as gillnetting (still permitted in Tasmania and WA) and spearfishing on SCUBA (still permitted in Victoria, WA and Tasmania).

So far, *no Australian fisheries management agency, State of Commonwealth, has prepared a policy or program to chart a course to meeting the 2012 phase-out deadline.*

Forward planning is essential to provide a period of say 5 to 10 years over which commercial operations, now legitimately using certain destructive fishing practices, can be phased out without undue hardship to the fishers. Compensation packages will nevertheless remain necessary in some circumstances, and governments must budget accordingly.

18.7 Summary:

The general conclusion of this discussion, based largely on limited case studies of Australian fisheries, is that progressive policies do not guarantee effective implementation. Failure to implement core government policies may be widespread within natural resource management agencies, in Australia and world-wide. According to former US attorney Richard Sutherland:

[M]y primary emotion when recalling the past 20 years of environmental law is one of profound disappointment. This disappointment is due to the continuing failure of federal agencies and officials to do a better job of implementing and enforcing our environmental laws... [G]overnment is all too often the environment's worst enemy. Agencies and officials charged with implementing and enforcing our environmental laws frequently fail to do so. They miss statutory deadlines, water down strict legal requirements, or simply refuse to use their enforcement powers, even when faced with blatant violations of the law... [T]he current situation, where laws are implemented, if at all, only half-heartedly... fosters cynicism and serves to undermine faith in our system of law.²¹⁷

Acknowledging the dependence of some of my findings on limited case studies, I conclude, on the basis of the discussion above (with the support of the more detailed analysis in the thesis itself) that:

1. Australia's developing national marine protected area network *is failing to meet important national and international commitments*;
2. The Commonwealth's strategic fishery accreditation program's *integrity is seriously compromised on several fronts*;
3. Fisheries management agencies generally display lip-service to the precautionary principle, *but avoid applying it in any effective way*; and
4. Destructive fishing practices in Australia *are not being effectively addressed*, in spite of an impending international phase-out deadline.

Similar problems of implementation failure may be found in completely different aspects of natural resource management in Australia: for example relating to freshwater protected area policy (Kingsford & Nevill 2006) and groundwater policy (Nevill 2009).

An explanation of continuing fisheries management failures:

In my view *these failures should not be unexpected* from organizational cultures focussed on fishing, rather than on the protection and management of the ecosystems which produce the fish. Marine ecosystems also provide other important ecosystem services, but the protection of these services invariably falls outside the responsibility of government fishery management agencies.

Organisational cultures are strongly influenced by the primary focus of the organization, and that focus is contained in the organization's name and its charter. The culture is also

influenced by the disciplinary mix of the professional staff, as well as the extent to which the organizational culture has been 'captured' by its clients' interests. This last point is in turn influenced by the strength or weakness of senior management, and the extent to which subtle corruption is allowed to permeate staff behaviour – for example by accepting small gifts or favours from clients.

On the issue of organisational charter and name, consider the changes in statutory focus which took place over a century in Victoria, Australia. In 1890 the Victorian Parliament passed two new statutes, the *Game Act 1890* – to promote and manage the hunting of game, and the *Fisheries Act 1890* – to promote and manage fisheries. The Game Act underwent two major revisions, the last in 1958. During this period, commercial harvesting of game gradually disappeared (although small industries survive in other Australian States, for example relating to kangaroos and shearwaters). Seventeen years later, the *Game Act 1958* was replaced by the *Wildlife Act 1975*, with the new statute having a strong focus on wildlife conservation.

In the terrestrial environment, the initial focus on harvesting was transformed into a focus on conservation. This metamorphosis did not occur in the marine environment. The Victorian Fisheries Act again underwent two major revisions to 1958, and thirty-seven years later the *Fisheries Act 1958* was replaced by the *Fisheries Act 1995*. Although the new Act acknowledged the need for sustainable harvests, the essential focus of the statute remained unchanged.

This metamorphosis which created such a change of attitude regarding land-based wildlife was also reflected in the way government departments were named over the decades. At the close of the nineteenth century, the colonies of Victoria and South Australia each created a *Department of Fisheries and Game* to control and promote these activities. The Victorian Department, many decades later, was replaced by two departments: a *Department of National Parks and Wildlife*, and a *Department of Fisheries*. These departments, years later, were subsumed by the creation of larger departments – fisheries into the *Department of Primary Industries*, and wildlife into the *Department of Sustainability and the Environment*. The former department has a statutory and organizational emphasis on resource use (exploitation) whereas the latter department has an emphasis on conservation. Similar changes occurred in South Australia. As an aside, the term 'wildlife' in Australia is almost never used in respect to aquatic fish or crustaceans, although they are 'life' and they are 'wild'.

The future for fisheries

The concerns I have expressed above are shared by many within the marine science community. The coming decades may see changes in line with Earle & Laffoley's (2006) call that "we must place biodiversity conservation at the center of ocean governance". The work of Pitcher & Pauly (2001) support this call in arguing that the proper goal for fisheries management should not be catch optimisation or sustainable harvests, but ecosystem rebuilding. Mangel & Levin (2005) recommend that community ecology should be the basic science for fisheries.

Pikitch et al. (2004) recommend that "the framework of fishery management must be broadened to include environmental effects, food web interactions and the impacts of fishing on ecosystems". Worm et al. (2007) emphasize "that the protection and restoration of biodiversity must be a cornerstone of any rational management regime." Walker & Salt (2006) argue that protecting ecosystem resilience must be the primary goal of natural resource management.

The conclusion I reach is that fisheries management agencies need to be replaced with asset management agencies, focused on the protection of marine biodiversity assets – and the maintenance of the ecosystem services which they produce – not least of which, of course, is the production of food. While acknowledging that marine biodiversity assets are affected by human activities well outside the purview of today's fishery management

agencies, the development of such asset management agencies would be totally in line with emerging concepts of integrated coastal management.

The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) arguably provides a model for the metamorphosis I recommend here.

Although the concept of ecosystem management has been under discussion for the best part of a century (Chapter 8), in many ways the birthplace of the concept as applied to the marine environment lies with the creation of CCAMLR. The concept of ecosystem based management appeared for the first time in a major international agreement in 1980. The *Convention on the Conservation of Antarctic Marine Living Resources 1980* Article II(3) defined three “principles of conservation”, of which the second and third principles identify the need for harvesting management to (a) protect entire ecosystems, and (b) take a cautious approach to ecological risk, particularly with regard to ‘irreversible’ effects. The boundaries of the Convention were – appropriately – defined by the approximate location of the Antarctic Polar Front (the Antarctic Convergence) which provides a rough natural boundary for the Antarctic large marine ecosystem. CCAMLR and its activities are discussed in more detail in Nevill chapter 10 above).

The Commission has devoted much time and effort into applying the precautionary and ecosystem approaches, and has been widely recognised as a global leader in sustainable fisheries (Mooney-Seus & Rosenberg 2007a, 2007b; FAO 2005b).

Endnotes:

²¹⁷ Richard Sutherland was an environmental attorney and head of the Sierra Club Legal Defense Fund. Quoted in Chasan (2000).

19. Conclusion and recommendations

This section provides a brief overview of the findings of the thesis, and proposes an answer to Lord Perry's question. It contains an amount of repetition of material from earlier chapters, with the intention of making it comprehensive as a summary for those without the time to read the entire thesis.

While by no means original, the implications of this answer have profound ramifications for the long-term management of fisheries, both in Australia and globally. The conclusion of the thesis adds weight to recommendations made by several prominent marine scientists over the last decade.

19.1 Overview:

In this thesis I attempt to answer Lord Perry's question: *why does overfishing persist under regulation?* In the course of this investigation I started with a global overview (Part One) which shows a state of crisis in oceans and coastal seas. The crisis, and the collapse of many fisheries, originates, I argue, from five major causes (Chapter 2). Of these five threats, fishing has been, and remains, the most damaging. In the background, and now not too far away, lies an even greater threat – the impacts of increasing levels of atmospheric carbon dioxide on ocean chemistry, temperature and circulation.

Behind these proximate causes lie fundamental realities which go far beyond the scope of my discussion: the continued growth in the planet's human population, the evolution of financial systems across the developed world which only remain healthy in a state of continual growth, and political decision-making systems geared to short-term objectives and even shorter-term political expediencies. These ultimate causes remain without discussion in my thesis – as within the global community.

Part One also considers questions of ethics – especially relating to the need for humans to respect other life forms (Chapter 3). Over the three-million year history of our species, humans, like other predators, have killed and eaten other living things. However, in the last millennium, and especially in the last century, we commenced wholesale destruction, not just of species, but of entire ecosystems. Forests were felled and grasslands cleared, and replaced by pasture and crops. Rivers and streams were dammed, and wetlands drained, replacing lotic ecosystems with lentic ecosystems, and shallow-water ecosystems with irrigated crops and pasture. The largest land-based predators, and the most vulnerable terrestrial herbivores, were removed from the landscape – a process which then commenced in the oceans. Bottom trawling destroyed existing ecosystems across the planet's oceans and coastal seas, many of which had developed over centuries and millennia (Appendix Four). These were replaced with ecosystems dominated by the most adaptable and highly reproductive animals – sometimes called 'weedy' species. Chapter 3 argues for the establishment of large marine no-take areas, partly at least on ethical grounds. It is time we set aside substantial parts of the oceans and seas to provide 'peaceful homes' for the other living beings with whom we share this planet, and our destiny.

Chapter 4 examines the evolution of fishery management paradigms over the last century, and especially over the last decade. I note changes in terrestrial governance arrangements which have seen government departments charged with the promotion of hunting and the management of game evolve into departments focused on the protection of wildlife and the conservation of natural landscapes. I note too that the fisheries departments of a century ago have not undergone this metamorphosis, and today retain the same names and the same focus – essentially that of the promotion and 'good management' of fisheries resources.

Chapter 4 concludes with the exposition of two alternative viewpoints of the future of fisheries management. The first, perhaps epitomised by well-respected scientists such as Ray Beverton and Ray Hilborn, looks back at the evolution of powerful modeling and management approaches, and sees the major challenge of this century as one of implementing these tools, unavailable half a century ago. The second group, which includes scientists such as Sylvia Earle, Jeremy Jackson and Tony Pitcher, sees the major challenge

of this century quite differently – fisheries science and management must refocus on understanding and protecting marine ecosystems. As Tony Pitcher puts it, the future of fisheries lies in re-discovering the past, when oceans were more populated and more productive than they are today. These two viewpoints are not necessarily distinguished by different values placed on harvesting – arguments have been advanced suggesting fishery yields under a ‘conservation’ paradigm might be around the same level, or higher than they generally are today. The thesis, and my conclusions, take inspiration from this latter group.

Chapter 5 examines several key international agreements, with an emphasis on examining the extent to which two management concepts in particular are incorporated and promoted. These two concepts are the precautionary and ecosystem approaches. Importantly, both concepts date back to the early 1980s – leaving little scope for fishery managers to argue that they have not yet had time to properly come to grips with at least the basics of their application. Amongst the key agreements examined are the UN Convention on the Law of the Sea 1982, the Convention on Biological Diversity 1992, the FAO Code of Conduct for Responsible Fisheries 1995, and the UN Fish Stocks Agreement 1995.

Chapter 6, the final chapter in Part One, examines the causes and consequences of uncertainty in fisheries management. This is an important chapter, as the precautionary approach in particular is predicated on the existence of uncertainty (Chapter 7 and Appendix Two). Fishery managers, and to a lesser extent fishery scientists, appear to be characterised by eternal optimism in the face of a long history marked more by failure than by success. The very uncertain environment in which they operate both permits this optimism, at the same time as predicating against it. Looking back, fishery scientists may be heard to remark that – back then – “we under-estimated uncertainty”. The same scientists, having ‘learnt’ this lesson, still appear surprisingly optimistic in the face of uncertainty – many aspects of which cannot be reasonably bounded by mathematical limits (Chapter 6). Comments by Bax et al. (2005) on perennial optimism are important (Chapter 12) but will not be revisited here.

Part Two of the thesis concentrates on case studies, largely of Australian fisheries. Here Chapters 7, 8 and 9 develop benchmarks for the precautionary and ecosystem approaches, and for active adaptive management. These benchmarks are derived, in general, from mainstream fisheries literature. Chapters 10 to 16 then apply these benchmarks to assess:

- CCAMLR’s southern ocean krill fishery;
- Australian’s northern prawn fishery;
- Australia’s orange roughy fishery;
- South Australia’s abalone fishery;
- Western Australia’s western rock lobster fishery;
- Victoria’s recreational spearfishery; and
- Tasmania’s recreational gillnet fishery.

Chapter 17 summarises the findings of Part Two. As noted in Chapter 1, any analysis based on case studies can be criticised on the basis that important examples of fisheries which contradict the study’s findings were ignored. This is an inherent problem with the use of case studies, and of course my findings must be viewed in this light.

The first important finding is that the regional krill fishery, managed by CCAMLR, scores well with regard to application of both the ecosystem and precautionary approach. Active adaptive management is also consciously applied by the Commission. It can certainly be argued that the recent history of the krill fishery is characterised by low to moderate harvesting pressures, and this no doubt has reduced difficulties which might otherwise have accompanied the successful introduction of the measures necessary to apply these approaches. Nevertheless, CCAMLR has been confirmed as a world leader in the application of the FAO *Code of Conduct for Responsible Fisheries* (FAO 2005b) so it is not surprising that the Commission is an acknowledged leader in the development of the ecosystem and precautionary approaches.

In my view, the strong focus of CCAMLR’s charter on ecosystem protection and conservation, set out in its Convention (Chapter 5) must be viewed as fundamental to its

success. The fact that the essential purpose of the Commission is to guide sustainable harvesting *within a framework of ecosystem protection* must be a critical aspect of its leadership in these areas.

The very first clause of Article II of the Convention states: “*The objective of this Convention is the conservation of Antarctic marine living resources*” (emphasis added). The third clause immediately enforces the application of three key “principles of conservation” which effectively require the Commission to use an ecosystem approach in managing fisheries (Chapter 5). In addition, the emphasis on the avoidance of irreversible changes introduces the necessity for caution with regard to risks of environmental damage.

Turning now to the remaining case studies, it must be noted that Australia, as a nation, has been committed on paper to the application of precaution to natural resource management since 1982, and this commitment was reinforced by the nation’s endorsement of both the FAO Code of Conduct, and the UN Fish Stocks Agreement (both dating to 1995). Adherence to the Code of Conduct involves the application of the ecosystem approach – also a requirement of Australia’s endorsement of the *Convention on Biological Diversity 1992* (Chapter 5).

Generally speaking, Australia has a reputation for good fisheries management. At a policy level, this reputation seems to be well deserved, as the rhetoric of both Commonwealth and State fisheries agencies supports many concepts of good management in general, and good fisheries management in particular. Independent peer review of the application of scientific advice, and independent scrutiny of overall management performance are just two of several prominent examples not directly connected to the ecosystem or precautionary approaches.

However, the assessments of Part Two reveal that, in spite of these important commitments and an appearance of enlightened management, behind a veneer of modern rhetoric lies a reality marked by lip-service to both the precautionary and ecosystem approaches, and considerable management inertia with respect to the prompt application of scientific findings. This general comment applies broadly to the case studies of both Commonwealth and State fisheries management agencies, and is most extreme in the two case studies dealing with recreational fisheries. As far as these latter case studies go, it appears that any substantial element of ‘good fisheries management’ is simply off the radar of recreational fisheries management (Chapter 17).

The two Commonwealth fisheries case studies raise a further issue of some considerable concern: there is clear evidence of incompetence, and possibly dishonest presentation of factual material and scientific findings (Chapters 11 & 12).

In summary, I find that:

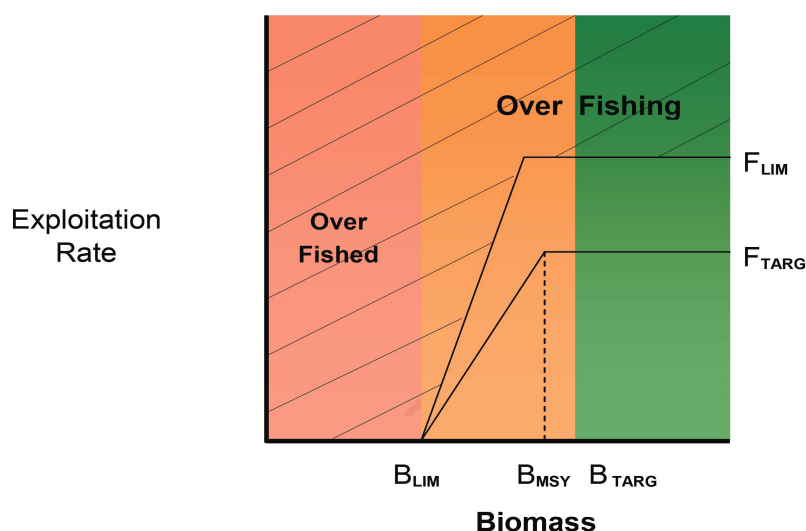
- a) the one management agency specifically charged with conserving marine ecosystems has been generally successful in implementing modern management approaches designed (in large part) to deal with the great uncertainties inherent in managing marine fisheries, and
- b) the Australian management agencies charged with the sustainable management of the nation’s fisheries appear to be singularly unsuccessful in applying these approaches in any comprehensive fashion.

The two case studies dealing with Commonwealth fisheries suggest that AFMA has a long track record of commendable rhetoric, combined with ineffective implementation. To some extent at least, judging by the recreational fisheries case studies, the same comments apply to State fisheries management agencies.

Basic and important commitments, at both State and Commonwealth levels, to the conservation of national marine biodiversity assets have been openly flouted for decades, and this lip-service continues today. Many examples are detailed in the case study chapters, and some of the most important of these examples are summarised in Chapter 17 (the case studies overview). For the purposes of this chapter, I will consider only one outstanding example – the issue of the definition of overfishing.

19.2 Defining overfishing:

Starting from first principles, 'overfishing' must mean fishing in excess – but in excess of what? A traditional approach to defining overfishing is extremely simple – overfishing is fishing which threatens the reproductive ability of a commercial stock. This definition, in effect, continues in use today by the Bureau of Rural Sciences in their annual *Fishery Status Reports* (see discussion in Chapter 11). A fishery is defined by the BRS as overfished if the spawning stock biomass has declined below half of that necessary to produce maximum sustainable yield – this is a default 'limit reference point' given the difficulty of estimating real risks to spawning stocks in dynamic and uncertain environments (Chapter 6). This definition is also supported by AFMA's Commonwealth fisheries harvest strategy (AFMA 2007b), illustrated in Figure 19.1:



Source AFMA (2007:17).

Figure 19.1: Exploitation rate, stock biomass and reference points

The use of such a narrow definition might have been excusable a century ago, but it is not excusable today. Since this concept of overfishing was developed a century ago, the world has changed, and fisheries paradigms have changed with it (Chapter 4). Half a century ago, Beverton & Holt (1957) remarked:

This is a generalisation of what is now perhaps the central problem of fisheries research: the investigation not merely of the reactions of particular populations to fishing, but also the interactions between them, and of the response of each marine community to man's activity.

Over the last century, the science of ecology developed (Chapter 8) and later spawned the science of conservation biology. The *Convention for the Conservation of Antarctic Marine Living Resources 1980* introduced the ecosystem approach to fisheries management, and a decade later the *Convention for Biological Diversity* initiated policy development processes which would later mandate the application of the ecosystem approach to management of the marine environment (Chapter 5). On paper, Australia supports these important agreements – yet the BRS continues to use a definition of overfishing in direct contradiction to the requirements of the precautionary and ecosystem approaches.

The UN Fish Stocks Agreement provides advice on the application of the precautionary approach: *Annex II of the UNFSA advises the use of Bmsy as a limit reference point in a precautionary context*. This approach itself provides no allowance to protect ecosystem interactions – the most obvious relating to food webs.

Overfishing is defined in this thesis as *a level of fishing which puts at risk values endorsed either by the fishery management agency, by the nation in whose waters fishing takes place,*

or within widely accepted international agreements. This appears to be a reasonable and logical definition.

A point of critical importance in this regard is that a level of fishing intensity which successfully meets traditional stock sustainability criteria (for example fishing a stock at maximum sustainable yield) is likely to be considerably higher than a level of fishing intensity which meets maximum economic yield criteria (Grafton et al. 2007) which in turn is likely to be considerably higher than a level designed to protect marine biodiversity (Jennings 2007, Walters et al. 2005, Murawski 2000, May et al. 1979).

The pursuit of maximum economic yield itself (considered apart from the precautionary and ecosystem approaches) should produce a very different definition of overfishing. Australia's *Harvest Strategy Policy* establishes a default target reference point of 1.2 Bmsy for fisheries aiming for MEY. Just on this basis alone, an overfished stock should be identified, using the above definition, as one in which fishing has reduced a stock below this level. Where modelling studies have produced a more accurate estimate for this target reference point, this should be used rather than the Policy default. For example, according to tiger prawn modeling by Dichmont et al. (2008:7) a value of 1.6 Smsy is "the spawning stock size which matches the actual values of Smey in the operating model most closely."

CCAMLR's approach to providing a trophic, or food web, allowance for wild predators of krill stocks is to use a target reference point of 75% of unharvested biomass (Chapter 10). This, using the simplistic but convenient assumption of logistic density dependence (Chapter 6) would translate to 1.5 Bmsy. Fishing a stock below this level would threaten ecosystem trophic interactions, and thus breach the ecosystem approach – threatening ecosystem values. Using the above definition, an overfished stock would be defined as one where fishing has reduced the stock below this point.

Given Australia's policy commitments to the ecosystem and precautionary approaches, and the nation's commitments to the protection of marine biodiversity (Chapter 5) the current definition of overfishing used by the BRS (and thus supported by the Australian Government) represents a major and extremely important abrogation of these commitments – and the nation's responsibilities for sustainable management of fishery resources. Yet the use of this definition goes unchallenged, other than by the authors listed above. It seems that papers in scientific journals have little weight beside the habits of long-standing tradition (no matter how illogical) and the short-term interests of the fishing industry.

19.3 Moving on:

"Why does overfishing persist under regulation?" I argue that overfishing results partly from managers' inability to deal effectively with uncertainty (Chapters 6 & 12). While uncertainty has many aspects, this thesis has examined the history and ramifications of the precautionary and ecosystem approaches in particular (Chapters 4, 7, 8 and Appendix Two), and argued that they represent powerful tools for addressing uncertainty in fisheries management (Chapters 6, 7 & 8). Of the case studies, Chapter 12 alone (Australia's orange roughy fishery) presents a classic story of overfishing. This case study highlights the important role of key stakeholders, including the fishers themselves, the management agency (AFMA) and the 'watchdog' agency (now DEWHA).

I suggest now that the stakeholders were acting (and still act) within organisational cultures which have been moulded by ideas of resource exploitation which are decades, even centuries old. These ideas include the notion of the 'freedom to fish' (noting the propensity for illegal behaviour exhibited by orange roughy fishers), and the idea that the oceans are huge and essentially resilient to mankind's impacts (noting AFMA's cavalier attitude to the destructive effects of bottom trawling) – both referenced in Chapter 12. These are ideas which undoubtedly were very much a part of fishery management a century ago, but remain today, by virtue of acts of parliament, and management agency cultures which focus, essentially, on the promotion of ocean harvesting. Considering the findings of Chapter 12, the failings that I identify could probably not have occurred in a very different organisational culture focused not on harvesting, but on the protection of marine biodiversity assets – the

sort of culture which appears to exist within the Commission for the Conservation of Antarctic Marine Living Resources. At the close of Chapter 12, I conclude that:

- 1) AFMA failed to apply basic elements of the precautionary approach to the management of the orange roughy fishery. In this respect AFMA's actions appear to be in breach of the *Fisheries Management Act 1991*, as well as the United Nations *Fish Stocks Agreement 1995*;
- 2) AFMA failed to apply basic elements of the ecosystem approach to the management of the Tasman Rise fishery, breaching obligations under the United Nations *Fish Stocks Agreement 1995*;
- 3) AFMA, in preparing the first accreditation review for the Commonwealth fisheries assessment process under the *Environment Protection and Biodiversity Conservation Act 1999* (AFMA 2000a) supplied false and misleading information which had the effect of underplaying previous management failures, and the precarious situation of the orange roughy stocks;
- 4) The outcomes of the Commonwealth's review and accreditation process in relation to orange roughy cast serious doubt over the integrity of the process – and this shadow may lie over the accreditation of all fisheries which have been assessed;
- 5) Although AFMA widely ignored the recommendations of fishery assessment scientists for substantial reductions in catch, even the assessment reports prepared by these scientists appear to underplay the importance of precaution in both stock assessment and management;
- 6) AFMA appear to have been extraordinarily slow in acting on responsibilities contained in the *Commonwealth Policy on Fisheries Bycatch 2000*.
- 7) AFMA did not act on important recommendations contained in the two independent reviews of orange roughy stock assessment (1994 and 2002); and
- 8) In response to the listing of orange roughy as a threatened species, AFMA prepared a conservation plan for the recovery of orange roughy which contained such a serious omission²¹⁸ as to call into question the competence of both the plan and AFMA's management, yet the plan was approved by the minister responsible for the EPBC Act, at the advice of his department, without comment or modification.

I suggest that, unlike the cultures in management agencies which had names like 'the Department of Hunting and Game' a century ago, and have now evolved into departments dealing with park management, and wildlife conservation – the cultures in fishery management agencies *have moved little with changing circumstances*, and are essentially still embedded in the harvesting cultures which the very name – "Department of Fisheries" implies. These departments look towards the fish rather than the ecosystems in which the fish reside.

The case studies reviewed in this thesis illustrate a general trend amongst Australian fishery management agencies towards lip-service (rather than genuine commitment) to the powerful approaches available to them to manage the uncertainties which will always characterise marine wild fisheries (Chapter 17). The explanation for this lip-service is that these approaches often (usually) mitigate against the high catch rates which fishers often want. In Chapter 12, I suggest it is the immediate needs of fishery management officers to placate their most vocal clients which is at the forefront of their daily concerns, rather than statutory obligations to apply good management practices. The same mistakes are repeated over and over again; the fishing industry generally appears unable to learn the lessons of the past (see Rosenberg (2003:102) quoted in section 6.12 above).

My answer to Lord Perry's question, then, is that overfishing persists under regulation because of the cultures inherent in agencies focused on harvesting, rather than (as in

CCAMLR's case, asset protection). It is no accident that the case study of CCAMLR's krill fishery indicated genuine commitment to both the precautionary and ecosystem approach, as well as to active adaptive management – which is almost invisible in the Australian case studies.

In short, overfishing persists because of a lack of commitment to the protection of the biodiversity assets on which the valuable fish stocks ultimately depend – the ecosystems of our oceans and coastal seas. Further, this lack of commitment – ultimately weak management in the context of statutory obligations to ensure sustainable management – is a direct result of cultures which exist within agencies focused on harvesting. This situation has persisted for many decades, and will persist indefinitely unless those cultures change. *Overfishing under regulation will persist indefinitely unless those cultures change.*

Judging by CCAMLR's example, the way to change these cultures is to re-name and re-direct fishery agencies into asset management agencies. Given CCAMLR's example, and acknowledged leadership globally in fisheries management matters (FAO 2005b), it would not be technically hard to do – but it will take intelligent and strong-willed politicians to do it.

The coming decades may see changes in line with Earle & Laffoley's (2006) call that “we must place biodiversity conservation at the center of ocean governance”. The work of Pitcher & Pauly (1998) and Pitcher (2001) support this call in arguing that the proper goal for fisheries management should not be catch optimisation or sustainable harvests, but ecosystem rebuilding. Mangel & Levin (2005) recommend that community ecology should be the basic science for fisheries, and Pikitch et al. (2004) recommend that “the framework of fishery management must be broadened to include environmental effects, food web interactions and the impacts of fishing on ecosystems”. Worm et al. (2007) emphasize “that the protection and restoration of biodiversity must be a cornerstone of any rational management regime.” Walker & Salt (2006) argue that protecting ecosystem resilience must be the primary goal of natural resource management (see section 6.13 above).

I believe that such views herald major changes to both fishery science and fishery management in coming decades.

The single most important recommendation of this thesis is that this change be made across both State and Commonwealth fisheries – and made as soon as possible.

The re-badging and re-directing of fishery management agencies into marine biodiversity asset management agencies would enable effective implementation of both the precautionary and ecosystem approaches. An immediate priority would be to move fisheries ‘to the other side of the MSY hump’. This issue is addressed in Chapter 20 below: *detailed recommendations*.

It is also essential – and this should be undertaken immediately as a first step – that the current definition of overfishing used by the BRS must be replaced with a definition in accord with Australia's commitments to protect ocean ecosystems (not to mention our commitments to goals of good economic management). The current definition of *overfishing* symbolizes the fact that the fishing industry (and more generally our politicians and the wider community) has not yet let go of the idea that the primary aim of fishing is to extract as much out of the sea as we can get – the “unobtainable dream” of pursuing short-term economic ‘optimization’ strategies²¹⁹.

As fishery agencies are replaced by asset management agencies around Australia (and hopefully around the world) changing organisational cultures will call for changing expertise. Universities teaching fisheries management will alter their courses to emphasize, for example, conservation biology and resource economics.

Overharvesting the fishes of our oceans and coastal seas is certainly not inevitable, and the lessons of the past can be learnt – but it will take a radical change in the focus of ocean governance to do it. Current governance arrangements often, unfortunately, seem to bring out the worst traits of human greed and weakness. The new arrangements which I (and

others) are now proposing will hopefully emphasize the benefits of managing ocean resources for long-term goals, and bring wisdom to bear in utilizing the impressive scientific knowledge we now have to reach the solution we can now see clearly but cannot reach – a win-win for both the oceans ecosystems, and sustainable harvesting.

19.4 Recommendations:

This section (a) revisits the central conclusion of the thesis; (b) suggests that ecological risk assessments of fisheries be used to establish different precautionary default reference points for fisheries of different risk categories; and (c) recommends the ultimate removal of the freedom to fish the high seas – a long-established precedent.

The single most important recommendation of this thesis is that Australian fisheries management agencies, at both State and Commonwealth levels, be replaced by asset management agencies, charged with the conservation of marine biodiversity assets. I recommend that, to the extent compatible with Australian administrative frameworks, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) be used as a model for the development of these agencies. In this respect it will be essential to define the purpose of the new agencies in terms of conservation. The first clause of Article II of the CCAMLR Convention states: “*The objective of this Convention is the conservation of Antarctic marine living resources*” (emphasis added).

Organizational cultures – which I argue are responsible for the examples of poor fishery management identified in the case study chapters – will develop very differently in organizations primarily focused on the conservation of marine biodiversity assets.

The re-badging and re-directing of fishery management agencies into marine biodiversity asset management agencies should enable effective implementation of both the precautionary and ecosystem approaches.

The MSY hump:

An immediate priority should be to move fisheries ‘to the other side of the MSY hump’.

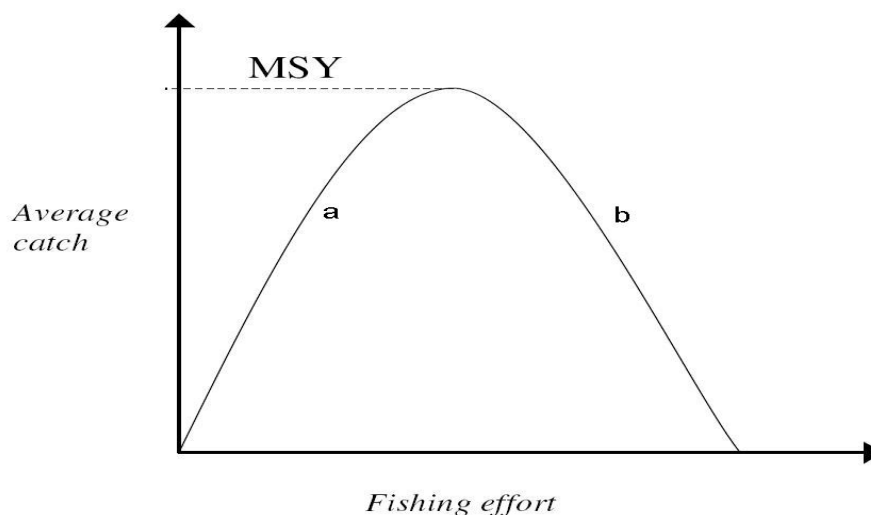


Figure 19.2. The catch / effort curve.

From Bonfil (2002)

Putting aside for the moment the many simplifications inherent in the above diagram (Chapter 6) the essential point to note here is that the diagram is roughly symmetrical (and in real life will be roughly symmetrical, although in a dynamic environment it will constantly change shape).

A given stock will yield the same average catch at two points in the curve, illustrated in this example by points (a) and (b). However the outcomes for fish stocks, for marine ecosystems, and for the profitability of fishers are very different. Although moving from point (b) to point (a) looks like a win-win outcome (and in fact it is) this movement has proved exceptionally difficult for fishery management agencies – in Australia and around the world.

The benefits are obvious. Fishing at point (b) – which is often the case both in Australia and overseas – is the result of overfishing. The factors driving fisheries into an overfished state are well understood, and this knowledge has been available for decades (Chapter 6) – although seldom effectively applied. Fishing at point (b) is economically inefficient, requiring much greater effort than that required to harvest the same catch from point (a) – and consequently fishery profits and incomes suffer. Fishing at point (a) can be achieved with a reduced effort and higher profits (Grafton et al. 2007). Fishing at point (a) is also safer for the stock itself, as it remains at a size closer to its unfished biomass – thus providing a greater 'margin of error' for natural environmental fluctuations which alter the survival of individual fish, and the resilience of the stock (such as changes in ecosystem productivity, or disease). Fishing at point (a) is also beneficial for the ecosystem as a whole, as it remains closer to its unfished state – thus protecting, for example, trophic relationships.

As discussed on several occasions in this thesis, fishery failures are primarily the result of failures in governance. Fishery management agencies have not had the mandate, or more commonly the moral and political strength, to enforce the reductions in fishing effort necessary to effectively rebuild both fish stocks and resilient ecosystems – in other words to move from point (b) to point (a). The discussion in Chapters 12 & 18 has placed the major blame for this situation on the cultures which develop in organisations whose primary focus is on harvesting rather than the protection of biodiversity assets.

Guidelines, reference points and decision rules:

In spite of Australia's reputation for advanced fisheries management approaches, and in spite of long-standing commitments to apply the precautionary and ecosystem approaches, there remain obvious and important gaps in management strategies regarding the practical application of these approaches.

Chapter 11 provides a good example relating to the use of bycatch reference points to make management decisions within bycatch reduction strategies. In this chapter I propose the use of a 'traffic-light' based set of decision rules (using bycatch target and limit reference points) to apply spatial controls aimed at reducing the bycatch of critical species (section 11.3). However, far from moving in this direction, AFMA have actually retreated from earlier commitments to use bycatch reference points to inform practical management decisions (section 11.4).

Application of decision rules:

The ecosystem and precautionary approaches have been the subject of considerable discussion and recommendation, particularly over the last decade, with the result that fisheries now have what are probably the most detailed guidelines in these areas of any natural resource sector. Of particular note are:

- guidance within the *FAO Code of Conduct for Responsible Fisheries 1995*;
- the provisions of the *Fish Stocks Agreement 1995*, particular those of Annex II;
- papers from the 2001 *Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem* (sponsored by FAO);
- FAO publications containing advice and recommendations (see references below 1993 – 2001);
- review papers such as Gislason et al. 2000, Sainsbury & Sumaila 2001, and Pikitch et al. 2004; and

- papers describing the CCAMLR application of the precautionary and ecosystem approaches in their fishery management framework, such as Constable et al. (2000), Constable (2006) and Kock (2000).

These latter papers by Constable are instructive in the use of pre-determined decision rules as a key element in the application of precaution to fisheries management:

By developing management procedures based on decision rules, decisions about management are made prospectively: agreements about what to do when certain situations arise are made in advance. If the management procedure has been shown to be sound, there may be a reasonable chance that pre-agreed decision rules will be followed. The CCAMLR experience has demonstrated that obtaining consensus to make difficult adjustments only after the need for them has become apparent presents a major problem. (Constable et al. 2000).

CCAMLR's experience with decision rules is born out in other fisheries. In South Australia's abalone fishery for example, decision rules related to target and limit reference points have been written in terms of "reconsidering the situation". In spite of the breaching of both target and limit points for certain abalone metapopulations, no decisive action has been taken to close areas to fishing, and populations at these locations are showing no signs of recovery (Chapter 13). Action-oriented decision rules must be pre-determined to work effectively.

As Richards & Maguire (1998) point out, the UN Fish Stocks Agreement and the FAO Code of Conduct both stress the need to agree in advance on actions to be taken when reference points are approached or crossed. Without predetermined decision rules, immediate socio-politico-economic concerns often dominate, potentially delaying or preventing needed remedial measures (Hilborn & Luedke 1987; Holden 1994; Cook et al. 1997).

Constable (2006) describes CCAMLR's approach to determining reference points for krill:

Operational objectives were initially specified for krill stocks. There are two parts to the objectives that need to be met simultaneously. The first part relates to the abundance of krill remaining after the introduction of the harvest strategy (catch limit in this case). The reference point prior to fishing was considered to be the median abundance of krill in the absence of fishing, which is the abundance about which the population would fluctuate such that the population would be above that level half the time and below it for the other half. In a single stock context, the usual "target level" after fishing is fully developed is for the median abundance to be 50% that of the unexploited median abundance. CCAMLR agreed that this did not provide for predators of krill and the maintenance of the ecosystem. In the absence of further information, CCAMLR agreed that an appropriate target would be a median abundance of 75% of the pre-exploitation median, half way between not taking account of predators (50%) to taking full account of predators (100% - no fishing).

The second part of the objective relates to a limit reference point below which the abundance of the population should not be reduced. This was set by CCAMLR at 20% of the pre-exploitation median. The aim of this limit is to help ensure that the productivity of the stock is not reduced to a point that the stock cannot sustain itself or recover to pre-exploitation levels.

The dynamics of marine ecosystems necessitate devising flexible management approaches based on probabilities. Constable (2006) describes CCAMLR's approach in this regard:

[The CCAMLR] approach seeks to determine the long term annual catch limit that is highly likely to be sustainable despite uncertainties in stock dynamics and key population parameters. It is envisaged that this approach is used in the interim of developing longer term feedback management procedures. This approach uses simulation methods to project a stock forward using possible sets of population and fishery parameters. Given the uncertainties in these

parameters then many simulated projections are undertaken with the variety of combinations of those parameters. The long-term annual catch limit is set at the catch level that satisfies the decision rule based on the objective. These rules are specified as the greatest catch that results in both a median expectation that the stock is greater than or equal to the target level at the end of 20 years or one generation period of the stock (whichever is greater) and there being only a 10% chance or less that the stock will become depleted (below the limit reference point) over that time.

It is informative to compare CCAMLR's target and limit reference points for krill with the reference points used in AFMA's harvest strategy (AFMA 2007b) and New Zealand's *Fishery Act 1996*. In New Zealand a target reference point for stock population biomass of 30% of unfished biomass (Bo) has been used for some years, with a limit reference point of 20% Bo. In Australia's case (fisheries managed through AFMA) a target reference point of Bmey is now used (since 2007) which has a default proxy of 48% Bo, together with a limit reference point of 20% Bo²⁷.

Experience over the last two decades in both Australia (prior to the Ministerial Direction in 2005) and in New Zealand has seen a substantial percentage of managed fisheries decline below the target point, and in several cases below the limit point (Caton et al. 1998, Wallace & Weber 2005, McLoughlin 2006). This suggests that a target reference point of 30% Bo is risky from a single-species fishery perspective. In addition (taking onto account Constable's comments above) such a target contains (in effect) no allowance for the maintenance of ecosystem structure and function, through support for food-chains.

Caddy (2004) has reviewed the use of spawner-per-recruit models in a single species context:

Recent meta-analyses for finfish (e.g. Myers et al. 1994) show that it is no longer safe to assume that spawning populations can be reduced by more than 60-70%, and even these figures may be dangerously optimistic (Caddy & Agnew 2004). Walters & Kitchell (2001) suggested that finfish stock abundance should not fall below 50% unfished spawning biomass, and similar conclusions were reached for abalone by Shepherd & Baker (1998) and for some crustacean resource by Orensanz et al. (1978).

The recent history of Australian fisheries management has shown what perhaps should have been obvious from the outset: the use of the reference points of 30% for target and 20% for limit is simply not precautionary, and more-over leaves no realistic allowance for (largely unknown) ecosystem interactions. Current fisheries failures underline the need for a new approach.

The role of decision rules in reducing the discretion of fishery managers to adopt non-precautionary responses to overfishing should not be under-estimated. According to Caddy & Agnew (2003) – discussing recovery after overfishing:

Apparently relevant here is that a majority of the small number of successful recoveries documented world-wide, occurred in United States waters under the jurisdiction of the Magnuson-Stevens Act. This suggests that overriding non-discretionary legislation is of critical importance, and should incorporate overfishing definitions and reference points. It should also require recovery to MSY conditions or their equivalent when these limit reference points for biomass and fishing mortality are infringed.

²⁷ AFMA (2007b:23) establishes a proxy for Bmsy of 40% of unfished biomass (Bo), and a proxy for Bmey of 1.2 Bmsy – yielding the proxy for Bmey of 48% Bo.

A risk-based approach in setting precautionary defaults; the example of water quality:

The Australian *National Water Quality Management Strategy*²²⁰ provides an example of long-standing industrial use of precautionary risk-based decision rules. The water quality guidelines within the strategy rest explicitly on conservative, precautionary levels. However, where detailed information is available to justify the use of less conservative levels, or where a developer undertakes scientific investigations to supply such information, the precautionary defaults are replaced by levels based on the best available science.

When the *Australian and New Zealand Water Quality Guidelines* (ANZECC 2000) were first published in 1992, the published guideline values relating to the protection of identified aquatic 'values' were chosen as (maximum) levels of contaminants which would protect the most sensitive aquatic ecosystem (of the type under consideration). This approach led to unnecessarily high levels of protection being imposed on the more resilient ecosystems within the type range.

When the second edition of the Guidelines was published in 2000, a risk-based approach was introduced. Default protection levels were published, largely based on global biological-effects information (like the previous edition), but using a more enhanced dataset and, wherever the dataset was large enough, more sophisticated statistical modelling of the available data. However, these levels, according to the guideline framework, are to be applied *in the absence of detailed data relating to the ability of a particular aquatic ecosystem to cope with the contaminant under consideration*. These levels – called trigger values – are in practice precautionary defaults. If exceeded (or likely to be exceeded by the discharge from a proposed development) they 'trigger' the need for further investigation. Both further investigation and the routine monitoring that is recommended to accompany a water quality management program embed further hierarchical sets of response indicators using chemical and biological techniques that reflect, initially, early warning (precautionary) and, ultimately, ecosystem-level information.

Given the conservative, precautionary basis on which the trigger levels were formulated, further investigation and monitoring (in most cases) are likely to show that the ecosystem in question is able to tolerate a higher level of contamination without significant ecological effect. However, the onus lies on the developer (or a government acting on behalf of a developer) to undertake the necessary investigation and provide the required data.

The framework recommends the use of identified 'target' levels for water quality indicators, to trigger pre-determined decision rules specifying remedial management action – the decision rules. This approach, as in fisheries, is essentially an issue of taking a precautionary approach in the face of uncertainty. The more uncertainty can be reduced, and the lower the likelihood of significant effects, then the less precautionary the water quality targets need to be.

A more detailed explanation of the Guidelines framework may be found at Appendix 1 of <http://www.tucs.org.au/~cnevill/marinePrecautionDecisionRules&RiskAssessment.doc>.

Ecological risk assessment in fisheries:

Sainsbury & Sumaila (2001) review methods for determining ecological risk assessment in fisheries, focusing on three progressive phases: qualitative, semi-quantitative, and quantitative. The assessment moves from one phase to the next depending on need and available data. Each phase demands more rigor and data, and thus time and expense.

Developing these ideas further, the CSIRO (Division of Marine and Atmospheric Research) undertook a major contract for the Australian Fisheries Management Authority (AFMA) between 2002 and 2006, providing a risk assessment methodology and preliminary risk assessments for about 30 Commonwealth-managed fisheries.

The primary risks considered in the CSIRO analysis are risks of:

- overfishing beyond reasonable recovery (stock collapse);
- ecological extinction of target or non-target species;
- significant habitat fragmentation or damage;
- significant change in community composition (such as loss of top predators); or
- fishery-induced regime shift or trophic cascade.

The ERAEF (ecological risk assessment of the effects of fishing) method developed by CSIRO is a hierarchical approach that moves from qualitative to quantitative risk assessment, and assesses risks from fishing activities for five ecological components of the ecosystem – target species; byproduct and bycatch species; threatened, endangered and protected species; habitats; and communities. At Level 2 in the ERAEF hierarchy, biological units (species, habitats or communities) within each fishery are assessed on two central criteria: productivity (a proxy for resilience or recovery ability) and susceptibility (exposure and vulnerability to damage from fishing activities). Where risks to specific components are assessed as low or negligible at one level, these risks are not re-evaluated as the assessment moves to the next (more detailed) level of the assessment. The steps in the hierarchy can be seen as a successive process of screening out risks, and an explicitly precautionary approach to uncertainty is adopted. Where risk is uncertain, assessment moves to the next level (Hobday & Smith 2006 – lecture 20/10/06, Webb & Hobday 2004).

The method provides a mechanism for focussing research resources where they are most needed in terms of ecological risk. The method also provides the necessary information to support a regime of default and science-based reference points, linked to decision rules, in that risks are ultimately expressed as qualitative (level 1) or quantitative (level 2+) values on a two 'dimensional' productivity/susceptibility surface. Overall risk in a fishery or sub-fishery is expressed as the risk to its most vulnerable component. Such values could be expressed in 'traffic light' form as high, medium or low risk (more below).

Precautionary reference points in fisheries management:

As mentioned above, the FAO Code of Conduct and the UN Fish Stocks Agreement (particularly Annex II) provide important advice regarding reference points in a single-stock context. This advice can be used as a starting-point in the development of ecosystem-based reference points.

In a broader context, several important reviews should be mentioned. Caddy (1998) reviewed the use of precautionary reference points in data-poor situations, and Smith et al. (2001) provide a comprehensive review of ecological indicators and reference points from the fisheries and ecological literature (focusing on non-target species) along with issues relating to their interpretation. The use of indicators and reference points within management frameworks is reviewed in Sainsbury & Sumaila (2001). Fulton et al. (2005) discuss the suitability of specific ecosystem indicators, and Link (2005) provides suggestions for extending indicators and reference points to the broader ecosystem, based partly on experiences from the Gulf of Maine. While the potential exists for the use of complex ecosystem indicators within decision rules, the discussion below, for clarity, does not examine the implied complications.

Once reference points have been established, fishery management strategies “shall ensure that the risk of exceeding limit reference points is very low, and that target reference points are not exceeded on average.” (UNFSA Annex II.5). The fishing mortality rate which generates maximum sustainable yield should be regarded as a minimum standard for limit reference points. For stocks which are not overfished, fishery management strategies shall ensure that fishing mortality does not exceed that which corresponds to maximum sustainable yield, and that the biomass does not fall below a predefined threshold. For overfished stocks, the biomass which would produce maximum sustainable yield can serve as a rebuilding target. (Annex II.7).

The Fish Stocks Agreement specifies F_{MSY} , the fishing mortality that can produce maximum sustainable yield (MSY), as a limit reference point that should not be exceeded. Therefore, fishing activities should be conducted such that the risk of exceeding F_{MSY} is very low (Caddy

and McGarvey 1996). In addition, B_{MSY} , the biomass that can yield the long-term average MSY on application of F_{MSY} , is suggested as a rebuilding target for overfished stocks. A specific limit reference point for stock biomass is not defined. However, given F_{MSY} as a limit reference point, B_{MSY} could also be interpreted as a limit reference point (Richards & Maguire 1998).

According to Richards & Maguire (1998):

With such clear statements in the Fish Stocks Agreement, application of the precautionary approach might appear straightforward. The responsibility lies with the scientific sector to identify limit reference points, and the current biomass with short-term projections in relation to these reference points, both with associated uncertainties. The management agency then has the responsibility to develop an effective implementation plan, perhaps through the use of target reference points. The plan must ensure that limit reference points are exceeded only with a low, pre-agreed probability.

If stock biomass is below or in danger of falling below the limit reference point B_{LIM} , then fishing activities should be curtailed to allow stock rebuilding. Conversely, if stock biomass is comfortably above B_{LIM} , then harvests can proceed as long as the risk of the stock biomass falling below B_{LIM} is very low, say of the order of 5%.

Neither the Fish Stocks Agreement nor the Code of Conduct offer detailed advice on how reference points need to be modified to taking ecosystem interactions into account. However, clearly, ecosystem-based reference points need to allow for natural mortality to support predator-prey interactions. The approach used by CCAMLR (above) could be generally used in the absence of detailed information on ecosystem function, modified through the application of the results from ecological risk assessment studies.

Ecological risk assessments can be applied to fisheries, as discussed above. A variety of approaches are possible – the approach above assesses the risk in a particular fishery according to ‘the weakest link’ – the most sensitive element – within the particular fishery. Such assessments could, as suggested above, be expressed through ‘traffic light’ indicators: (a) high or unknown risk, (b) medium risk, and (c) low risk.

These indicators could then be linked to *default* reference points, supplemented by precautionary science-based reference points – in cases where the detailed information to support such reference points could be obtained. These reference points could then be linked to decision rules. For example, risk could be linked to reference points as in Table 20.1 below, where B_0 is selected as a reference standard:

Table 19.1: Using ecological risk assessment to establish default reference points:

	Target B reference point	Limit B reference point
Risk level: high or unknown	80% B_0 ; \geq 90% probability	60% B_0 ; \geq 90% probability
Risk level: medium	65% B_0 ; \geq 85% probability	40% B_0 ; \geq 85% probability
Risk level: low	50% B_0 ; \geq 80% probability	20% B_0 ; \geq 80% probability
<i>Detailed ecosystem-specific risk study outcome:</i>	Determined from specific ecosystem / fishery studies	Determined from specific ecosystem / fishery studies

B_0 = estimated unfished spawning biomass.

Such reference points are arbitrary, in both level and probability, and are suggested in light of the discussion above. Prager et al. (2003) discuss the need to couch reference points

within probabilistic frameworks. As Gilbert et al. (2000) have pointed out, most (or all) reference points in fishery literature are likewise arbitrary to some extent.

As Caddy (2004) put it, in determining the value of a limit reference point, “a precautionary judgement must be made that when an indicator approaches an agreed limit reference point, this corresponds with an unacceptable risk of some negative event occurring.” Ultimately the selection of reference points, whether indicators of abundance, mortality or recruitment, is a matter for expert discussion and ultimately judgement. The same comment would apply to more complex multivariate ecosystem indicators (see for example Link et al. 2002) when sufficient data are collected to support their use.

These reference points should then be linked with predetermined management actions. For example, reaching a limit reference point might close the fishery pending stock recovery (Figure 20.2).

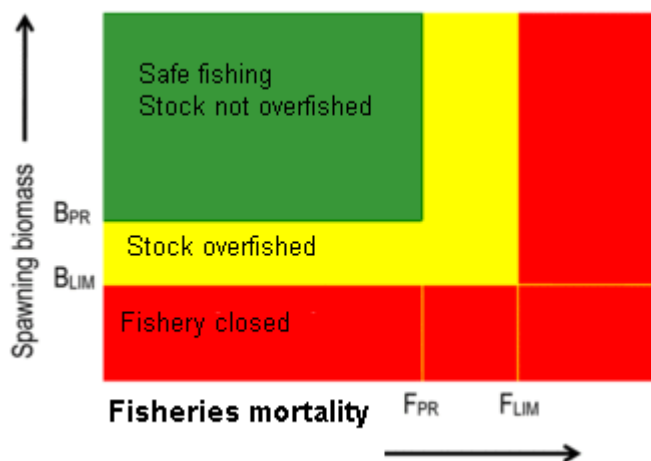


Figure 19.3 Precautionary stock and mortality reference points should be linked to both management actions and definitions of “overfishing”.

Precautionary stock and mortality reference points need to be defined using both precautionary and ecosystem approaches. Reference points should provide safely for ecosystem function and process. Definitions of stock status (eg: “overfished”) need to take these factors into account (Chapters 11 & 18).

The application of such a regime is likely to assist in the achievement of sustainable fisheries harvests over the long term.

The global scene: the high seas and the ‘right to fish’:

As Botsford et al. (1997) pointed out, it is abundantly clear that, at a global level, “[fishery] management has failed to achieve a principal goal, sustainability”.

The application of the ecosystem and precautionary approaches have been widely advocated since the early 1980s, and consolidated in international soft law in 1995 through the FAO Code of Conduct for Responsible Fisheries. The Code of Conduct was explicitly endorsed by 124 nations (including Australia) through the Rome Declaration 1999. In hard law, the UN Fish Stocks Agreement 1995 applied these approaches to straddling and migratory fish stocks.

The first marine protected areas were created over 100 years ago. While their fishery benefits remain the subject of much discussion and differing views, the value of networks of marine protected areas for biodiversity conservation is now widely recognised within the marine science community. However, in spite of considerable discussion and enthusiasm on the part of practitioners, and endorsement through international soft law, these areas still occupy only a minute fraction of the ocean²²¹ (virtually all within national EEZs). While it can be argued that some parts of the high seas are protected, the weakness of these protective

mechanisms has so far prevented such areas being listed on the IUCN World Database of Protected Areas.

The high seas, and their protection, remain 'someone else's problem'.

Considerable guidance is now available on the application of the ecosystem and precautionary approaches to fishery management – through FAO guidelines and conference proceedings, through papers in the scientific press, and even through explicit inclusion of recommended approaches in the addendum to the UN FSA (Appendix Two).

The UN Convention on the Law of the Sea (UNCLOS) substantially modified the prior doctrine of 'freedom of the high seas', partly by the EEZ framework, and partly by defining broad responsibilities accompanying the new rights created within the EEZ framework.

However, while EEZ rights have been enthusiastically endorsed by nation-States, the environmental responsibilities defined by UNCLOS have been substantially ignored within EEZs (Chapter 12), and almost completely ignored on the high seas. This is the case in spite of the provisions of the Convention on Biological Diversity, the UN FSA, the resolutions of Rio and Johannesburg, and the FAO Code of Conduct.

Nations around the world are attempting to respond to these concerns. Fishery management within national EEZs is improving where nations are beginning to develop management regimes incorporating ecosystem and precautionary approaches, and where effective compliance monitoring and enforcement programs are being developed. Smaller third world States have understandable problems in this respect.

The high seas remain, in spite of the efforts of RFMOs, largely without effective regulation, and fishing operators forced out of EEZs by increasingly restrictive national fishery regimes have been able to continue to operate under flags of convenience. The freedom to fish the high seas provides unregulated fishing vessels with a golden opportunity. As industry spokesman Martin Exel (Austral Fisheries) puts it: "Until the high seas are managed they will remain sinkholes for unregulated and unreported fishing, and that is unacceptable in this day and age of knowledge and understanding of our oceans" (pers. comm. 10/9/2006).

Regional fisheries management organisations (RFMOs) have, for the most part, been ineffective, with little attempt to apply precautionary or ecosystem approaches, or even to monitor and enforce their own fishery rules. For example a recent FAO report indicated that, although several regional fishery management organisations claimed to be using a precautionary approach, only two (CCAMLR and NASCO) could actually name precautionary elements in their management framework (FAO 2005b). This same report (in an assessment of implementation of Article 8 of the Code of Conduct – dealing in part with environmental protection responsibilities) found that about 30 percent of the responding RFMOs indicated that they "had not yet taken steps to ensure that only fishing operations in accordance with the fisheries management measures adopted were conducted within their areas of competence". Considering that only about half of the world's RFMOs responded to the FAO survey, this suggests that most RFMOs have yet to implement effective compliance monitoring and surveillance regimes.

Amongst fishery managers and marine scientists, there is a general consensus that "governance, not science, remains the weakest link in the management chain" (Browman & Stergiou 2004:270). In spite of the urgency of the situation, several important reforms put forward at the FAO FSA Review Conference (2006) did not achieve consensus, resulting in marginal progress in strengthening or widening the provisions of what is perhaps the most important international hard law in the fisheries area (Beintema et al. 2006).

It is time now to consider further major restrictions on freedoms which are being widely abused, to the great detriment of the planet and its inhabitants.

The path not taken:

Einstein is often quoted as saying that the most difficult problems of today cannot be solved through the same thinking which created them. This is very much the case with the high seas, where the very concept of MPAs rests on the premise that most of the ocean is at risk - and this in turn rests on the historic acceptance of freedom of the seas and the freedom to fish. This is the thinking we need to confront and change.

Who benefits by these freedoms today? Industry spokesman Martin Exel recently said that legitimate fishing companies want governments to manage the high seas, and that freedom of the seas primarily benefits unregulated fishers, operating under flags of convenience (pers. comm. 10/9/2006). In theory, political pressure (through the UN) could be put on nations offering flags of convenience, but this course of action has been discussed for decades with little significant progress. It is becoming increasingly obvious Exel's point is legitimate and important – the freedom of the high seas benefits only pirates, scoundrels, and other IUU fishers. Yet in a recent document, the Australian Government stated: "We support the freedoms of the high seas, but recognise that States have obligations to protect and preserve the marine environment..." (Government of Australia 2006). As a nation, I believe that Australia needs to take a different line - one that increasingly suggests that these freedoms need to be replaced with an effective international governance regime.

Where do we need to go in the long term? Sylvia Earle (echoing the concerns of marine scientists and conservation biologists worldwide²²²) has said: "*We must place biodiversity conservation at the center of ocean governance.*" (Earle & Laffoley 2006). This is the crucial point. And governance of the high seas is a necessary condition before biodiversity can be protected and resources managed in a sustainable way.

The resources of the deep ocean floor, under the terms of the Law of the Sea, are seen as the 'common heritage of mankind'. Russ & Zeller (2003) have argued, I believe persuasively, that this concept needs to be extended to the entire high seas ocean, not just the sea floor. They suggest that the high seas should be zoned and managed, and that fishing in these zones, now often seen as a right, should become a privilege, mandated through enforced conditions. This may seem a large step from the current governance arrangements – but perhaps this is more an appearance than a reality. Most of the high seas now fall under the (admittedly often ineffective) governance of regional fisheries management organizations. In fact it may not be such a major step to strengthen these agencies and expand their scope.

Government wildlife agencies in many countries have, over long periods, undergone important name changes and changes in focus. In Victoria (Australia), for instance, the late 19th century "Department of Hunting and Game" evolved into the 20th century "Department of Wildlife" which is now part of a large "Department of Sustainability and Environment". The activities and priorities of a department, and the culture of its staff, are importantly shaped by department name, charter and statutory focus – which in this example has evolved from a harvesting charter to a conservation charter. Fishery Departments around the world have not evolved in the same way, to the great detriment of marine biodiversity, and, in many cases, to the great detriment of the fisheries themselves.

The Australian Government needs to move towards a future which will see Fishery Departments replaced by Ocean Conservation Departments, where biodiversity conservation *is* placed at the centre of their statutory charters. And the Australian Government in turn needs to promote this agenda to the United Nations General Assembly, and through the UNGA, the wider global community.

The CCAMLR convention²²³ is the best model we have today for this fundamental change in outlook, partly due to the embodiment of the precautionary and ecosystem approaches into its charter (Constable et al. 2000). While certainly not faultless, the Commission is by far the most effective RFMO globally (FAO 2005b). Yet (and again this is the point) it is not really an RFMO, it is an organisation focussed on conservation. It is an "ocean conservation agency" and a model for the growth of "regional ocean conservation agencies" throughout the world. Article 2 of the Convention states: "*The objective of this Convention is the conservation of Antarctic marine living resources. For the purposes of this Convention, the term*

'conservation' includes rational use." As already mentioned, the convention rests explicitly on the principles of ecosystem-based management and caution, with a requirement that these principles *must* be applied, monitored and reported. As a consequence, the whole of the CCAMLR area, vast as it is, technically meets the IUCN criteria for a class IV protected area (putting aside for a moment the issue of non-member State fishing).

However, this issue put aside is in fact the broken thread on which the entire global marine governance framework is unravelling – and will continue to unravel in spite of the best intentions of marine scientists, managers and lawyers around the world.

The Vienna Convention on the Law of Treaties 1969 establishes a principle that a nation-State cannot be bound by international law which it has not, at an earlier time, agreed to.

Within the CCAMLR area, there are currently at least as many fishing vessels flagged to non-member States as there are 'legitimate' fishing vessels flagged to member States. CCAMLR estimates that around half of the annual take from their area goes to IUU fishers (illegal, unreported or unregulated fishing vessels). Most of these vessels are in fact operating under flags of convenience. Increasingly, the IUU fishing industry is using vessels purpose-built to operate under the flags of nations which do not support CCAMLR, the UN FSA, or any other RFMO (Gianni & Simpson 2005).

Four factors combine to provide a recipe for ineffective management and the inevitable slide of marine ecosystems into deeper crisis:

- the freedom to fish the high seas, still endorsed by UNCLOS;
- the provisions of the Vienna Convention;
- the willingness of some nations to put short-term (and relatively small) economic gains ahead of important principles of international cooperation and ecosystem management; and
- the financial incentives driving the IUU industry.

The UN FSA attempts to moderate the provisions of the Vienna Convention by allowing boarding and inspection rights over non-member State vessels. While to be applauded, this approach has not yet been successful in assisting the establishment of a workable governance framework over high seas fish stocks. These provisions were also the subject of heated debate between member and non-member participants at the recent FSA Review Conference (Beintema et al. 2006).

High seas conclusion:

Two major changes are necessary to address the current crisis:

The first change is to revoke the "freedom to fish" on the high seas and replace it with absolute accreditation rights vested in authoritative regional bodies (such as RFMOs or CCAMLR). In other words, only vessels accredited by the regional bodies would have a legal right to fish in the areas under the jurisdiction of these bodies.

The second change is to re-name and re-direct existing RFMOs along the lines of the CCAMLR model, so that they become regional high seas ocean conservation agencies, not regional fishery management organisations as they are now.

Although these changes are obvious to many within the marine fraternity (and the first has been advocated by some fishing industry representatives²²⁴ for many years) they represent major shifts in thinking from current governance frameworks. They are not being discussed widely within mainstream international law circles. The negotiations which took place in early 2006 within the frameworks of the *UN FSA Review Conference* and the *Conference of the Parties to the Convention on Biological Diversity* have not addressed these issues in outcome statements, although undoubtedly they featured in verbal discussions.

The International Seabed Authority (created under the provisions of UNCLOS) provides another model for international governance beyond areas of national jurisdiction. The ISA is founded on the essential principle that the resources of the sea bed are “the common heritage of mankind”. While focussed on utilisation, principles of equity between nations, and sustainability are also embodied in the Authority's charter.

These changes need to be backed up by political will. The financial incentives behind the IUU fishing industry must be removed. A combination of satellite surveillance, catch documentation schemes, port State and flag State controls, and provisions for the seizure of the financial assets of those funding the industry, could be very effective if widely applied.

And, unless fishing agencies and conservation agencies push their States to move towards this evolution, nothing will change. The UNGA is the most appropriate vehicle to promote this change, and this is the venue where Australian Government pressure is most likely to be successful.

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Endnotes:

²¹⁸ The orange roughy conservation plan entirely ignores the link between the species and its habitat – in spite of the very obvious point that the method of harvesting potentially destroys vulnerable benthic ecosystems which are a known habitat of the orange roughy. If orange roughy have an obligate dependency – in any part of its life cycle – on these habitats, this would have profound ramifications for the fishery. At this point in time the relationship between orange roughy and deepsea coral habitats is not understood, and in the absence of this knowledge a precautionary approach is called for – but nowhere evident in the orange roughy conservation plan.

²¹⁹ See Walker & Salt (2006) and Johannes (1998:243).

²²⁰ www.environment.gov.au/water/quality/nwqms/index.html

²²¹ Marine protected areas listed on the World Database on Protected Areas (www.unep-wcmc.org) account for less than 2% of ocean area, while fully protected areas (no-take) account for less than 0.2%.

²²² See, for example, comments like those of Dr Bill Ballantine (Leigh Marine Laboratory NZ): “The main challenge facing MPAs is to make the concept redundant as soon as possible” (*MPA News* October 2005, p.3).

²²³ CCAMLR: Convention for the Conservation of Antarctic Marine Living Resources 1980.

²²⁴ Martin Exel (Austral Fisheries) pers. comm. 10 September 2006. The concept is also advocated by fisheries scientists such as Constable (2006).

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Appendices:

Appendix One: Good governance: principles of ocean management.

Appendix Two: The precautionary principle in ocean governance.

Appendix Three: Development of the EPBC Act sustainable fisheries guidelines: a critique.

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Appendix One: Good governance: principles of ocean management

A1.1 Introduction:

All government programs rest ultimately on a small number of key principles which embody the essential logic behind the programs. While in some cases these principles are not clearly stated, it is often the case that they are explicitly listed within national and international law and policy. This is usually done in an attempt to guide interpretation of the instrument as time progresses, and new circumstances arise which might not have been predictable when the instrument was first drafted.

I argue here that such principles can be best understood as hierarchies. It is possible to derive a small set of core principles which embody the essential logic within the much larger array of principles found in different national and international instruments related to managing the impacts of human activities on the ocean environment. Examples of such instruments include the Convention on the Law of the Sea 1982, and the Convention on Biological Diversity 1992. This analysis focuses on three core 'first tier' principles: *ecological protection*, *good governance*, and *resource management*. These three 'primary principles' contain clear subsets of 5, 9 and 6 'second tier' principles. These 'secondary principles' are listed, and encapsulate most of the logical concepts of a very large array of principles explicitly stated within major legal and policy instruments relating to management of natural resources (including the marine realm).

A1.2 Discussion

Definition:

prin'ciple *n.* i. Fundamental source, primary element; fundamental truth as a basis for reasoning; general law as guide to action. ii. (pl. and collect. sing.) Personal code of right conduct; *on ~*, from settled moral motive.

(Concise Oxford Dictionary)

Principles are the essential concepts which, explicit or implicit, underlie all government legislation, policies, and programs. They provide both the reason for existence, as well as the fundamental logic of the instrument. The term is sometimes misinterpreted, and used to include modes of action, or mechanisms chosen to assist in the achievement of objectives. This misconception is not merely a matter of semantics, and should be avoided wherever possible as it may lead to confusion.

The explicit statement of principles is important, particularly during the preparation of draft legislation, or environmental policy set at a high level of generality. This assists readers in understanding the intent of the statute or policy, and is thus an invaluable aid in interpreting the implications of the "conceptual head" as it develops and diverges into more detailed processes and programs – either within a single piece of legislation, or within subordinate policy or procedure. This is, of course, of particular use within the judicial process, when clear interpretation of statutory law may help resolve disputes.

Statements of principle are also important in establishing the legitimacy of international law. The notion of legitimacy is different from legality, which concerns the legal validity of an instruction, rule or behaviour, measured against a backdrop of precedent and recognised statute. According to Franck (1990:16,19) legitimacy comprises, first "a property of a rule or rule-making institution which itself exerts a pull towards compliance on those addressed normatively" and, second, "the perception of those addressed by a rule or rule-making institution that the rule or institution has come into being and operates in accordance with generally accepted principles of right process".

The detailed discussion in which the lists presented below are derived involves an examination of the exact wording of many different instruments – and is exceptionally tedious. Readers interested in this detail are referred to two web-based documents:

- Relevant lists and extracts from a number of international and Australian instruments related to ocean management can be accessed at <http://www.tucs.org.au/~cneville/marineOceanPrinciples.htm>. It is from this collection that the extracts used in the present discussion are drawn.
- The detailed derivation of the "first tier" and "second tier" principles (including references) is set out in: <http://www.tucs.org.au/~cneville/marineTieredPrinciples.doc>.

Principles are grouped under three headings according to three fundamental principles:

A. Ecological protection: management regimes should recognise, understand and protect the ecosystems of the ocean, in the interests of current generations, future generations and other life forms.

B. Good governance: management regimes should include the participation of all stakeholders, and should be transparent, reliable, accountable, enforceable, have integrity, and be cost-effective, flexible and practical.

C. Resource management: The planet's resources should be used wisely, fairly, and without unnecessary waste, taking into account the needs, rights and responsibilities of current generations, the differing economic, cultural, political and technical resources of both developed and developing nations, as well as the need to pass on both renewable and non-renewable resources to future generations in a way which does not unduly prejudice their options. In doing so, management regimes should take account of: the rights and responsibilities of stakeholders, market behaviour and imperfections, the need for a precautionary approach in the face of complex and uncertain futures, the need to manage the cumulative impacts of incremental growth in resource use, and the ability of an adaptive approach to deliver continuous improvement in management outcomes.

Ecological protection principles:

A1. Protected areas and sympathetic management. Biodiversity should be protected by the establishment of a comprehensive, adequate and representative system of ecologically viable protected areas, integrated with the sympathetic management of all other areas²²⁵.

A2. Special ecological values. Ecosystems and species of special value or vulnerability need special protection.

A3. Economic progress within ecological limits. Sustainable economic progress works on the basis of no net loss of ecological assets. Short-term gains must be weighed up from a long-term perspective - sustainability must not be prejudiced by short-term gains achieved at the expense of declining ecological services, values or resilience.

A4. Ecological scale. Arrangements for the management of ecosystems (or for managing the human impacts on ecosystems) need to recognise, understand and accommodate the important ecological functions, processes and linkages, and the scales and time-frames at which they apply. Integrated and cohesive management should be applied across jurisdictional boundaries within the commons, recognising that the integrity of cross-boundary ecosystems needs to be understood and protected.

A5. Market externalities and ecological incentives. Economic incentives should be applied to markets so as to ensure that economic progress in the long term goes to those who compete best while maintaining or improving ecological assets and integrity.

Good governance principles:

B1. Participation: resource management arrangements should include adequate participation of all stakeholders. Long term programs for stakeholder education and awareness should be undertaken to facilitate informed participation.

B2. Transparency: decisions regarding resource management should follow a defined and established process. All elements of the process should be clearly understood by all participants, and the factual basis of decisions should be made widely available.

B3. Reliability (Certainty): the process (of reaching strategic management decisions) should have clear objectives, be consistent, and be conducted within agreed time-frames.

B4. Accountability: decision makers within government need to be able to provide clear and detailed reasons for their decisions to all stakeholders. Appeal provisions to an independent authority should exist. Private operators must be accountable for commitments made during the activity approval process. Impact assessments should incorporate impartiality, for example through use of independent panels to oversee or review the process.

B5. Enforceability: while governance arrangements should be designed to minimise the costs and need for enforcement, such enforcement must be achievable in practice, adequately resourced, and undertaken when necessary.

B6. Integrity; decisions need to be based on the best available information, and all relevant factors need to be taken into account by decision-makers. Where impacts are uncertain, outcomes should rely on sound risk assessment and management, erring on the side of caution. Where necessary information is lacking, extension of scientific knowledge should be undertaken.

B7. Cost-effectiveness; approval processes and on-going management arrangements should meet stated objectives while imposing the least cost to participants. Economic incentives should be used, where applicable, to minimise the need for enforcement.

B8. Flexibility; management, including activity approval processes, should be able to accommodate proposals varying in type, scope of impact, and complexity. Flexibility is desirable in terms of the form of assessment and management processes, issues to be addressed, process time-frames, and degree of public participation.

B9. Practicality; activity approval processes and ongoing management arrangements should recognise community concerns, commercial realities, best practice technology, and scientific knowledge and uncertainties.

Resource management principles

C1. Full cost allocation: All costs and benefits concerning the use of natural resources should be identified and allocated and economic markets should reflect these costs and benefits.
(Wording taken from the *Lisbon Principles 1997*).

C2. Cumulative impacts: the cumulative impacts of incremental developments should be recognised, assessed and managed by imposing strategic limits well ahead of ecosystems approaching a crisis situation.

C3. Precautionary: where the possibility exists of serious or irreversible ecological damage, lack of scientific certainty should not preclude cautious action by decision-makers to prevent such damage. Management needs to *anticipate*, rather than react to ecological damage as it occurs. The onus of proof lies on the activity proponent.

C4. Responsibility: rights to resource use entail responsibilities for environmental effects including both long term and indirect effects (this includes the more widely stated user pays principle).

C5. Adaptive management: management arrangements should include explicit cyclic phases designed to set, measure and achieve objectives in a complex and changing environment. Management options should be chosen partly with a view to expanding understanding of ecosystem dynamics.

C6. Continuous improvement: management arrangements should explicitly seek to increase both efficiency and effectiveness over time.

Endnote:

²²⁵ Adapted from **Principle 8** in: Commonwealth of Australia (1996) *National strategy for the conservation of Australia's biological diversity*. Department of Environment and Heritage, Canberra.

Appendix Two: The precautionary principle in Australian ocean management.

Where the possibility exists of serious or irreversible harm, lack of scientific certainty should not preclude cautious action by decision-makers to prevent such harm.

- a generic version of the precautionary principle.

A2.1 Preface:

The purpose of this chapter is to briefly introduce the precautionary principle, to describe mechanisms promoting resource over-exploitation, to consider the precautionary principle in this context, and to identify areas related to Australian ocean management where (a) the principle has been applied, and (b) where it has not been applied in spite of an apparent need. The chapter argues that use of the precautionary principle is a *necessary* management approach in order to balance powerful and pervasive forces which promote over-exploitation, particularly against a background of uncertainty. As far as can be judged by the examples studied in this chapter, enthusiastic application of the principle is rare in Australian government marine programs, contrary to government rhetoric.

This appendix contains seven attachments:

- Attachment 1: Article 7.5, FAO Code of Conduct for Responsible Fisheries 1995;
- Attachment 2: Summary, FAO Lysekil Statement 1995;
- Attachment 3: Section 4, FAO Lysekil Statement 1995;
- Attachment 4: Article 6, UN Fish Stocks Agreement 1995;
- Attachment 5: Annex II, UN Fish Stocks Agreement 1995;
- Attachment 6: Principles and decision rules from Garcia (1995);
- Attachment 7: Practical guidelines from Garcia (1995)

Keywords: Australia, fisheries, precautionary, orange roughy, abalone, bycatch, marine, governance.

A2.2 Introduction:

There are many definitions of the precautionary principle²²⁶. Precaution is caution in advance, or 'caution practised in the context of uncertainty'. All definitions of the precautionary principle have two key elements.

- an expression of a need by decision-makers to anticipate harm before it occurs. Within this element lies an implicit reversal of the burden of proof: under the precautionary principle it is the responsibility of an activity proponent to establish that the proposed activity will *not* (or is very unlikely to) result in significant harm²²⁷.
- the establishment of an obligation, if the level of harm may be high, for action to prevent or minimise such harm even when the absence of scientific certainty makes it difficult to predict the likelihood of harm occurring, or the level of harm should it occur. The need for such control measures increases with both the level of possible harm *and* the degree of uncertainty.

According to Cooney (2004) "the precautionary principle is widely recognised as emerging from the *Vorsorgeprinzip* (directly translated as "fore-caring" or "foresight" principle) of German domestic law, although it has earlier antecedents in Swedish law". The precautionary principle is in some ways an expansion of the English common law concept of

'duty of care' originating in the decisions of the judge Lord Esher in the late 1800s. According to Lord Esher: "Whenever one person is by circumstances placed in such a position with regard to another that everyone of ordinary sense who did think, would at once recognise that if he did not use ordinary care and skill in his own conduct with regard to those circumstances, he would cause danger or injury to the person, or property of the other, a duty arises to use ordinary care and skill to avoid such danger" (Wikipedia 23/6/08). This statement clearly contains elements of foresight and responsibility, but does not refer to a lack of certainty, as the word "would" is used rather than "might", or "could". A second important difference is that the duty of care applies only to people and property, not to the environment.

The precautionary principle has been current in international agreements and statements, and various national strategies and policies, for over 25 years²²⁸. It is an accepted principle within Australian government resource management strategies, at all three levels: Commonwealth (the Australian Government), State and Territory, and local government²²⁹. Much has been written about the [precautionary principle](#) and its use, although clear examples of its application are relatively rare in Australia (Kriwoken et al. 2001, Coffey 2001, Stein 1999, Kriwoken et al. 2006, Preston 2006).

Some Australian and New Zealand case law dealing with the precautionary principle is discussed by Kriwoken (2006) and Stein (1999). Notable cases include: *Leatch v National Parks and Wildlife Service of NSW (1993)* (presided over by Justice Stein), *Nicholls v Director-General of National Parks and Wildlife of NSW (1994)*, *Greenpeace Australia Ltd v Redbank Power Co (1995)*, *Northcompass v Hornsby Council (1996)*; *Friends of Hinchinbrook Society Inc v Minister for Environment (1997)*, and *Tuna Boat Owners Association of South Australia Inc v Development Assessment Corporation (2000)*.

These cases provided little consistent precedent. They have, however, been overshadowed by an important case in 2006 (although it had nothing to do with fisheries): *Telstra Corporation Limited v Hornsby Shire Council*. This case, heard in the NSW Land and Environment Court under Justice CJ Preston (24 April 2006) provides the most detailed consideration of the precautionary principle in Australian case law at this stage. Mohr (2006) provided a short review of the rather detailed case findings.

The version of the principle discussed in the case was that of the NSW *Protection of the Environment Administration Act 1991*:

"If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reasoning for postponing measures to prevent environmental degradation. In the application of the principle... 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 consequence of various options".

The most significant points of the decision by Justice Preston are (after Mohr 2006):

- a) The principle and accompanying need to take precautionary measures is "triggered" when two prior conditions exist: a threat of serious or irreversible damage, and scientific uncertainty as to the extent (likelihood and severity) of possible damage.
- b) Once both are satisfied, "a proportionate precautionary measure may be taken to avert the anticipated threat of environmental damage, but it should be proportionate."
- c) The threat of serious or irreversible damage should invoke consideration of five factors: the scale of threat (local, regional etc); the perceived value of the threatened environment; whether the possible impacts are manageable; the level of public concern, and whether there is a rational or scientific basis for the concern.
- d) The consideration of the level of scientific uncertainty should involve factors which may include: what would constitute sufficient evidence; the level and kind of uncertainty; and the potential to reduce uncertainty.

- e) The principle shifts the burden of proof. If the principle applies, the burden shifts: "a decision maker must assume the threat of serious or irreversible environmental damage is... a reality [and] the burden of showing this threat... is negligible reverts to the proponent..."
- f) The precautionary principle invokes preventative action: "the principle permits the taking of preventative measures without having to wait until the reality and seriousness of the threat become fully known".
- g) "The principle should not be used to try to avoid all risks."
- h) The precautionary measures appropriate will depend on the combined effect of "the degree of seriousness and irreversibility of the threat and the degree of uncertainty... the more significant and uncertain the threat, the greater...the precaution required". "...measures should be adopted... proportionate to the potential threats".

The precautionary principle rests heavily on history and ethics rather than logic or science. It incorporates the concept that a person should take responsibility for unintentional damage which may (directly or indirectly) result from actions taken by this person²³⁰. It is also a principle based on experience. According to [Ludwig](#) et al. 1993: "Although there is considerable variation in detail, there is remarkable consistency in the history of resource exploitation: resources are inevitably overexploited, often to the point of collapse or extinction." Even though the medium and long-term costs far outweigh short-term benefits, resource over-exploitation continues today (Pauly et al. 2005). The need for caution is a clear message from the history of resource exploitation (Harremoës et al. 2002).

This is nowhere more prominent than in the area of fisheries, where, in spite of a long history of over-exploitation of ocean resources (Jackson et al. 2001), overfishing remains a major global problem (Crowder & Norse 2005, Myers and Worm 2003, Duda and Sherman 2002). The need for, and benefits of, caution have been advocated for many years (eg: Walters & Hilborn 1978). The theoretical application of precaution to fisheries has received considerable attention, and is perhaps more detailed than in any other industry. The FAO guidelines on the precautionary approach (FAO 1995) for example appear to have no equivalent in other resource sectors. See attachments below.

In the voluminous literature on the application of the precautionary principle (see for example the references cited by Preston 2006) authors commonly make the perhaps obvious point that caution, under the principle, should be applied on a sliding scale, determined by two elements²³¹. First, the greater the possible harm, the greater should be the caution applied, even if the possibility of that harm seems remote. Secondly, the greater the uncertainty, the greater should be the caution applied. In summary: the greater the possible harm, and the greater the uncertainty, then greater should be the caution.

No introduction to the precautionary principle would be complete without brief reference to the difference between the precautionary **principle** and the precautionary **approach**. Principle 15 of the Rio Declaration²³² states that: "*in order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.*" As Garcia (1995) pointed out, "the wording, largely similar to that of the principle, is subtly different in that: (1) it recognizes that there may be differences in local capabilities to apply the approach, and (2) it calls for cost-effectiveness in applying the approach, e.g., taking economic and social costs into account." The 'approach' is generally considered a softening of the 'principle'.

A2.3 Precaution and overfishing: the Australian context:

Within the Australian context, fisheries are managed either by:

- the Commonwealth (Australian) government where the fishery is primarily in offshore waters²³³, or
- by the governments of the States and Territories²³⁴ where the fishery is primarily within coastal waters, or
- jointly or cooperatively by the Commonwealth in conjunction with the States under the Australian Offshore Constitutional Settlement²³⁵.

Although the resource management responsibilities of the Commonwealth are limited by the Australian Constitution, Commonwealth controls over fisheries are extended by the *Environment Protection and Biodiversity Conservation Act 1999*, which requires (amongst other matters) that fisheries be managed in a sustainable and precautionary way. The precautionary principle is a central feature of the EPBC Act (Kriwoken et al. 2001) although the Act contains a curious anomaly in this respect – see the detailed discussion of the EPBC Act below. The precautionary principle is also a central principle of Australia's Oceans Policy (Commonwealth of Australia 1998:19). The EPBC Act only applies to (a) State fisheries wishing to export product, and (b) fisheries managed by the Commonwealth.

The Commonwealth's *Fisheries Administration Act 1991* established the Australian Fisheries Management Authority, and lists as an objective of the Authority (s.6(b)):

...ensuring that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development *and the exercise of the precautionary principle*²³⁶, in particular the need to have regard to the impact of fishing activities on non-target species and the long term sustainability of the marine environment.

The Commonwealth's *Fisheries Management Act 1991* section 3 states:

The following objectives must be pursued by the Minister in the administration of this Act and by the Australian Fisheries Management Authority in the performance of its functions:

- (a) implementing efficient and cost-effective fisheries management on behalf of the Commonwealth; and
- (b) ensuring that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development *and the exercise of the precautionary principle*, in particular the need to have regard to the impact of fishing activities on non-target species and the long term sustainability of the marine environment... (emphasis added).

The Bureau of Rural Sciences (BRS) has been preparing assessments of the status of fisheries primarily under Commonwealth management²³⁷ since 1992. In 1994, three fisheries were identified as overfished. This figure rose to four in 1997, six in 1998, seven in 1999, eleven in 2001, sixteen in 2003, and twenty-four in 2005 (Larcombe & McLoughlin 2007).

Each year, on release of the status report, the Commonwealth minister responsible for fisheries has released a press statement underlining the need for a sustainable approach to fisheries management²³⁸. In spite of the best intentions by the minister and his department²³⁹, overfishing problems are clearly continuing, and this appears to be part of national and global trends which have a long history²⁴⁰.

The stocks assessed as overfished decreased in the 2006 assessment, perhaps partially the result of improved management. AFMA received a 'Ministerial Direction' in 2005, requiring some tightening in fishery controls.

A2.4 Cultural, financial and administrative mechanisms underpinning over-exploitation:

Judging from the lessons of history, it appears that humans have major difficulties in controlling the over-exploitation (and subsequent degradation) of the resources on which they rely (Ludwig et al. 1993). The demise of ancient civilizations of northern Africa, the middle-east, Oceania (eg: Easter Island) and central and southern America (Diamond 2005, Wright 2004) suggests that powerful social mechanisms promoting over-exploitation may be at work which are resistant to differences in culture, religion, governance regimes and technologies.

The precautionary principle has evolved within this historical context.

What are the key factors promoting over-exploitation, and could the application of the precautionary principle make a real difference in curbing over-exploitation? I argue that, in fact, the application of the precautionary principle *is a necessary* (rather than an optional) component of programs designed to manage natural resources in a sustainable way, and it is vital that decision-makers treat the principle much more seriously than they do at present. The precautionary principle is one of the few management strategies²⁴¹ which can be used to balance pervasive and powerful mechanisms promoting over-exploitation.

A number of key mechanisms can be identified which promote the over-exploitation of resources. Six of the most important are:

- 1) The existence of a cultural value framework legitimising the consumption of planetary resources to meet the needs of current generations of humans, irrespective of the needs of other inhabitants of the planet;
- 2) Where the resources of the commons are being degraded by human use, the costs and benefits of that use tend to be distributed in ways which reinforce, rather than curtail, the processes of degradation;
- 3) Where management arrangements are put in place to control the cumulative effects of many small incremental increases in resource exploitation, the smallness of each decision, and the fact that each small decision is separated in time from the next, leads to a situation where strategic plans and intentions are undermined by many small decisions which contradict wider, long term goals;
- 4) Even where a few major decisions must be made rather than many small ones, and where resource exploitation decisions take place within a framework where long-term ramifications must be considered; the reality of human preferences places little weight on costs which are likely to occur well into the future, compared with immediate tangible benefits likely to accrue in the short term;
- 5) The exploitation of living resources is inherently uncertain and subject to unpredictable variation, due in part to the complexity of the exploited ecosystems themselves, and in part due to complexities of global oceanographic and weather systems. These uncertainties provide human decision-makers with the leeway to skew resource exploitation programs towards short-term objectives; and
- 6) New knowledge is always accumulating. This provides human decision-makers with an excuse to ignore the lessons of the past. There is a tendency to look back with hind-sight, and imagine that the mistakes of the past would have been avoided "if only they had known..." that which we now know. Decision makers thus ignore the continued operation of pervasive and very powerful social mechanisms which promote over-exploitation.

The next section discusses these mechanisms in more detail. Where terrestrial case studies provide the best examples, they are used rather than marine examples.

A2.5 Six key mechanisms outlined:

Supremacy of humans:

Australian fishermen have argued that seal populations around southern Australia need to be culled to reduce the amount of fish being eaten by these animals – thus leaving more fish for humans to catch and eat. The Japanese government has argued that whale populations need to be culled to reduce the amount of fish and squid being eaten – again to leave more for humans to catch and eat²⁴² (International Whaling Commission 1994, Yodzis 2001). These arguments are underpinned by widely held concepts of the supremacy of humans above other planetary life forms. White (1967) and other philosophers have discussed the origins of these ideas. They are pervasive and powerful within global resource exploitation cultures, and underlie, at some level, most international agreements relating to the utilisation of living resources.

Contrary views have often been expressed, but have gained little credence within the global community engaged in resource exploitation. For example, in the *National strategy for the conservation of Australia's biological diversity* (Commonwealth of Australia 1996) – a statement endorsed by the Australian Commonwealth and all eight State and Territory governments²⁴³, we find the statement:

There is in the community a view that the conservation of biological diversity also has an ethical basis. We share the earth with many other life forms which warrant our respect, whether or not they are of benefit to us. Earth belongs to the future as well as the present; no single species or generation can claim it as its own.

If this concept was taken seriously, substantial areas of habitat, both on land and ocean, would have been set aside purely for the use of other species many years ago. The reality is that one species *is* claiming the earth as its own (Chapter 3). The only marine example I can find of humans consciously sharing the planet with other living creatures, for their own sake, is the creation of whale sanctuaries in the Southern Ocean (see below) and the South Pacific Ocean.

Tragedy of the commons:

Garrett Hardin (1968) used the example of shepherds grazing flocks of sheep on land owned by the community (the commons) – a situation not unlike many wild fisheries. Under light grazing pressures, there is no noticeable degradation of the commons. Shepherds have an economic incentive to increase the size of their flocks, as the benefit of increasing numbers of sheep accrue principally to the shepherds. As sheep numbers increase, over-grazing occurs, and the commons starts to degrade. However, the costs of such degradation are spread broadly over the community, so the individual bears little of these costs in the short term. In the face of a degrading environment, the incentive for each individual shepherd to keep increasing flock size remains (again, at least in the short term) as the benefits accrue directly to the responsible shepherd. Continued degradation of the commons is thus underpinned by the way the costs and benefits of human use of the land (or ocean) are unevenly distributed.

Modern financial accounting procedures, based on 12-month accounting and reporting cycles, reinforce these trends by distributing costs unevenly between present and future generations. Currently accepted procedures for calculating the value of future assets use economic discount rates loosely based on inflation or interest rates. The use of such rates reduces calculated asset values a decade or more into the future to virtual insignificance (Goulder & Stavins 2002). While such techniques are entirely unsuitable for the management of natural resources having long recovery cycles (such as old-growth forests or slow-recovery fisheries) these techniques continue to be used, thus promoting present over future consumption, and providing a strong incentive to overharvest (Clark 1973). The result is the 'mining' of theoretically sustainable resources.

Tyranny of small decisions:

William Odum's 1982 essay draws attention to a mechanism which rests, not on economic drivers like the tragedy of the commons, but on the administrative realities in which small decisions are made. Odum's essay extended an earlier discussion which had focused on economic effects.

Most nation-states use planning procedures which require scrutiny of large resource development proposals, and these provisions sometimes provide careful assessment accompanied by comprehensive stakeholder consultation. A proposal to construct a large agricultural dam to allow extensive development of irrigation in the surrounding region provides a good example. However, while the development of hundreds of small farm dams over one to two decades may well have a similar (or greater) overall environmental impact to this one large dam, the reality is that planning provisions associated with the approval of each individual farm dam will not (due to the small size of the dam and the fact that each approval is separated from the next in time) be able to do anything more than take a very cursory look at likely effects. These planning provisions inevitably fail to properly account for effects of cumulative incremental developments (Finlayson et al. 2008).

The government officers administering the approval system are also faced with a farmer who needs water, while knowing that the actual affect of this one approval will be insignificant in the overall scheme of things. Where no strategic assessment of the capacity of the catchment to supply the needs of farmers has been carried out, decisions will inevitably err on the side of the farmer. Even when a strategic assessment is in place, the history of water allocation in Australia (and other parts of the world) indicates that decisions will still be taken – contrary to the strategic planning objectives which have been put in place – which err on the side of the farmer (Finlayson et al. 2008).

Water allocation in Australia's Murray-Darling Basin provides an example. This basin contains Australia's largest river system, and some of the nation's most productive soils. In spite of concerns expressed by farmers, governments and academics over many decades, State government water resource agencies continued to allocate surface waters for the use of individual farmers, up until a cap was finally imposed in 1994, by which time well over 100% of the average surface river flow had been allocated. Even though the basin was clearly stressed by this stage, governments experienced difficulties in implementing and enforcing the cap (Nevill & Phillips 2004 chapter 4). By 2006, total surface water and groundwater allocations had been reduced to ~14 gicalitre/year, still in excess of the annual average river flow of ~10 gicalitre/year (Nevill 2007).

The tyranny of small decisions, and the tragedy of the commons are considered in more detail in Finlayson et al. (2008). These mechanisms apply irrespective of whether the resource under consideration is terrestrial or marine. The need to impose strategic control over the tyranny of small decisions was one of the drivers behind the Commonwealth HoRSCERA²⁴⁴ 1991 report *The Injured Coastline* which laid the foundation for the Commonwealth Coastal Policy 1995.

Short and long-term trade-offs:

A basic facet of human society involves discounting long term effects (whether costs or benefits) when considering immediate gains or losses. This characteristic is amplified many-fold in democratic consumption-driven cultures which are now pervasive around the planet. Within these cultures political success²⁴⁵ is largely measured within 3-to-4 year election cycles, and financial success is measured within 12-month accounting cycles – cycles which are totally out of step with the long-term ecological processes on which ultimately all life depends. To these forces we must add the almost ubiquitous belief in the ability of the planet to support never-ending population and economic growth (Meadows 1972, Ehrlich & Ehrlich 1972).

The development of irrigation programs provides an excellent example to illustrate the difficulties humans have in balancing short and long term effects in a sustainable way. Ludwig et al. (1993) draw attention to a long history of the failure of irrigation programs, and

suggest that over 3000 years of accumulated experience is not enough to prevent the same mistakes being made again.

Large scale irrigation developments are still being constructed in various locations around the world. These developments are planned well in advance, and funds estimated and allocated. In essence, dams are built to store and supply water to relatively flat areas of fertile soil. Pipes and channels convey the water to the land, and channels are constructed to drain the land. Both surface and ground waters contain salt, and this salt is applied (unavoidably) to the land along with the water. To prevent build-up of salt in the soil, water and salt must be drained, eventually to the ocean or to another similar sink.

However, during the construction of the irrigation developments, complications inevitably occur and capital costs overshoot original estimations (which have been optimistically framed to present the original proposal in a good light). Short term profits depend on the supply network being fully developed, so savings cannot be made here. However, short term profits will not be jeopardised by an incomplete or inadequate drainage network – so savings are made in this area, on the assumption that, as irrigation profits begin to flow in the initial years of operation, funds can be channelled towards completing an effective drainage network. This does not usually occur, as there is a tendency for the management agency to leave the issue until the following year – after all, the system works, doesn't it? By the time significant salt build-up has occurred, and the structure of the area's soils has been damaged, remedial action is extremely expensive, and sometimes impossible (WCD World Commission on Dams 2000). In this example long term costs are discounted over short term benefits.

Difficulties in managing activities which will produce effects in the long term are evident in the management of marine fisheries. In many instances, overfishing has reduced stocks well below the point of maximum sustainable yield (MSY) predicted by traditional fisheries models, yet fishing management agencies are often quite unable to institute strategic action to restore stocks to these levels, to the extent that the use of the MSY concept itself (as a management target rather than a limit) has been discredited (Garcia 1995, Ludwig et al. 1993²⁴⁶, Larkin 1977). In this example long term benefits are discounted over short term costs.

The pervasive discounting of the importance of long-term ecological damage is magnified in the marine context by cultures surrounding both commercial and recreational fishing – obsolete but persistent remnants of historic beliefs that the resources of the sea were virtually infinite. According to Dayton (1998):

Unlike other effects of private interests on the resources of the general public, fishing often is considered a right not a privilege. Regulations often are barely tolerated by the fishing community, and poaching is rampant and minimally penalized. Management of fisheries has typically aimed to maximize the number of fish caught, while allowing little safety margin for assessment error, interannual variability in recruitment of young fish, or other factors such as El Nino and diseases.

[Protective] policies cannot be expected to be implemented until the burden of proof is placed on exploiters of public marine resources to prove that they do not cause damage rather than simply assuming this to be the case until demonstrated otherwise. Similar commercial use of land resources requires extensive environmental impact studies and is carefully regulated. Continued monitoring is required, and all data are readily accessible to the public. Our marine resources need the same careful protection and stewardship.

If society's environmental needs are to be protected so that future generations can also enjoy, learn, and profit from marine ecosystems, this legal burden of proof must be applied to our marine resources so that those hoping to exploit them must demonstrate no ecologically significant long-term changes. If the public hopes to preserve our marine environment, they must act quickly to change the relevant regulations and reverse the burden of proof.

The precautionary principle, if carefully applied within fisheries management, would reverse the burden of proof. Fisheries management agencies often express token support for the precautionary principle, but do little or nothing to apply it (FAO 2005b, RCEP 2004).

Uncertainty and variability:

Most natural systems exhibit a high level of variability, and the drivers of this variability are often poorly understood (Chapter 6). Human harvesting arrangements, including arrangements related to investment financing, work best where variability is low or absent. In fisheries, where variability is high, financial drivers encourage over-harvesting, especially in lean years. According to Ludwig et al. (1993:17):

Scientific understanding and consensus is hampered by the lack of controls and replicates, so that each new problem involves learning about a new system. The complexity of the underlying biological and physical systems precludes a reductionist approach to management. Optimum levels of exploitation must be determined by trial and error. Large levels of natural variability mask the effects of overexploitation. Initial overexploitation is not detectable until it is severe and often irreversible.

In such circumstances, assigning causes to past events is problematical, future events cannot be predicted, and even well-meaning attempts to exploit responsibly may lead to disastrous consequences. Legislation concerning the environment often requires environmental or economic impact assessment before action is taken. Such impact assessment is supposed to be based upon scientific consensus. For the reasons given above, such consensus is seldom achieved, even after collapse of the resource.

Harvesting of irregular or fluctuating resources is subject to a ratchet effect: during relatively stable periods, harvesting rates tend to stabilize at positions predicted by steady-state bioeconomic theory. Such levels are often excessive. Then a sequence of good years encourages additional investment in vessels or processing capacity. When conditions return to normal or below normal, the industry appeals to the government for help; often substantial investments and many jobs are at stake. The governmental response typically is direct or indirect subsidies. These may be thought of initially as temporary, but their effect is to encourage over-harvesting. The ratchet effect is caused both by the lack of inhibition on investments during good periods, but also by strong pressure not to disinvest during poor periods. The long-term outcome is a heavily subsidized industry that over-harvests the resource.

Uncertainty has a number of other aspects which contribute to overharvesting. These are discussed in Chapter 6 dealing with uncertainty.

The illusion of scientific knowledge:

Scientific knowledge is important in understanding and managing natural ecosystems. However, the history of resource exploitation provides many examples where 'a little knowledge is a dangerous thing'. New knowledge is always accumulating, and there is thus the tendency to think that that 'we can do better next time'. A lesson of history is that reliance on science (which will always remain imperfect) is dangerous if financial and cultural drivers encouraging overexploitation are ignored. Again, Ludwig et al. (1993) provide a perspective:

We propose that we shall never attain scientific consensus concerning the systems that are being exploited. There have been a number of spectacular failures to exploit resources sustainably, but to date there is no agreement about the causes of these failures. Radovitch reviewed the case of the California sardine and pointed out that early in the history of exploitation scientists from the (then) California Division of Fish and Game issued warnings that the commercial exploitation of the

fishery could not increase without limits and recommended that an annual sardine quota be established to keep the population from being overfished. This recommendation was opposed by the fishing industry, which was able to identify scientists who would state that it was virtually impossible to overfish a pelagic species. The debate persists today.

The great difficulty in achieving consensus concerning past events and a fortiori in prediction of future events is that controlled and replicated experiments are impossible to perform in large-scale systems. Therefore there is ample scope for differing interpretations. There are great obstacles to any sort of experimental approach to management because experiments involve reduction in yield (at least for the short term) without any guarantee of increased yields in the future. Even in the case of Pacific salmon stocks that have been extensively monitored for many years, one cannot assert with any confidence that present levels of exploitation are anywhere near optimal because the requisite experiments would involve short-term losses for the industry. The impossibility of estimating the sustained yield without reducing fishing effort can be demonstrated from statistical arguments. These results suggest that sustainable exploitation cannot be achieved without first overexploiting the resource.

Fishery managers and scientists have a long track record of optimism in the face of uncertainty (Bax et al. 2005) and there are no indications that this will change – at least until the harvesting-oriented cultures within management agencies change (Chapter 17). Substantial irreducible uncertainties within fisheries management (Chapter 6) will always remain, and provide the backdrop within which unrealistic optimism can continue to flourish.

A2.6 The six mechanisms in Australian government programs:

Supremacy of humans:

Although the Australian government and all eight State / Territory governments are, apparently, committed to a concept which recognises the rights of other planetary life-forms (see above), it is difficult to find expressions of this concept in government programs. The most obvious places where it might appear are within over-arching policies and subordinate programs related to natural resource management at a terrestrial level, fisheries management within the context of Australia's oceans policy, or reserve development in terrestrial or marine environments (Commonwealth of Australia 1998, ANZECC Task Force 1999).

Within this general area the only evidence which I have found of the concept in practice relates to Australia's policy on whales. The Australian government has prohibited the killing or harassment of whales within Australia's territorial waters and extended economic zone, in line with the moratorium on commercial whaling imposed by the International Whaling Commission (IWC). The Commonwealth's *Whale Protection Act 1980* has been replaced by broader provisions within the EPBC Act 1999. However, Australia has gone well beyond its strict obligations under IWC agreements in further promoting a whale sanctuary in the South Pacific – although the concept of this sanctuary has been undermined by Japan continuing its program of 'scientific' whaling within the sanctuary boundaries.

The tragedy of the commons, and the tyranny of small decisions:

In some areas government programs have been developed explicitly to control the cumulative impact of incremental developments in resource use. Three examples are: landuse planning, fisheries management, and freshwater resource management. In managing the first two of these areas, government programs explicitly recognise the importance of placing strategic caps on development ahead of resources entering a crisis situation. In Australia, strategic caps on the development of freshwater resources have not been implemented ahead of catchments approaching crisis levels of resource use (Finlayson et al. 2008) in spite of serious and intractable degradation of natural freshwater ecosystems (Nevill & Phillips 2004).

Even where major efforts have been focused on achieving strategic caps – in both land use planning and fisheries areas – failure to control cumulative effects has been a common outcome. For example, strategic urban plans for greater Melbourne (developed at great expense with major community consultation programs in the late 1970s) had to be almost completely abandoned when strategic directions were reviewed in 2002, due to erosion of the ‘green wedge’ concept by incremental development under control of the local municipalities of outer Melbourne.

Worldwide, achieving sustainable harvesting of fisheries resources, in spite of management philosophies which apply caps to resource exploitation well ahead of theoretical crisis situations, has proved difficult or impossible in many situations (see above). The same comment applies to attempts to modify markets through financial mechanisms to account for the externalities (external costs) of resource exploitation – a fundamental driver of the tragedy of the commons effect.

Short & long-term tradeoffs, resource variability & uncertainty, and the illusion of knowledge:

Governments in Australia, at various levels and situations, have attempted to address issues relating to long term ecological considerations, and issues of uncertainty and lack of knowledge. However, the non-implementation of resource conservation policy is a pervasive outcome of such attempts. Soil degradation and erosion, the subject of major government inquiries in the 1940s, still remains an area of the most serious concern²⁴⁷, with many key recommendations of early inquiries never implemented.

In the area of irrigation development, a government-sponsored study recommended the integrated assessment of coupled major dam and irrigation components (CWPR 1999). These recommendations have never been implemented. More broadly, a major Commonwealth Government inquiry (HoRSCER 2000) recommended procedural and administrative changes in government programs to address long-term catchment degradation around Australia: no major recommendations of this inquiry have yet been implemented.

In the area of protection of freshwater biodiversity, the development of protected areas has been a major foundation of protection strategies which attempt to meet long-term and uncertainty concerns. The Australian Government, and all State and Territory governments have committed themselves to the development of systems of freshwater protected areas to conserve representative examples of all major ecosystems (Commonwealth of Australia 1992b).

The commitments relating to the establishment of representative protected areas over rivers have not been actioned by the Commonwealth, or by Queensland, New South Wales, South Australia, the Northern Territory or Western Australia. Only the Australian Capital Territory, Victoria and Tasmania have attempted to action the commitments, and in the case of Victoria and Tasmania, these programs remain substantially incomplete (Nevill and Phillips 2004). The selection of Queensland’s ‘Wild Rivers’ has not been done with the intent of systematic representation.

Fisheries legislation in Queensland, New South Wales, South Australia, Victoria and Tasmania all contain provisions for establishing freshwater protected areas (in line with the 1992 commitments in the InterGovernmental Agreement on the Environment); however, many years later, none of these provisions have been used. The Victorian Parliament alone amongst State jurisdictions developed a specific statute (the *Heritage Rivers Act 1992*) to protect 18 identified high-conservation value rivers. However, after 12 years, the legislation remains without legal effect as the 18 required management plans have not been authorised by the minister (Nevill and Phillips 2004). Meanwhile degradation of Victoria’s rivers is widespread (Government of Victoria 2002).

In summary, many major programs instituted by governments within Australia to address issues relating to the long-term protection of ecosystems (and the development of natural

resources over the long-term in the face of uncertainty and variability) have been marked by half-hearted implementation and ultimately substantial failure (Nevill 2007). The general findings of Ludwig et al. (1993) (see above) on the apparent inevitability of resource over-exploitation appear to hold in Australia as elsewhere (Nevill 2009).

A2.7 The precautionary principle in the international marine context:

This entire section is extracted from Cooney (2004). At the time it was written, Dr Cooney was the Director of the Precautionary Principle Project www.pprinciple.net, a joint initiative of IUCN-The World Conservation Union, Fauna & Flora International, ResourceAfrica and TRAFFIC²⁴⁸.

Uncertainty and traditional fisheries management approaches:

By way of background to this section, it is important to recognize the approach to uncertainty adopted by 'traditional' fisheries management. The aim of traditional fisheries management is to achieve the maximum sustainable yield (MSY). This is the maximum harvest from a stock that can be maintained indefinitely (assuming steady-state conditions), taking into account the increase in productivity that usually results from a decrease in the stock size. Pursuit of MSY has often been associated with over-fishing, due in large part to lack of adequate recognition of, or incorporation of uncertainty (see e.g. Wade 2001). Retrospective analysis of fish stocks has demonstrated that reality often lies outside model estimates, and targeting modeled MSY can lead to overexploitation and stock collapse (Punt & Smith 2001). This has been an important factor in the wide incorporation of the precautionary approach in fisheries management agency charters (at least at a token level).

Multilateral agreements and policy processes

Against this background of 'non-precautionary' management and widespread stock over-exploitation, the recognition and incorporation of uncertainty, and attendant risks, have been major drivers of the evolution of fisheries policy and regulatory approaches (Chapter 4). Recent decades have seen the strong emergence in international, regional and national fisheries law and policy of a 'precautionary approach' to fisheries management, and it is probably within the fisheries context that the concept of precautionary resource utilization and management has received the most detailed attention and fullest elaboration to date (for comprehensive analyses see Freestone 1999; Juda 2002).

UN Law of the Sea Convention

The major international agreement regulating conservation and utilization of high seas marine resources is the 1982 United Nations Convention on the Law of the Sea (UNCLOS). The UNCLOS contains no explicit mention of precaution and enshrines the concept of MSY, requiring the adoption of measures to "maintain or restore populations of harvested species at levels which can produce the maximum sustainable yield" (Article 119). Measures must be based on the best scientific data available. As to whether this requirement means that conservation measures aimed at averting potential but scientifically undemonstrated risks cannot be taken, a leading commentator suggests that if adequate scientific data are not available, then the general obligations of the convention remain, and the primary applicable obligation is that of conservation (Freestone 1999:159). This arguably provides a basis for subsequent wide acceptance of the precautionary approach.

Despite the absence of reference to precaution in the UNCLOS, the precautionary approach may influence judicial decisions pursuant to it. The ruling of the International Tribunal for the Law of the Sea in the Southern Bluefin Tuna cases²⁴⁹ does not rely expressly on the precautionary approach, but has been interpreted as necessarily implying acceptance of it (eg: Marr 2000).

It is worth noting that the World Charter for Nature 1982, a widely supported resolution of the UN General Assembly, dates from about the same period as the UNCLOS, and explicitly advocates a version of the precautionary approach (Article 11). The wording of the Charter also establishes an expectation that implementation of the Charter extends not just to States and State agencies, but to individuals within signatory States. Australia supported the Charter at the UNGA.

UN Fish Stocks Agreement

The 1995 United Nations Fish Stocks Agreement (UNFSA)²⁵⁰ marks a significant shift of emphasis and approach. Environmental considerations are strongly highlighted in the preambular language and given effect throughout the operative provisions. The UNFSA is the first global fisheries agreement requiring a precautionary approach to fisheries management - a precedent-setting and highly influential development. Article 6 requires that to preserve the marine environment as well as protect marine living resources, the precautionary approach should be applied to conservation, management and exploitation measures. It includes requirements that States apply a prescribed methodology for precautionary measures (set out in Annex II and included below as Attachment Five), implement improved techniques for dealing with risk and uncertainty, take into account both ecological and socio-economic uncertainties, and develop research and monitoring programs and plans aimed at conserving non-target and dependent species (Article 6(3)). Annex II sets out guidelines for precautionary measures based on the establishment of precautionary reference points and actions to be taken where such points are approached and exceeded. Reference to MSY is retained in these Annex II guidelines, but as a "limit" point, constraining harvest, rather than as a "target" for management.

The UNFSA establishes obligations for signatory States that affect both management within national waters of straddling or highly migratory stocks, and management of high seas stocks by international and regional fishing organizations. Its influence, in conjunction with voluntary FAO agreements, has already been demonstrated by the adoption (at least on paper) by a range of States and organisations of explicitly precautionary fisheries management methodologies (FAO 2005b).

FAO Code of Conduct for Responsible Fisheries, and the FAO Technical Guidelines on the Precautionary Approach

The voluntary United Nations Food and Agriculture Organization (FAO) Code of Conduct for Responsible Fisheries, also concluded in 1995, includes an exhortation to apply the precautionary approach widely in the conservation, management and utilization of living aquatic resources, directed at States, sub-regional and regional fisheries management organisations and arrangements (see Article 6.5 and 7.5). While the code of conduct is voluntary, there is evidence that it is and will continue to be influential in shaping fisheries management (FAO 2005b). Australia formally supported the Code of Conduct through the Rome Declaration 1999 (Chapter 5).

Detailed technical guidance for implementation of the precautionary approach has been developed by the FAO (see the Attachments below). These guidelines represent probably the most detailed treatments of the operational meaning of precaution in a natural resource management or conservation arena, and offer valuable lessons for other sectors. The summary statement is included below as Attachment Two. The FAO guidance first characterizes the general concept of the precautionary approach, setting out that the precautionary approach requires, *inter alia*:

- a) avoidance of irreversible changes;
- b) prior identification of undesirable outcomes;
- c) initiation of corrective measures without delay;
- d) priority given to conserving the productive capacity of the resource;
- e) harvesting and processing capacity commensurate with estimated sustainable levels of the resource;

- f) that all fishing activities have prior management authorization and are subject to periodic review;
- g) legal and institutional frameworks for fishery management, with management plans implementing the above for each fishery; and
- h) appropriate placement of the burden of proof through meeting these requirements (para. 6(a)-(h)).

Detailed guidance is then developed for the implementation of the precautionary approach in relation to fisheries management, research, technology development/transfer, and species introductions, including, for example, management planning and design, monitoring, stock assessment methods, review and evaluation of new technologies, and cooperation and information systems on invasive species.

It is not clear that this broad and far-reaching understanding of the precautionary approach is widely reflected in legal and policy developments. Within the Fish Stocks Agreement, guidance on the precautionary approach focuses on target and limit biological reference points, rather than including the more “systemic” changes set out in the FAO guidance. It has been argued that this narrow understanding of the precautionary approach characterizes current efforts in this area, at the expense of the broader management implications (Mace & Gabriel, 1999).

The FAO has developed guidance across a range of fisheries (eg, Caddy and Mahon 1995; Caddy 1998; FAO 2001b). More recently, the precautionary approach has been endorsed by and incorporated into ongoing work under FAO auspices on developing guidance for the ecosystem approach to fisheries (FAO 2003).

CCAMLR

Of the regional fisheries organizations and arrangements, the Commission on the Conservation of Antarctic Marine Living Resources (CCAMLR) is often viewed as being among the most precautionary (Mace and Gabriel, 1999). While precaution is not explicitly adopted in the convention²⁵¹, since at least the early 1990s it has been understood that in the case of uncertainty, CCAMLR Conservation Measures should be consistent with a precautionary approach (CCAMLR 1993), although in practice this is often subject to dispute (TAP 2001). CCAMLR adopts an ecosystem-level approach to conservation and management, widely understood as necessitating or at least being consistent with a precautionary approach.

International Whaling Commission

The precautionary principle has been prominent in discussion and advocacy within the International Whaling Commission (IWC), established under the *International Convention for the Regulation of Whaling 1946*. A moratorium (referred to as a “pause” – indicating that it would be of short duration) on all commercial whale harvesting was instituted in 1982 (taking effect in 1985/6) pending the development of an appropriate procedure for the sustainable management of relevant stocks.

In 1994, Parties agreed on the Revised Management Procedure (RMP) to govern the level of any resumed harvesting, but have not been able to accept this as a basis for removal of the moratorium. The RMP has been called a “radical framework for risk-averse management of natural resources” (Donovan and Hammond, 2004), and is often cited as a leading example of a highly robust, explicitly precautionary approach to uncertainty in the establishment of fisheries harvest limits (eg, Cook, 1999). On the other hand, however, it should be noted that the IWC has achieved precautionary management, by simply curtailing the action that it is designed to manage. Further relevant measures include the establishment of whale sanctuaries in which commercial harvesting is prohibited, for which precaution has been an explicit rationale (see e.g., IWC Resolution 2002-1).

ICES

The International Council for Exploration of the Sea (ICES), which coordinates research and advises management bodies such as the European Union with respect to North Atlantic fisheries, has since 1999 provided “precautionary” advice for fisheries managers, in line with requirements of the UNFSA and the FAO Code of Conduct, and the requirements of the European Commission (CoEC 2000). Work to develop theoretical and practical understanding of precautionary measures is ongoing within ICES.

Other multilateral instruments

A number of regional agreements that pre-date the adoption of precautionary terminology involve a clear reversal of the burden of proof. The 1952 International Convention for the High Seas Fisheries of the North Pacific Ocean reverses the burden of proof: scientific evidence was required for stocks to be released from “abstention” (fishing ban) (Freestone, 1999). The UN General Assembly Resolution of 1989 prohibiting the use of large scale driftnet fishing bans this activity in the absence of certainty as to its harm, and places the burden of proof on those wishing to lift the ban²⁵².

More recently, in regional fisheries agreements, the precautionary approach has been adopted by the International Commission for the Conservation of Tunas (ICCAT COMSCRS/99/11) and the North Atlantic Fisheries Organization, the International Pacific Halibut Commission (see IPHC 1999 Catch Recommendations), and the precautionary approach forms part of the recently negotiated Convention on the Conservation and Management of Fishery Resources in the South-East Atlantic Ocean 2001. In Europe, the UNEP Mediterranean Action Plan pursuant to the Barcelona Convention on the Protection of the Marine and Coastal Environment of the Mediterranean 1995 stipulates that member States must apply the precautionary principle according to their capacity (Article 4).

A2.8 Related Commonwealth legislation and policy:

Government structure and constitutional responsibilities:

Australia has a three-tiered government structure. Under the Australian Constitution, the Australian Government (also referred to as the Federal or Commonwealth Government) is responsible for taxation, defence, economic regulation and international affairs, including export/import controls, the ratification of international agreements, and the management of fisheries in the Exclusive Economic Zone (EEZ) and extended continental shelf zone. The Australian Government owns and controls certain areas of land, such as defence training grounds. Six States and three territories form the second layer of government (the small Jervis Bay Territory being governed by the Australian Capital Territory), and are responsible for most health, education, law enforcement, social services, and resource management functions – including fisheries management (States having sole jurisdiction to the 3 nm boundary). Fisheries which overlap administrative boundaries are governed under the arrangements of the Australian Offshore Constitutional Settlement, which seeks to establish cohesive management regimes for fish stocks crossing State/Commonwealth borders (Haward 1989, 1995). Local governments form the third tier, and have responsibilities for the provision of many local services. Their land use planning and related development approval controls have major implications for estuary health, particularly in densely populated coastal areas.

Australia’s six States are: New South Wales (NSW), Queensland (Qld), South Australia (SA), Tasmania (Tas), Victoria (Vic), and Western Australia (WA). The two self-governing territories are the Australian Capital Territory (ACT) and the Northern Territory (NT).

Given the division of responsibilities provided by the Constitution, where responsibilities overlap, dual approval regimes would be required in the absence of cooperative arrangements between government levels. Such approval regimes are in some ways inefficient, but continue to be used for many marine fisheries in Australia. For example, an export fishery based in coastal waters would need approval to harvest from the relevant State, and approval to export from the Commonwealth.

The Environment Protection and Biodiversity Conservation Act 1999:

See section 10 below.

Australian government guidelines for assessing fishery sustainability:

The EPBC Act was passed in 1999 and came into effect in July 2000. At that time, all Commonwealth managed fisheries which had not been assessed under the *Environment Protection (Impact of Proposals) Act 1974* were required to be assessed under the strategic assessment provisions of the EPBC Act. As discussed above, a central object of the EPBC Act is to promote ecologically sustainable development, an objective already listed in the Commonwealth's *Fisheries Management Act 1991* through amendments introduced in 1997.

Prior to the passage of the EPBC Act, commercial fisheries had been granted a general exemption from the assessment requirements of the *Wildlife Protection (Regulation of Imports and Exports) Act 1982*. This exemption was removed just before that Act was subsumed by the EPBC Act, which has similar powers to restrict exports of wildlife, including fish. The effect of these provisions resulted in a requirement that a fishery under State or Territory management which needed export approval had to undergo an EPBC Act assessment to demonstrate ecological sustainability.

Guidelines were required to assist in developing assessments which would demonstrate that a particular fisheries was ecologically sustainable. Draft guidelines were developed by the two Commonwealth departments responsible for environment and fisheries, and were published for comment in July 1999 (Commonwealth of Australia 1999) and finalised in 2001 (Commonwealth of Australia 2001). These two documents are compared in Appendix Five. This review concluded:

A comparison between the draft and final versions of the guidelines indicates substantial weakening of the ability of the guidelines to promote sustainable approaches to fishery management.

The evolution of the guidelines (after close of public comment) indicates that both gains and losses have occurred from a sustainability perspective. Gains are generally in matters of clarification of detail. Losses on the other hand, are far more substantial, and three in particular are of considerable concern:

- A loss of auditability brought about by the replacement of measurable conservation targets by commitments to 'minimise' harm;
- A loss of specific requirements for reference points designed to signal a situation so serious as to warrant temporary halts to fishing effort - these have been replaced by a requirements simply to 'reduce fishing effort' as the critical reference point is reached; and
- The replacement of demonstrable management aspects, such as the *existence* of compliance and enforcement programs, with 'paper' commitments to the development of *proposals* which could produce the desired effect. There is a major difference between a good idea and an on-ground reality.

Dilution of the precautionary approach is also apparent in comparing the original and final texts. The original wording required that "*the fishery shall be subject to ... arrangements ... which give effect to ... the precautionary approach to management.*" This requirement has been removed in the final text, and replaced with vague references to the use of the precautionary approach which move well clear of establishing a requirement.

A2.9 The application of the precautionary principle to Australian ocean management:

The Australian Commonwealth government, and all State and Territory governments are committed to the application of the precautionary principle as part of programs aimed to achieve the sustainable management of the nation's natural resources (Commonwealth of Australia 1992a, 1992b). Kriwoken et al. (2006) review Commonwealth and State legislation containing commitments to the precautionary principle or approach, noting, as did Stein (1999) relatively few examples of the principle appearing as an important element in court cases.

It appears that in some cases the principle is being applied. However in many cases it does not appear to be applied in situations where, given the powerful mechanisms promoting over-exploitation of marine resources, and the serious nature of the possible harm involved, its application seems warranted as a tool to balance these mechanisms.

The discussion below provides examples of the application of the precautionary principle to ocean management issues in Australia, including examples where the precautionary principle has been incorporated into statutes, policies and procedures relating to aspects of ocean management.

Prohibition of seismic testing at the Twelve Apostles.

The Victorian Minister for Environment, John Thwaites, announced that consent would not be granted for seismic exploration in part of the Twelve Apostles Marine National Park (Thwaites 2003). According to Thwaites: "After careful consideration I was not satisfied that there would be no detrimental impacts to marine flora and fauna in the national park... A higher environmental test applies to national parks and we have adopted a precautionary approach in this case".

Australian support for whale sanctuaries.

The IWC voted for the creation of a Southern Ocean Whale Sanctuary at its Forty-sixth annual meeting (IWC 1994). The operation of the sanctuary is to be reviewed at 10-year intervals. At the 1994 meeting Japan argued that the northern boundary should not be decided until the IWC Scientific Committee had considered the scientific implications of its position. This could have been a delaying tactic, but it could also have been prompted by a genuine desire to 'use the best available information' in reaching a decision. Spain and Argentina (but not Australia) argued that (contrary to the Japanese position) the precautionary approach required action in the absence of scientific certainty, concluding that there was therefore no need to further delay the sanctuary proposal. This view, with Australia's support, prevailed with the necessary three quarter majority when put to the vote, and the sanctuary came into being.

In arguing the case for the proposed South Pacific Whale Sanctuary at the 54th meeting of the IWC, the Australian government argued that, given uncertainties related to the recovery of great whale stocks, and the lack of knowledge of their critical habitat requirements, a precautionary approach justified the extension of the existing whale sanctuary into the South Pacific as a strategy to promote their recovery (Commonwealth of Australia 2002).

Establishing boundaries for marine protected areas.

One of the objectives of establishing systems of marine protected areas is to protect a collection of ecosystems which represents the biodiversity within a particular region (ANZECC 1998; ANZECC 1999a). In the Australian context, a core management objective is to ensure that such systems are 'comprehensive, adequate and representative' (ANZECC 1999b). However, to do this in a detailed and rigorous way requires information which, generally speaking, is presently unavailable (Marine Parks Authority NSW 2001). Consequently, both generic biodiversity surrogates and a degree of judgement on the part of

management must be used, and the precautionary principle is sometimes quoted as a reason for making decisions on boundaries in the absence of adequate data.

A typical view is expressed in the Cape Byron marine park assessment report: "...given the poor understanding of marine systems in general, and the limited availability of basic ecological data for defining patterns of biodiversity distribution, the precautionary principle was applied in this assessment." (Marine Parks Authority NSW 2004:1.2).

It can, however, be argued that Australian decisions in relation to establishing marine protected area boundaries have been anything but cautious, as the resulting areas almost always appear particularly small when considered against size estimates in the current literature on marine biodiversity protection (Nevill 2004b).

A2.10. Apparent failure to apply the precautionary principle to Australian marine issues:

There are a number of instances where application of the precautionary appears warranted, yet the principle does not appear to be applied.

Application of the precautionary approach within the EPBC Act:

Section 391 of the EPBC Act 1999 requires the responsible minister to consider the precautionary principle in making a number of key decisions, referenced to sections within the Act. Importantly, this list *excludes* the section relating to approval of fishery management plans for Commonwealth-controlled fisheries (see discussion above). Implicitly, this releases the minister from an obligation to consider, if not apply the precautionary principle, which would otherwise be required by a number of key government decisions. These decisions include:

- Australian government endorsement of the use of the precautionary principle through ratification of important international instruments in 1982²⁵³ and 1992²⁵⁴ (see discussion above)
- The inclusion of the precautionary principle in key national strategies in 1992²⁵⁵, 1996²⁵⁶ and 1998²⁵⁷ (see above)
- Australian government endorsement of the UN Fish Stocks Agreement 1995 and the voluntary FAO code of conduct 1995, both of which incorporate and emphasise the need to apply the precautionary principle to fisheries,
- The general endorsement of the precautionary principle by the EPBC Act itself, and
- Amendment of Commonwealth fisheries legislation in 1997 to incorporate a requirement to apply the precautionary approach (see discussion above).

This feature of the EPBC Act is a major anomaly within Australian international, oceans and fisheries policies, and appears to be an attempt to dilute the application of the precautionary approach to fisheries management. As such, it arguably constitutes a breach of Australia's international obligations under the UN Fish Stocks Agreement 1995, and other more general obligations imposed by the World Charter for Nature 1982 and the Rio Declaration 1992.

The EPBC Act contains another provision which is at odds with principles of natural resource management²⁵⁸ – in particular the management of the cumulative effects of many small incremental activities impacting on a resource (see principles and management approaches discussed in Finlayson et al. 2008). Sections 23-24 of the Act are intended to establish a requirement for prior approval of activities which may involve a significant impact on the marine environment – including fishing activities. However, the wording of the Act renders this requirement effectively unenforceable with respect to fishing activities, as it is likely to be extremely difficult or impossible for a prosecutor to establish that such an apprehended activity was in fact likely to have a 'significant' impact on the environment – as the effects of fishing activities are almost always only significant in a cumulative sense. Effective control of cumulative impacts requires adherence to an agreed strategic plan, and the creation of statutory offences need to be appropriately worded in this context.

Development of Commonwealth guidelines for assessing fishery sustainability:

As discussed above, guidelines have been developed to assist in the statutory assessment of Commonwealth fisheries and State export fisheries under the requirements of the EPBC Act. Draft guidelines were published for comment in July 1999 (Commonwealth of Australia 1999) and finalised in 2000 (Commonwealth of Australia 2001). These two documents were compared by Nevill 2004d, who concluded:

Dilution of the precautionary approach is also apparent in comparing the original and final texts. The original wording of the draft required that *“the fishery shall be subject to ... arrangements ... which give effect to ... the precautionary approach to management.”* This requirement has been removed in the final text, and replaced with vague references to the use of the precautionary approach which move well clear of establishing a requirement.

This change in wording between draft and final versions appears to contradict the apparently strong commitments made by the Australian government to the precautionary principle in international agreements, national policy statements, and in legislation (discussed above). The change substantially diminishes the ability of the Commonwealth Government to encourage the use of the precautionary principle as an operational concept.

Recent expansion of No Take Areas on the Great Barrier Reef:

In 2004 the Commonwealth Government announced a decision, as part of a review of the protection of representative ecosystems within the Great Barrier Reef Marine Park, to expand the amount of the Park under full harvesting restrictions from 4.5% to nearly 33% (Sampson 2004). At first sight this could be seen as an example of the application of the precautionary principle, however it can also be argued that a truly precautionary approach would have seen the establishment of considerably larger no-take areas.

The Great Barrier Reef Marine Park is one of the most intensively studied Australian coastal marine areas, and the State of the Great Barrier Reef Marine Park Report is available on-line (GBRMPA 2003). The most intensive monitoring has taken place over the last 20 years, with good data on some indicators going back 40 years or more. During this period of time, some indicators of ecosystem health have shown substantial declines, in spite of the ‘best endeavours’ by the Authority and the Queensland Government in sustainable management. Indicators of degradation include:

- Over the last 40 years, numbers of nesting loggerhead turtles have declined (at various nesting beaches) by between 50% and 80%²⁵⁹;
- Estimates of dugong populations adjacent to the urban coast of Queensland indicate that they are currently only about 3 percent of population levels in the early 1960s²⁶⁰. Populations in the 1960s were themselves hugely reduced from pre-European populations.
- Populations of the grey nurse shark resident on southern reefs have declined to ecological extinction, and are not likely to recover (Otway et al. 2004);
- The biomass of heavily harvested reef fish is hugely reduced in comparison to unharvested levels. Coral trout, for example, have been reduced to around 20% of their pristine biomass (Hughes 2004); and
- Commercial fisheries within the GBR World Heritage Area have been characterised by unsustainable harvest levels, and in the case of trawl fisheries, by huge bycatch mortalities. My reading of government reports by the Queensland Fisheries Service and GBRMPA is that no serious attempt was made to address these issues until the late 1990s. As recently as 2002 the QFS (with their revised draft of the reef line fishery management plan) was still trying to reduce commercial catches to sustainable levels. The dive fishery for the black teat fish has collapsed (GBRMPA 2003a).

Coral cover (a critical indicator of the health of the reef) is monitored by GBRMPA programs. GBRMPA undertook a comparison of historical photographs indicating coral cover dating back to 1893. Of 14 reefs investigated, four showed general decreases in hard coral cover, while another four showed piecemeal decreases in hard coral cover. According to the GBRMPA report: “readily observable symptoms of stress can lag far behind the onset of ecosystem dysfunction. As such, conclusive evidence of a decline may only be found after major and potentially irreversible impacts have occurred” (GBRMPA 2003b). In my view, major impacts have already occurred.

The report continues: “The variability and complexity of coral reefs makes it very difficult for scientists to detect and identify clear declines in coral reef condition that are attributable to human influences. However, subtle signs of reef dysfunction are now apparent on some inshore reefs” (GBRMPA 2003b). In my view, this is a distinct and important understatement. Deterioration in coral cover is driven partly by factors outside the control of the Authority (global warming and ocean acidification, for example) but partly (in my view) by the Authority’s failure to apply the precautionary approach in a timely and comprehensive manner.

Nevill (2005c) has provided an overview of recent papers dealing with no-take zone targets. The range of targets surveyed encompasses 10-50%. Walter’s comments are of particular significance: “A revolution is underway in thinking about how to design safe and sustainable policies for fisheries harvesting” (Walters 2000). Fish stocks repeatedly declining in the face of modern management, major ecosystem damage, and an awareness of the degradation of global biodiversity resources call for a new approach. According to Walters: “Sustainable fisheries management may eventually require a reversal of perspective, from thinking about protected areas as exceptional to thinking about fishing areas as exceptional. This perspective is already the norm in a few fisheries, such as commercial salmon and herring net fisheries along the British Columbia coast”. Walters points out that, historically, many apparently sustainable fisheries were (in years past) stabilised by the existence of ‘effective’ protected areas, and the erosion of these areas through adoption of new technology subsequently resulted in the collapse of the fishery.

This is the kind of vision I would expect from the Authority, but the reality is far from it. Walter’s vision, borne of an examination of the historical realities of marine harvesting regimes around the world, suggests we should be aiming at perhaps 80% of marine ecosystems subject to closure to harvesting activities. Within this 80% would be a core of say 50% (the upper bounds of the recommendations reviewed in Nevill 2005c) which would remain closed on a permanent basis. A further 30% would be managed by temporary or rotational closures. The remaining 20% would, within conditions applicable to each fishery, remain open to commercial and recreational harvesting activities.

If the Authority had set about developing such a vision from its inception (when protection of representative areas was already a *requirement*) the reef would probably now be in a much better ecological condition, and fishers would have had decades to adapt to restrictions, which themselves could have been phased in over considerable periods of time – thus easing costs to both commercial and recreational sectors.

If my ideas seem unrealistic, it may be worth bearing in mind the words of Ludwig et al. (1993) in their overview of the history of man’s exploitation of the natural world: “Although there is considerable variation in detail, there is remarkable consistency in the history of resource exploitation: resources are inevitably overexploited, often to the point of collapse or extinction.” As has been said many times before, those who are unaware of history seem bound to repeat it.

The precautionary principle element of ‘possibility of serious or irreversible harm’ is certainly present: serious harm is not only possible, but is occurring and on-going. While the causes of the decline are likely to be complex, there appears little doubt that human activities, including harvesting activities, are strongly implicated (Bellwood et al. 2004). Many harvesting pressures, judging by declining catches and increasing fishing efforts, are not

sustainable. Careful application of the precautionary principle, I believe, would see no-take areas expanded, not to 33%, but to 80% or 90% for at least a decade in an attempt to not only halt, but to reverse the decline. Once halted and reversed, no-take areas could be reduced in size and number. Far from being a precautionary step, the current 33% protected in no-take areas might in fact be 'too little too late', although time alone will tell.

Coral bycatch from the South Tasman Rise orange roughy fishery.

The New Zealand Ministry of Fisheries placed observers on NZ vessels fishing the newly-discovered South Tasman Rise orange roughy fishery in October 1997 (Anderson 2004).

According to Anderson:

This fishery, which lies mostly in international waters south of the exclusive economic zone below Tasmania, operates on several small seamount features on the flanks of the main ridge summit. It was discovered in September 1997 and participation for the most part has been confined to New Zealand and Australian vessels. The annual landings of orange roughy were high in the first few years, peaking at about 4000 t in the 1997-98 and 1999-2000 fishing years, then declining rapidly to the point where annual landings are now less than 200 tonne.

Sea floor communities are easily damaged in orange roughy seamount fisheries because they tend to be fragile, erectile, slow growing and susceptible to damage by the heavy fishing gear used.

Between October 1997 and August 2000 observers examined and recorded the contents of 545 trawls, covering 10-22% of the annual New Zealand plus Australian catch. They collected a wide range of specimens, corals in particular.

The most notable outcome of this analysis was the large amount of coral trawled up from the seamounts. Observers recorded coral in the catch of almost 40% of trawls. A hundred kilogram or more of coral was recorded in 12% of trawls and one tonne or more in 5% of trawl, with one catch of 15 t recorded.

Over time, as the coral was gradually removed from the area and fishing effort eased due to declining catch rates, both the bycatch ratio and estimates of total annual bycatch diminished, the latter from about 1750 t to 100 t per year. These estimates of coral catch are thought to be the first from a new orange roughly fishery, and were only possible due to the high level of observer coverage on vessels at the beginning of the fishery.

The precautionary principle element of "possibility of serious or irreversible harm" is present: serious harm was not only possible, but was already occurring from the time the fishery commenced.

Given knowledge of the number of boats and the number of trawls placed per boat, and estimates of the size of the trawl grounds, estimates could be made of the extent of habitat damage to the seamount sea floor. The very high coral bycatch rates recorded on the first (virgin) year should have signalled a need for immediate action by the NZ and Australia governments. These governments can control the operations of nationally-flagged fishing vessels on the high seas, and are required to do so by Article 8.2 of the FAO code of conduct. Both Australia and NZ have endorsed the use of the voluntary FAO code (FAO 1995).

If the precautionary principle had been applied, fishing activity would have been stopped immediately on the grounds that further activity would be likely, in fact would certainly, have resulted in major damage to marine habitat. Although there is not a great deal of information available on the importance of deep sea coral habitat to commercial fisheries, it is known that deep corals are slow growing. Given existing knowledge of shallow corals, the

importance of corals in providing shelter, and in some cases food for marine animals can be readily inferred.

The action taken by both NZ and Australian government fishing agencies in allowing fishing activities to continue in the face of heavy coral bycatch and steeply declining catch rates clearly breaches the precautionary principle, and represents a mining operation (rather than any form of sustainable harvesting) of both the fish and deep sea habitat. The actions of both NZ and Australian fisheries management agencies in this case runs counter to the requirements of the FAO code of conduct 1995, particularly articles 7.5 and 8.2. Article 7.5, dealing with the need for caution, states: "in the case of new or exploratory fisheries, States should adopt as soon as possible cautious conservation and management measures..." (7.5.4). Article 8.2 dealing with flag State duties, makes it clear that responsibility for flagged fishing vessels extends to the high seas. The actions of the Australian and NZ governments also run counter to sections 2 and 4 of the Lysekil Statement (Attachment Two below) which require prior identification and assessment of negative impacts, and protection of the productive capacity of the resource. Further, the need for reference points set out in Annex II of the UN Fish Stocks Agreement (Attachment Five) appear to have been simply ignored by both governments.

It is also worth noting that Article 21(e) of the World Charter for Nature 1982 (a resolution of the UN General Assembly, supported by Australia) requires States, corporations and individuals to "safeguard and conserve nature in areas beyond national jurisdiction". Also of note is section 17.50 of Agenda 21 chapter 17 (the implementation strategy from the 1992 United Nations Rio de Janeiro Conference on Environment and Development): "States should ensure that fishing activities by vessels flying their flags on the high seas take place in a manner so as to minimize incidental catch." Section 17.74 of chapter 17 also committed supporting States (including Australia and New Zealand) to the protection of fragile habitats. These important provisions appear to have been entirely ignored by the Australian and NZ governments.

It is interesting to note that New Zealand had earlier submitted a paper to the UN Straddling Fish Stock Conference (co-authored by Argentina, Canada, Chile, and Iceland) (United Nations 1993) which proposed selected precautionary measures on the high seas, distinguishing between existing and newly discovered fisheries. *For existing fisheries*, the text suggested *inter alia* that: (a) TACs and effort limitations shall be established to maintain exploitation rates below the level of MSY and, where appropriate, to allow the stock to rebuild; (b) precautionary management thresholds shall be established at which pre-determined management courses of action should be taken; (c) where stocks decline over time, TACs and effort shall be reduced to arrest the decline and subsidies for fishing operations shall be stopped, and (d) by-catch limitations should be established and stocks of associated or dependent species should be maintained or restored. *For newly discovered stocks*, the text suggested also that: (a) early large-scale development of fisheries on newly discovered stocks shall be prohibited and limitations shall be applied immediately on effort and on Government assistance, and (b) precautionary Total Allowable Catches (TACs) and quotas shall be established below the MSY level. Four years later, the NZ fisheries management agency appears to have taken a contradictory, and much less conservative approach in regard to the newly discovered Orange Roughy fishery.

Garcia's (1995) recommendation also appears to have been ignored: "A reasonable precautionary approach, in such a case, should lead to agreement for a pilot fishery large enough to collect data and build up the scientific evidence required, but small enough to ensure that no irreversible effect is likely".

Failure of State fisheries management agencies to adequately control spearfishing:

Australian agencies responsible for regulating marine harvesting activities have been lulled into a false sense of security in relation to the impacts of spearfishing. While participation rates related to harvesting by recreational divers and snorkellers are low (in the order of 1 in 1000), and bycatch from such harvesting activities is also close to zero, there is strong

anecdotal evidence that the concentration of harvesting activities on shallow reef environments has caused major damage. Local extinctions have almost certainly occurred, perhaps widely, and entire reef ecosystems have been altered. A significant regional extinction (the eastern grey nurse shark) is approaching, brought on in large part by historical spearfishing pressures (Appendix Six).

According to Nevill (Appendix Six): "These impacts are significant in a national context, yet appear to have been ignored or under-estimated by both spearfishers and the government agencies charged with conserving and regulating marine environments - running counter to the voluntary *FAO Code of Conduct for Responsible Fisheries*. Current management of the sport of spearfishing in Australia fails accepted precautionary guidelines."

The South Australian abalone fishery: failure to apply a precautionary approach:

The Commonwealth of Australia accredited the South Australian abalone fishery under the EPBC Act in 2004 on the basis of their assessment (Commonwealth of Australia 2004 – referred to below as the DEH report) of the fishery. This assessment was based on an earlier assessment report by the SA government (Government of South Australia 2003 – referred to below as the PIRSA report) as well as stakeholder submissions during the review process.

An examination of the PIRSA and DEH accreditation reports indicates that the discussion of precautionary management is superficial in both the South Australian and Commonwealth reports, in spite of the statutory obligations (see Chapter 13 and Appendix Five) of the Commonwealth to ensure that fisheries under its control adopt a precautionary approach. The issue of defining management benchmarks in both qualitative and quantitative aspects is entirely ignored in both reports. As far as the PIRSA report goes, this is surprising given that Shepherd et al. 2001 had addressed the issue of precautionary management of the SA abalone fishery, making a number of detailed and carefully-argued recommendations. At the very least these recommendations should have been discussed in both assessment reports.

This apparently cavalier attitude to the precautionary approach is underlined by a comparison of the existing SA abalone management framework with FAO fishery guidelines. The voluntary *FAO Code of Conduct for Responsible Fisheries 1995*, echoing the *Rio Declaration 1992*, requires all compliant States to apply the precautionary approach. The FAO precautionary guideline (the Lysekil Statement²⁶¹) advocates (paragraph 7) that:

(a) all fishing activities have environmental impacts, and it is not appropriate to assume that these are negligible until proved otherwise,

and that:

(c) the precautionary approach to fisheries requires that all fishing activities be subject to prior review and authorization; that a management plan be in place that clearly specifies management objectives and how impacts of fishing are to be assessed, monitored and addressed; and that specified interim management measures should apply to all fishing activities until such time as a management plan is in place.

Given the high commercial value of the SA abalone fishery, and the sensitivity of abalone fisheries to overfishing (Shepherd et al. 2001) the failure of the South Australian fishery agency to develop management plans for the recreational harvesting of abalone, or to monitor effects and publish findings, appears to place the agency in contravention of the precautionary elements of the *Rio Declaration* and the *Code of Conduct* in this respect.

The Lysekil Statement contains a number of other recommendations, which are relevant to the management of the SA abalone fishery:

Para.	Recommendation	State fishing agency response
6b	Prior identification of undesirable outcomes and of measures that will avoid them or correct them promptly.	Recommendation ignored with respect to local serial overfishing (see Shepherd and Rodda 2001).
6c	Any necessary corrective measures are initiated without delay.	Ignored – see comment above.
6d	Where the likely impact of resource use is uncertain, priority should be given to conserving the productive capacity of the resource.	Ignored – see comment above.
25	For all fisheries, plans should be developed or revised to incorporate precautionary elements.	Ignored with respect to recreational abalone harvesting.
28	To be precautionary, priority should be accorded to restoration of overfished stocks, avoidance of overfishing, and avoidance of excessive harvesting capacity.	Ignored – see comment above (6b).
29	Targets identify the desired outcomes for the fishery. For example these may take the form of a target fishing mortality or a specified level of average abundance relative to the unfished state.	Mortality targets have not been established, other than relating to egg production. Relative abundance data is discussed only with respect to a few of many metapopulations.
33	Plans should include explicit effort-reduction measures that apply in response to unpredicted declines in recruitment.	Some areas (eg: Waterloo Bay) have been closed following population crashes.
41	Precautionary monitoring of fishing should seek to detect and observe a variety of ancillary impacts, eg: environmental changes, fish habitat degradation...	Ignored with respect to determining environmental and ecological impacts through the establishment of no-take areas (see Lysekil para 37).

In conclusion, the PIRSA abalone management regime, as described in the PIRSA assessment, fails to meet several important accepted precautionary benchmarks. The management regime has not adopted a precautionary approach.

Ecosystem-based fisheries management: taking account of seabirds as predators:

As already mentioned, Australia endorsed the FAO Code of Conduct for Responsible Fisheries 1995 – requiring ecosystem-based fishery management (EBM). Australia’s Ocean Policy 1998 and Australia’s Fisheries Policy 2003 require the application of both EBM and the precautionary approach.

However, neither approach is being effectively applied in regard to the protection of pelagic seabirds in Australia’s ocean jurisdiction. According to Baker et al. (2002:84), under the heading “over-extraction of prey species”:

Responsibility for ensuring the ecological sustainability of fisheries in Australia rests with the Australian Fisheries Management Authority (AFMA). Activities of AFMA are governed and guided by legislative objectives contained in the *Fisheries Management Act 1991*. One objective of the Act is to ensure that exploitation of fisheries resources is conducted in a manner consistent with principles of ecologically sustainable development and the exercise of the precautionary principle — in particular, the need to have regard to the impact of fishing activities

on non-target species and the long-term sustainability of the marine environment. *To date, we know of no Australian fishery where this principle has been applied to consider the resource requirements of seabirds where they compete directly with a targeted fishery species, such as squid, jack mackerel or pilchards [my emphasis].*

In their concluding comments dealing with the ongoing survival of seabird populations, Baker et al (2002:90) recommend: "The Australian Fisheries Management Authority must take into account the resource requirements of seabirds when they are determining total allowable catches for fisheries that are also utilized extensively as prey species by albatrosses and petrels."

Introduced pests: use of comprehensive ecosystem-based control strategies

The preservation of the number, types and relative abundance of resident species can enhance invasion resistance in a wide range of natural and semi-natural ecosystems. *Millennium Ecosystem Assessment: biodiversity synthesis (2005:25).*

Introduced marine organisms pose a serious threat to national coastal ecosystems (Australian Senate ECITA References Committee 2004). Steve Raaymakers, an Australian on staff to the International Maritime Organisation (IMO) stated: "the global economic impacts of invasive marine species have not been quantified but are likely to be in the order of tens of billions of US dollars a year" (Raaymakers 2003). This may be an underestimate. The Association of Australian Ports and Marine Authorities²⁶², quoting information from the Global Ballast Water Program, state: "It is estimated that the cost of all invasive species exceeds US\$138 billion per year in the USA alone". Costanza et al. (1997) estimated the total value of the annual goods and services provided by healthy marine and coastal ecosystems at US\$10.6 trillion. It appears that a careful cost estimate of the effects of introduced marine pests on the Australian economy has not yet been prepared; however the costs and future risks are undoubtedly high.

The management of threats posed by invasive organisms is complex, and the Commonwealth's current approach is in many respects comprehensive, if belated (further information at <http://www.deh.gov.au/coasts/imps/index.html>). The central strategy is four-pronged: risk-based prevention, surveillance, emergency response, and ongoing management once invasive species are established. In a general sense it would be possible to argue that the precautionary principle was being applied, at least in the philosophy underpinning the overall approach. While Commonwealth and State governments are taking actions aimed at reducing risks of invasion from hull fouling and ballast water dumping, these approaches will be only partially effective – the approach is one of 'cost-effective' risk minimisation. Once established, invasions are usually impossible to eradicate, and difficult and expensive to control. The apparent eradication of the black-striped mussel *Mytilopsis sp.* from Darwin Harbour in 1999 (at a cost of \$m 2.4) is an outstanding exception to the usual rule.

The Commonwealth Government has proposed a National System for the Prevention and Management of Marine Pest Incursions, and has developed an InterGovernmental Agreement which may be endorsed by most State Governments (Commonwealth of Australia 2005b). Preventative actions feature as part of this general approach, including a watch list and pre-border measures, for example a CSIRO survey of the ports of Australia's trading partners to identify high-risk invasive marine species.

By their nature, marine invasions start with very small populations. Small populations are vulnerable to extinction. The chances of such extinctions are increased where native herbivores and predators are abundant. It is widely accepted that exotic invasions occur more readily in depauperate or damaged ecosystems (Elton 1958, McCann 2000).

Excessive harvesting of native marine organisms commonly occurs worldwide, and can cause severe damage to local ecosystems (Jackson et al. 2001). Comparative studies of the abundance of harvested marine animals inside and outside marine protected areas often show that abundances are much higher inside MPAs, as expected in these circumstances

(see, for example Edgar & Barrett 1999, or reviews such as those by Roberts & Hawkins 2000). Animals such as the heavy-harvested rock lobster, as well as many fish species, prey on the larval and juvenile stages of a variety of marine organisms.

A widely-expressed view is that not enough is being done in Australia to control invasive marine species. According to the Australian *Invasive Species Council*:

...in general, the focus and scale of resourcing by the government on the invasive marine pest problem has not been commensurate with the scale of the threats. In particular, the government has failed to address the problems posed by biofouling of vessels. In addition, although the government established a marine pest centre, it is not adequately funding it or requiring that the industry primarily responsible for invasive marine pests contribute to research to resolve or manage the problems.

(Invasive Species Council, *Submission 33b*, p. 3, quoted in Australian Senate ECITA References Committee 2004).

The precautionary approach states that, where the potential for damage is high, lack of scientific certainty should not deter preventative action. The establishment of no-take marine protected areas in ports and their buffer zones, specifically to protect against invasive species, is one obvious management strategy for minimising the risks posed by introduced marine organisms. It is notable, however, that this strategy is not being recommended, investigated or pursued by any Australian jurisdiction at this stage (see the InterGovernmental Agreement - Commonwealth of Australia 2005b). More-over, it does not appear to be recommended or promoted by any Australian scientific or conservation organisation (HLG 2003; Australian Senate ECITA References Committee 2004).

This remains the case, despite the recommendations of scientists such as Dr Ron Thresher (CSIRO Marine Research):

The best and most cost-effective defence against new invaders is a healthy marine biota in ports – the ‘invader unfriendly port’ concept. We need to improve port conditions and develop methods of re-seeding disturbed environments with native, invader-resistant species (Thresher 2003).

Thresher’s views echo those of Scheffer et al (2001). In discussing trophic cascades and catastrophic shifts in ecosystems, the authors state: “Although diverse events can trigger such shifts, recent studies show that a loss of resilience usually paves the way for a switch to an alternative state. This suggests that strategies for sustainable management of such ecosystems should focus on maintaining resilience”.

It appears that a precautionary approach is not being adopted by Commonwealth or State governments on this issue. While there are obvious questions of costs and benefits (and their time-scales) as well as public acceptance, it would appear that the issue of no-take areas within and around major ports should at least be thoroughly investigated and discussed at academic, agency and public levels. It may be that such a strategy would provide relatively low-cost ‘insurance’ against damaging invasions by alien marine species.

Listing of species as threatened under international, Commonwealth or Australian State protective mechanisms

According to Jeffrey Hutchings (2000) (my emphasis below):

Over-exploitation and subsequent collapse of marine fishes has focused attention on the ability of affected populations to recover to former abundance levels and on the degree to which their persistence is threatened by extinction. Although potential for recovery has been assessed indirectly, actual changes in population size following long-term declines have not been examined empirically. Here I show that there is very little evidence for rapid recovery from prolonged declines, in contrast to the perception that marine fishes are highly resilient to large population reductions. With the possible exception of herring and related species that mature early in life and are fished with highly selective equipment, my analysis of 90 stocks

reveals that many gadids (for example, cod, haddock) and other non-clupeids (for example, flatfishes) have experienced little, if any, recovery as much as 15 years after 45–99% reductions in reproductive biomass. Although the effects of overfishing on single species may generally be reversible, the actual time required for recovery appears to be considerable. *To exempt marine fishes from existing criteria used to assign extinction risk would be inconsistent with precautionary approaches to fisheries management and the conservation of marine biodiversity.*

Retaining resilience: ecosystem based fishery management and the need to protect against catastrophic shifts in ecosystems

According to Scheffer et al. 2001 (my emphasis):

All ecosystems are exposed to gradual changes in climate, nutrient loading, habitat fragmentation or biotic exploitation. Nature is usually assumed to respond to gradual change in a smooth way. However, studies on lakes, coral reefs, oceans, forests and arid lands have shown that smooth change can be interrupted by sudden drastic switches to a contrasting state. Although diverse events can trigger such shifts, recent studies show that a loss of resilience usually paves the way for a switch to an alternative state. *This suggests that strategies for sustainable management of such ecosystems should focus on maintaining resilience.*

A2.11 Concluding comments:

There appear to be a small number of instances where the Australia Commonwealth Government, and some State Governments, have applied the precautionary principle to ocean management issues. However, these examples are overshadowed by a number of important examples where the principle has not been applied, even though its application was warranted. In some of these cases it can be argued that application of the principle was *required* by either national or international commitments and obligations. If this argument is accepted, serious doubts must be raised as to the effectiveness of procedures applied by both the Commonwealth and the States in relation to sustainable ocean management, given the importance of the principle and its elevated place in Commonwealth and State policies and statutes.

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ATTACHMENTS

A2 Attachment One: Article 7.5, FAO Code of Conduct:

Extract: Article 7.5 Precautionary approach

7.5.1 States should apply the precautionary approach widely to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment. The absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures.

7.5.2 In implementing the precautionary approach, States should take into account, inter alia, uncertainties relating to the size and productivity of the stocks, reference points, stock condition in relation to such reference points, levels and distribution of fishing mortality and the impact of fishing activities, including discards, on non-target and associated or dependent species, as well as environmental and socio-economic conditions.

7.5.3 States and subregional or regional fisheries management organizations and arrangements should, on the basis of the best scientific evidence available, inter alia, determine:

- a. stock specific target reference points, and, at the same time, the action to be taken if they are exceeded; and
- b. stock-specific limit reference points, and, at the same time, the action to be taken if they are exceeded; when a limit reference point is approached, measures should be taken to ensure that it will not be exceeded.

7.5.4 In the case of new or exploratory fisheries, States should adopt as soon as possible cautious conservation and management measures, including, inter alia, catch limits and effort limits. Such measures should remain in force until there are sufficient data to allow assessment of the impact of the fisheries on the long-term sustainability of the stocks, whereupon conservation and management measures based on that assessment should be implemented. The latter measures should, if appropriate, allow for the gradual development of the fisheries.

7.5.5 If a natural phenomenon has a significant adverse impact on the status of living aquatic resources, States should adopt conservation and management measures on an emergency basis to ensure that fishing activity does not exacerbate such adverse impact. States should also adopt such measures on an emergency basis where fishing activity presents a serious threat to the sustainability of such resources. Measures taken on an emergency basis should be temporary and should be based on the best scientific evidence available.

A2.Attachment Two: Summary, FAO Lysekil Statement 1995:

Summary statement by the FAO Technical Consultation on the Precautionary Approach to Capture Fisheries, held in Lysekil, Sweden 6-13 June 1995. Source: FAO 1995.

The Technical Consultation on the Precautionary Approach to Capture Fisheries, held in Lysekil, Sweden, 6–13 June 1995 (FAO, 1995), elaborated the following statement which could provide a useful operational summary of the approach: Within the framework outlined in Article 15 of the UNCED Rio Declaration, the precautionary approach to fisheries recognises that fisheries systems are slowly reversible, poorly controllable, not well understood, and subject to changing human values. The precautionary approach involves the application of prudent foresight. Taking account of the uncertainties in fisheries systems, and the need to take action with incomplete knowledge, it requires, *inter alia*:

- 1) consideration of the needs of future generations and avoidance of changes that are not potentially reversible;
- 2) prior identification of undesirable outcomes and measures that will promptly avoid or correct them;
- 3) that any necessary corrective measures are initiated without delay, and that they should achieve their purpose promptly, on a timescale not exceeding two or three decades;
- 4) that where the likely impact of resource use is uncertain, priority should be given to conserving the productive capacity of the resource;
- 5) that harvesting and processing capacity should be commensurate with estimated sustainable levels of resource and that increases in capacity should be further constrained when resource productivity is highly uncertain;
- 6) all fishing activities must have prior management authorization and be subject to periodic review;
- 7) an established legal and institutional framework for fishery management, within which management plans that implement the above points are instituted for each fishery, and
- 8) appropriate placement of the burden of proof by adhering to the requirements above.

A2 Attachment Three: Guidelines, FAO Lysekil Statement 1995:

Guidelines on the precautionary approach to capture fisheries and species introductions. FAO Fisheries Technical paper No. 350, Part 1. FAO, Rome.

Section 4. Precautionary approach to fishery research.

51. Application of the precautionary approach to fishery management depends on the amount, type and reliability of information about the fishery and how this information is used to achieve management objectives. The precautionary approach to fishery management is applicable even with very limited information. Research to increase information about a fishery usually increases potential benefits while reducing the risk to the resource. The scientific and research input that is required for the precautionary approach to fisheries is considered under the following headings; management objectives, observations and information base, stock assessment and analysis and decision processes.

4.1 The Role of Research in Establishing Management Objectives

52. There is a valid scientific role in helping managers develop objectives, so that scientific input to the overall management process is as effective as possible in achieving management intent. The precautionary approach requires continuing and anticipatory evaluation of the consequences of management actions with respect to management objectives. Scientific evaluation of consequences with respect to management objectives requires explicit definition of quantifiable criteria for judgement. An important scientific contribution is in the development of operational targets, constraints and criteria that are both scientifically usable and have management relevance.
53. Research is required to help formulate biological objectives, targets and constraints regarding the protection of habitat, the avoidance of fishing that significantly reduces population reproductive capacity, and reduces the effects of fishing on other (e.g., non-target) species. Combined with biological research, research on socio-economics and the structure of fishing communities is needed to formulate management objectives.
54. Until stock specific research leads to the establishment of alternative operational target based on research and practical experiences, a precautionary approach would seek to: (a) maintain the spawning biomass at a prudent level (i.e., above 50% of its unexploited level), (b) keep the fishing mortality rate relatively low (i.e., below the natural mortality rate), (c) avoid intensive fishing on immature fish, (d) protect the habitat.

4.2 Observation Processes and Information Base

55. A precautionary approach to fisheries requires explicit specification of the information needed to achieve the management objectives, taking account of the management structure, as well as of the processes required to ensure that these needs are met. Periodic evaluation and revision of the data collection system is necessary.
56. A precautionary approach would include mechanisms to ensure that, at a minimum, discarded catch, retained catch and fishing effort data are accurate and complete. These mechanisms could include use of observers and identification of incentives for industry co-operation.
57. Recognizing that resource users have substantial knowledge of fisheries, a precautionary approach makes use of their experience in developing an understanding of the fishery and its impacts.
58. The precautionary approach is made more effective by development of an understanding of the sources of uncertainty in the data sampling processes,

and collection of sufficient information to quantify this uncertainty. If such information is available it can be explicitly used in the management procedure to estimate the uncertainty affecting decisions and the resulting risk. If such information is not available, a precautionary approach to fishery management would implicitly account for the unknown uncertainty by being more conservative.

59. Precautionary fishery monitoring is part of precautionary research. It includes collection of information to address issues and questions that are not only of immediate concern but which may reasonably be expected to be important for future generations on in case objectives are changed. Information should be collected on target species, bycatch, harvesting capacity, behaviour of the fishery sector, social and economic aspects of the fishery, and ecosystem structure and function. Measures of resource status independent of fishery data are also highly desirable.
60. The precautionary approach relies on the use of a history of experience with the effects of fishing, in the fishery under consideration and/or similar fisheries, from which possible consequences of fishing can be identified and used to guide future precautionary management. This requires that both data and data collection methods are well documented and available.
61. There are many management processes and decision structures used throughout the world, such as regional management bodies, co-management, community-based management, and traditional management practices. Research is needed to determine the extent to which different management processes and decision structures promote precaution.

4.3 Assessment Methods and Analysis

62. Biological reference points for overfishing should be included as part of a precautionary approach.
63. A precautionary approach specifically requires a more comprehensive treatment of uncertainty than is the current norm in fishery assessment. This requires recognition of gaps in knowledge, and the explicit identification of the range of interpretations that is reasonable given the present information.
64. The use of complementary sources of fishery information should be facilitated by active compilation and scientific analysis of the relevant traditional knowledge. This should be accompanied by the development of methods by which this information can be used to develop management advice.
65. Specifically the assessment process should include:
 - a. scientific standards of evidence (objective, verifiable and potentially replicable), should be applied in the evaluation of information used in analysis;
 - b. a process for assessment and analysis that is transparent, and
 - c. periodic, independent, objective and in-depth peer review as a quality assurance.
66. A precautionary approach to assessment and analysis requires a realistic appraisal of the range of outcomes possible under fishing and the probabilities of these outcomes under different management actions. The precautionary approach to assessment would follow a process of identifying alternative possible hypotheses or states of nature, based on the information available, and examining the consequences of proposed management actions under each of these alternative hypotheses. This process would be the same in data-rich and data-poor analyses. A precautionary assessment would, at the very least, aim to consider: (a) uncertainties in data; (b) specific alternative hypotheses about underlying biological, economic and social processes, and (c) calculation of the theoretical response of the system to a range of alternative management actions. A checklist of issues for consideration under these headings is found in the following paragraphs.
67. Sources of uncertainty in data include: (a) estimates of abundance; (b) model structure; (c) parameter values used in models; (d) future environmental conditions; (e) effectiveness of implementation of management measures; (f)

- future economic and social conditions; (g) future management objectives, and (h) fleet capacity and behaviour.
68. Specific alternative hypotheses about underlying biological, economic and social processes to be considered include: (a) depensatory recruitment or other dynamics giving rapid collapse; (b) changes in behaviour of the fishing industry under regulation, including changes in coastal community structure; (c) medium-term changes in environmental conditions; (d) systematic underreporting of catch data; (e) fishery-dependent estimates of abundance not being proportional to abundance; (f) changes in price or cost to the fishing industry; and (g) changes in ecosystems caused by fishing.
 69. In calculating (simulating) the response of the system to a range of alternative management actions, the following should be taken into account:
 - a. short-term (1–2y) projections alone are not sufficient for precautionary assessment; time frames and discount rates appropriate to inter-generational issues should be used, and
 - b. scientific evaluation of management options requires specification of operational targets, constraints and decision rules. If these are not adequately specified by managers, then precautionary analysis requires that assumptions be made about these specifications, and that the additional uncertainty resulting from these assumptions be calculated. Managers should be advised that additional specification of targets, constraints and decision rules are needed to reduce this uncertainty.
 70. Methods of analysis and presentation will differ with circumstances, but effective treatment of uncertainty and communication of the results are necessary in a precautionary assessment. Some approaches (see also the Appendix to this section) that could prove useful are:
 - a. where there are no sufficient observations to assign probabilities to different states of nature that have occurred, decision tables could be used to represent different degrees of management caution through the Maximin and Minimax criteria;
 - b. where the number of different states of nature and the number of potential management actions considered are small, but probabilities can be assigned, decision tables can be used to show the consequences and probabilities of all combinations of these, and
 - c. where the range of states of nature is large, the evaluation of management procedures is more complex, requiring integration across the various sources of uncertainty.
 71. A precautionary approach to analysis would examine the ability of the data collection system to detect undesirable trends. When the ability to detect trends is low, management should be cautious.
 72. Since concern regarding the reversibility of the adverse impacts of fishing is a major reason for a precautionary approach, research on reversibility in ecosystems should be an important part of developing precautionary approaches.

A2 Attachment Four: Article 6, Fish Stocks Agreement 1995:

Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, *New York 1995*.

Article 6: Application of the precautionary approach

- 1 States shall apply the precautionary approach widely to conservation, management and exploitation of straddling fish stocks and highly migratory fish stocks in order to protect the living marine resources and preserve the marine environment.
- 2 States shall be more cautious when information is uncertain, unreliable or inadequate. The absence of adequate scientific information shall not be used as a reason for postponing or failing to take conservation and management measures.
- 3 In implementing the precautionary approach, States shall:
 - (a) improve decision-making for fishery resource conservation and management by obtaining and sharing the best scientific information available and implementing improved techniques for dealing with risk and uncertainty;
 - (b) apply the guidelines set out in Annex II and determine, on the basis of the best scientific information available, stock-specific reference points and the action to be taken if they are exceeded;
 - (c) take into account, *inter alia*, uncertainties relating to the size and productivity of the stocks, reference points, stock condition in relation to such reference points, levels and distribution of fishing mortality and the impact of fishing activities on non-target and associated or dependent species, as well as existing and predicted oceanic, environmental and socio-economic conditions; and
 - (d) develop data collection and research programs to assess the impact of fishing on non-target and associated or dependent species and their environment, and adopt plans which are necessary to ensure the conservation of such species and to protect habitats of special concern.
- 4 States shall take measures to ensure that, when reference points are approached, they will not be exceeded. In the event that they are exceeded, States shall, without delay, take the action determined under paragraph 3(b) to restore the stocks.
- 5 Where the status of target stocks or non-target or associated or dependent species is of concern, States shall subject such stocks and species to enhanced monitoring in order to review their status and the efficacy of conservation and management measures. They shall revise those measures regularly in the light of new information.
- 6 For new or exploratory fisheries, States shall adopt as soon as possible cautious conservation and management measures, including, *inter alia*, catch limits and effort limits. Such measures shall remain in force until there are sufficient data to allow assessment of the impact of the fisheries on the long-term sustainability of the stocks, whereupon conservation and management measures based on that assessment shall be implemented. The latter measures shall, if appropriate, allow for the gradual development of the fisheries.
- 7 If a natural phenomenon has a significant adverse impact on the status of straddling fish stocks or highly migratory fish stocks, States shall adopt conservation and management measures on an emergency basis to ensure that fishing activity does not exacerbate such adverse impact. States shall also adopt such measures on an emergency basis where fishing activity presents a serious threat to the sustainability of such stocks. Measures taken on an emergency basis shall be temporary and shall be based on the best scientific evidence available.

A2 Attachment Five: Annex II, Fish Stocks Agreement 1995:

Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks
New York, 4 December 1995

ANNEX II

GUIDELINES FOR THE APPLICATION OF PRECAUTIONARY REFERENCE POINTS IN CONSERVATION AND MANAGEMENT OF STRADDLING FISH STOCKS AND HIGHLY MIGRATORY FISH STOCKS:

1. A precautionary reference point is an estimated value derived through an agreed scientific procedure, which corresponds to the state of the resource and of the fishery, and which can be used as a guide for fisheries management.
2. Two types of precautionary reference points should be used: conservation, or limit, reference points and management, or target, reference points. Limit reference points set boundaries which are intended to constrain harvesting within safe biological limits within which the stocks can produce maximum sustainable yield. Target reference points are intended to meet management objectives.
3. Precautionary reference points should be stock-specific to account, *inter alia*, for the reproductive capacity, the resilience of each stock and the characteristics of fisheries exploiting the stock, as well as other sources of mortality and major sources of uncertainty.
4. Management strategies shall seek to maintain or restore populations of harvested stocks, and where necessary associated or dependent species, at levels consistent with previously agreed precautionary reference points. Such reference points shall be used to trigger pre-agreed conservation and management action. Management strategies shall include measures which can be implemented when precautionary reference points are approached.
5. Fishery management strategies shall ensure that the risk of exceeding limit reference points is very low. If a stock falls below a limit reference point or is at risk of falling below such a reference point, conservation and management action should be initiated to facilitate stock recovery. Fishery management strategies shall ensure that target reference points are not exceeded on average.
6. When information for determining reference points for a fishery is poor or absent, provisional reference points shall be set. Provisional reference points may be established by analogy to similar and better-known stocks. In such situations, the fishery shall be subject to enhanced monitoring so as to enable revision of provisional reference points as improved information becomes available.
7. The fishing mortality rate which generates maximum sustainable yield should be regarded as a minimum standard for limit reference points. For stocks which are not overfished, fishery management strategies shall ensure that fishing mortality does not exceed that which corresponds to maximum sustainable yield, and that the biomass does not fall below a predefined threshold. For overfished stocks, the biomass which would produce maximum sustainable yield can serve as a rebuilding target.

A2 Attachment Six: Principles and Decision Rules (Garcia 1995):

Extract from Garcia 1995: Section 7.2.

Once agreement has been reached on what risk and what levels of impact are acceptable, one of the major tasks for research and management is to develop agreement on standards, rules, reference points and critical thresholds by reference to which decisions will be made to meet the selected management objectives and the requirements of the 1982 Convention, UNCED Agenda 21 and the FAO Code of Conduct. Over-restrictive rules (e.g., rules implying socio-economic consequences without proportion to the risks involved) or recommended without a clear understanding of their practical implications, are not likely to lead to the level of consensus required for the wide application of a precautionary approach required in UNCED Principle 15.

Because of the universality of conservation principles, precautionary management rules need to be established for all resources whether in EEZs or in the high seas. Because of the transboundary nature of many high seas resources, straddling stocks and highly migratory species, precaution should be applied across the entire area of distribution of the stock. This implies that coherent precautionary management regimes should be put in place, taking into account the geographical location of critical life phases (e.g., nursery, feeding or spawning areas) and ensuring that the measures taken inside the EEZs, and outside them, are coherent and are, overall, conducive to stock sustainability at safe levels of abundance. The following list gives some examples of principles or decision rules that have been proposed in the literature with a view to illustrating both the need for them and the difficulty of defining them in realistic terms:

- 1) fisheries should not result in the decrease of any population of marine species below a level close to that which ensures the greatest net annual increment of biomass;
- 2) fisheries should not catch amounts of either target or non-target species that will result in significant changes in the relationship among any of the key components of the marine ecosystem of which they are part;
- 3) the mortality inflicted on any target or non-target species is unacceptable if it exceeds the level that would, when combined with other sources of mortality, result in a total level that is not sustainable by the population in the long term;
- 4) fish management authorities should set target species catch levels in accordance with the requirement that fishing does not exceed ecologically sustainable levels for both target and non-target species;
- 5) fisheries management should take into account the combined stresses imposed by fishing, habitat loss and destruction, point and non-point sources of pollution, climate change, ozone level changes and other environmental and human impacts, and
- 6) fishery management should preserve the evolutionary potential of aquatic species.

Garcia continues to examine the advantages and disadvantages of these approaches, and finally concludes:

In summary, a precautionary strategy would have to be consistent with the internationally agreed principles of sustainable development included in the 1982 Law of the Sea Convention, the Rio Declaration 1992, the UN Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks 1995, and in the FAO International Code of Conduct for Responsible Fisheries 1995 and would, *inter alia*:

- prohibit any fishing that is not explicitly authorized;
- reflect precaution in the explicitly stated objectives;
- develop an independent and effective research capacity;
- be based on the best scientific evidence, taking account of uncertainty;
- consider all potential management alternatives and their consequences;
- adopt a broad range of management reference points;

- agree on acceptable (tolerable) levels of impact and risk;
- adopt action-triggering thresholds and pre-agree on courses of action;
- integrate them in a management strategy (and management plan);
- aim at preserving flexibility at all levels;
- introduce impact assessment and recurrent evaluation of management;
- implement experimental management and development strategies;
- improve participation (including non-fishery users);
- establish explicit user-rights;
- improve decision-making procedures;
- promote the use of more responsible technology;
- strengthen monitoring, control and surveillance;
- raise enforcement to effectively deterrent levels, and
- institutionalize transparency and accountability.

A2 Attachment Seven: Guidelines from Garcia (1995):

Practical Guidelines (s 7.4)

In most fishery systems, a progressive but systematic and decisive shift towards more risk-averse exploitation and management regimes is advisable. This implies that precautionary measures for fisheries management should be widely used as a means to avoid crises and reduce long-term costs to society. Because uncertainty is pervasive in the ocean ecosystem and fisheries, precaution should become an integral part of fishery management systems, to be applied routinely in decision making.

Unnecessarily stringent and costly measures, should be avoided as they would rapidly become counter-productive by deterring fishery authorities from using the concept as widely as possible and discrediting the approach among industry.

A precautionary management strategy would need both a sufficient *preventive capacity* to avoid predictable problems, and enough *reactive (corrective) capacity*, flexibility and adaptability to ensure a safe “trial-and-error” process, as knowledge about how the system works is collected. It should recognize the uncertainties in the data and promote adaptability and flexibility of management regimes through appropriate institutions and decision-making processes. It would rely not only on expert advice but also on people's participation. As stated by Holling (1994) “*effective investments in a sustainable biosphere are therefore ones that simultaneously retain and encourage the adaptive capabilities of people, of business enterprises and of nature*”. In case of doubt, decisions should “err on the safe side” with due regard to the risk for the resource and the social and economic consequences.

A fishery management policy based on a reasonable interpretation of the concept of precaution should: (a) explicitly adopt the principle of sustainable development as defined by the FAO Conference (given in the introduction to this appendix); (b) explicitly state a set of objectives that are compatible with this principle, and (c) adopt a precautionary approach based on the following measures:

Promotion and use of research

1. Promote research in support of the precautionary approach to management, e.g., research aimed at understanding better the conservation requirements of the ecosystem, biodiversity, species and genetic levels as well as research towards a better definition of management reference points, including economic ones.
2. Use the best scientific evidence available and, if it is not sufficient, invest in emergency research while interim management measures are taken at the level required to limit risk of irreversible damage.
3. Improve information systems commensurate with the level of risk, covering costs through fishing fees as required, addressing all resources, directly or indirectly affected and promoting joint research programmes in international and regional arrangements.
4. Experiment with management strategies and pilot development projects with the support of research, generalizing the use of Environmental Impact Assessment (EIA).

Reference points, rules and criteria

5. Adopt a set of objectives for the fishery and a related set of reference points (broader than the traditional MSY) and management benchmarks, and use the latter to measure the efficiency of the management system (e.g., in terms of

- achieving production targets, controlling fleet capacity, and maintaining spawning stock size or recruitment levels).
6. When alternative options are considered, adopt a risk-averse attitude, considering *a priori* that: (a) fisheries are likely to have a negative impact on the resource, and (b) risk of unacceptable or irreversible impact should be minimized.
 7. Ensure that precautionary management plans specify, *inter alia*, the data to be collected and used for management and their precision, the methods of stock assessment, the decision rules and reference points needed for determining and initiating management measures as well as contingency measures to be taken in case of danger for the resource.
 8. Adopt provisional reference points when data are poor or lacking, establishing them by analogy with other similar and better known fisheries and updating/revising them as additional information becomes available.
 9. View Maximum Sustainable Yield (MSY) as a minimum international standard, ensuring that fishing mortality does not exceed the level needed to produce it and that stock biomass is maintained above it (or rebuilt at least at this level).
 10. Adopt precautionary management reference points defined on the basis of agreed scientific procedure and models, including Target Reference Points (TRPs) and Limit Reference Points (LRPs). Because of the uncertainty inherent in their determination, these reference points should preferably be expressed in statistical terms (i.e., with a central value and a confidence interval).
 11. Adopt action-triggering thresholds and management strategies which include pre-agreed courses of action, automatically implemented if the stock or the environment approaches or enters a critical state as defined by pre-agreed rules, criteria and reference points.
 12. Adopt Threshold Reference Points (ThRP) where specific conditions require added precaution, to indicate that the state of a fishery and/or a resource is approaching a TRP or a LRP and that a certain type of action (preferably agreed beforehand) is to be taken, to avoid (or reduce the probability) to accidentally go beyond the selected TRPs or LRPs.
 13. Ensure that management action maintains the stock around the selected TRP on average (e.g., through establishment of total allowable catches and quotas or through effort controls) and that the probability of exceeding the target, and the extent by which it is exceeded, are kept at acceptable levels.
 14. Severely curtail or stop fishery development, as appropriate, when the probability of exceeding the adopted LRP is higher than a pre-agreed level and take any corrective action deemed necessary. If the LRP is indeed exceeded, implement a stock rehabilitation programme using the LRP as a minimum rebuilding target to be reached before the rebuilding measures are relaxed or the fishery is re-opened.
 15. Bring into force, "automatically" the set of pre-established measures, or courses of action, when a ThRP is reached particularly in cases or situations involving high risk.
 16. Ensure that selected reference points are robust to short- and long-term fluctuations in fish stocks due to recruitment variability and other factors and that they are periodically re-assessed as new data is collected and new understanding or methods become available.
 17. For newly discovered stocks, establish safe biological limits (in absolute or relative terms) and threshold reference points from the onset; prohibit large scale development; limit removals, through effort and catch limitations and resource allocation schemes, to a fraction of the stock well below annual natural mortality; set-up monitoring and assessment programmes on the target and associated species.
 18. Aim at maintaining the fundamental components of the ecosystem (nurseries, spawning areas, feeding areas, migration routes, etc.), minimizing their degradation and, where possible, re-establishing them in order to ensure permanency of the ecosystem structure and productivity mechanisms even

though the abundance (or even the permanence) of some of its species components cannot be absolutely warranted.

Acceptable impacts

19. Promote discussion and agreement on acceptable levels of impact (and risk) in a process that will identify trade-offs and promote transparency, particularly in relation to public opinion.
20. Take into account the combined stresses of fishing and environment on resources. Effort reductions may be imposed or special measures affecting fisheries taken when the stock faces unusually unfavourable environmental conditions.
21. Address as far as possible all combined stresses to the resource, including those imposed by non-fishing activities or related to natural fluctuations.
22. Prohibit irreversible impacts as well as decrease of any population of marine species below the which ensures the greatest net annual increment of biomass (i.e., the MSY level). For overfished fisheries, an important objective should be to rebuild the stock at least to that level.
23. Set catch and effort levels for target species in accordance with the requirement that they do not result in unsustainable levels of mortality for both target and non-target species.

Management framework

24. Manage fisheries in the context of integrated management of coastal areas, raising sectoral awareness about exogenous impacts on the state of the resources and on fisheries productivity.
25. Improve public awareness, as well as consultation of non-fishery users, taking all interests into account when developing and managing fisheries, as required in Agenda 21, improving management transparency and reporting procedures.
26. Improve decision-making procedures, replacing consensus decision-making by voting procedures wherever possible.
27. Strengthen monitoring, control and surveillance, thereby improving detection and enforcement capacity (including legal tools), raising penalties to deterrent levels, and exerting more effectively the responsibilities pertaining to the flag or the port States.
28. Avoid overburdening of management systems and industry by limiting the number of precautionary devices and measures implemented at all times, based on an analysis of the probability of occurrence of negative impacts of a certain magnitude, pre-agreed as part of the management scheme and reflected in appropriate reference points.
29. Establish safety-net arrangements (e.g., in terms of insurance, compensation, etc.) to protect the users from the consequences of exceptional hazardous occurrences.
30. Establish precautionary management regimes for all resources, across their whole area of distribution, whether in EEZs, in the high seas, or both (high seas, straddling and highly migratory resources).

A2 Endnotes:

²²⁶ Principle 15 of the Rio Declaration 1992 is one of the most widely quoted definitions: “Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation”.

²²⁷ Cooney (2004) discusses early application of the principle in the recommendations of the ministerial conferences on North Sea pollution in the late 1970s, which explicitly acknowledged the need to reverse the onus of proof. See also the discussion in Dayton 1998.

²²⁸ For example, it appears in the *World Charter for Nature 1982*, a resolution of the General Assembly of the United Nations, endorsed by the Australian Government. The Charter places a non-binding obligation on both States and individual persons within those States to apply the precautionary principle (amongst other matters). According to Cooney (2004) “the precautionary principle is widely recognised as emerging from the *Vorsorgeprinzip* (directly translated as “fore-caring” or “foresight” principle) of German domestic law (von Moltke, 1988), although it has earlier antecedents in Swedish law (Sands, 2000)”.

²²⁹ See, for example, the Australia’s *National Strategy for Ecologically Sustainable Development 1992*, and the *InterGovernmental Agreement on the Environment 1992*. Kriwoken et al. 2001 discuss other national and state examples of endorsement of the principle.

²³⁰ The precautionary principle is in some ways an expansion of the English common law concept of ‘duty of care’ originating in the decisions of the judge Lord Esher in the late 1800s. As discussed in the footnote above, it is also related to early concepts in Swedish and German law. According to Lord Esher: “Whenever one person is by circumstances placed in such a position with regard to another that everyone of ordinary sense who did think, would at once recognise that if he did not use ordinary care and skill in his own conduct with regard to those circumstances, he would cause danger or injury to the person, or property of the other, a duty arises to use ordinary care and skill to avoid such danger”. This statement clearly contains elements of foresight and responsibility, but does not refer to a lack of certainty, as the word “would” is used rather than “might”, or “could”. A second important difference is that the duty of care applies only to people and property, not to the environment (Wikipedia 4/7/08).

²³¹ See, for example, Justice CJ Preston (2006) *Telstra Corporation Limited v Hornsby Shire Council*, New South Wales Land and Environment Court 133, 24 March 2006, para 161.

²³² United Nations Conference on the Environment and Development, Rio, 1992.

²³³ Including the 200 nautical mile Exclusive Economic Zone, and, where declared, the extended 350 nm zone over Australian continental shelf.

²³⁴ Australia has a three-tiered government structure – comprising the federal or Commonwealth level, which represents the nation in international fora, followed by the State/Territory level (six States and two Territories), followed by the local government level. Under the Australian Constitution the States have primary responsibility for natural resource management within their jurisdiction. Many fisheries which cross the State/Commonwealth nautical boundaries (~ 3 nm) are managed by either the State or the Commonwealth under the provisions of the Offshore Constitutional Settlement (OCS).

²³⁵ The purpose of the Offshore Constitutional Settlement (OCS) is to provide a single responsible jurisdiction for fisheries which overlap Commonwealth and State jurisdictions. About 140 OCS Agreements are in place.

²³⁶ Emphasis added.

²³⁷ At least within the Australian Exclusive Economic Zone. Some fisheries are jointly managed under international bilateral or regional agreements.

²³⁸ On release of the 2003 report, Senator Ian Macdonald, the Australian Fisheries Minister, stated: “I know my concern is shared by the fishing industry, and I will be working with it and the fisheries management authorities to address these concerns. Our fish stocks are the basis of the high-quality seafood products that our industry provides to the domestic and export markets, and we are determined to ensure their long-term sustainability”. *Waves* 9(4):12.

²³⁹ The Australian Fisheries Management Authority.

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- ²⁴⁰ Roughley (1916) drew attention to serious problems of overfishing in what was the first major review of Australian fisheries. When he revised this major work in 1951, overfishing had increased in scope and severity.
- ²⁴¹ Adaptive management, and ecosystem-based management are two approaches which, if thoughtfully and rigorously applied, can also assist in balancing mechanisms promoting over-exploitation.
- ²⁴² Japan and Grenada argued that opportunities for culling whales and seals should not be foreclosed by the creation of a Southern Ocean Whale Sanctuary on the grounds that these animals consumed food which might otherwise be available for humans (IWC 1994).
- ²⁴³ In effect this key policy was the non-statutory precursor of the current EPBC Act.
- ²⁴⁴ House of Representatives Standing Committee on Environment, Recreation and the Arts (Australian Government).
- ²⁴⁵ Taylor and Rose (2004): Story line: Speaker for the WA Legislative Assembly lobbied against extending no-take areas on the basis that "... Mr Riebeling is believed to have told Cabinet on Monday that the extension of no-fishing zones at the northern end of Ningaloo Reef off Exmouth could cost him his seat. Mr Riebeling is the Labor MLA for Burrup." "Mr Riebling is supported by the Recfishwest recreational fishers lobby group and the WA Fishing Industry Council, but is opposed by conservationists."
- ²⁴⁶ According to Jake Rice (2003): "If local opinion were formed primarily by objective and relevant information, participants in fisheries long ago would have embraced reduced effort, capacity and catches. After all, existing fisheries models clearly demonstrate how much more yield could be taken from stocks were they allowed to rebuild."
- ²⁴⁷ See the website of the Australian Department of Agriculture, Fisheries and Forestry <http://www.daff.gov.au/>.
- ²⁴⁸ Extract from Cooney (2004).
- ²⁴⁹ *Southern Bluefin Tuna cases* (New Zealand v Japan, Australia v Japan) International Tribunal for the Law of the Sea, Order of 27 August 1999, Order on Provisional Measures of 27 August 1999.
- ²⁵⁰ Agreement for the Implementation of Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks 1995.
- ²⁵¹ Convention on the Conservation of Antarctic Marine Living Resources 1980.
- ²⁵² UN General Assembly Resolution on Large-scale Pelagic Driftnet Fishing and its Impact on the Living Marine Resources of the World's Oceans and Seas 1989.
- ²⁵³ The World Charter for Nature 1982.
- ²⁵⁴ The Rio Declaration 1992.
- ²⁵⁵ The InterGovernmental Agreement on the Environment 1992, and the National Strategy for Ecologically Sustainable Development 1992.
- ²⁵⁶ National Strategy for the Conservation of Australia's Biological Diversity 1996.
- ²⁵⁷ Australia's Ocean's Policy 1998.
- ²⁵⁸ See the discussion of principles of good governance in Nevill (2004a).
- ²⁵⁹ GBRMPA (2003c) State of the Great Barrier Reef. http://www.gbrmpa.gov.au/corp_site/info_services/publications/overview/ viewed 22/9/04.
- ²⁶⁰ GBRMPA (2003c) State of the Great Barrier Reef. http://www.gbrmpa.gov.au/corp_site/info_services/publications/overview/ viewed 22/9/04.
- ²⁶¹ See reference list under "Technical Consultation..."
- ²⁶² AAPMA information from the Global Ballast Water Management Program at <http://aapma.org.au/marine-pests/04.php3>.

Appendix Three: The EPBC Act sustainable fisheries guidelines: a critique

A discussion of the evolution of the Australian Government's *Guidelines for the Ecologically Sustainable Management of Fisheries* from draft to final version.

A3.1 Introduction:

The purpose of this document is to introduce the Australian Government's *Guidelines for the Ecologically Sustainable Management of Fisheries 2000*, and discuss the way in which the final guidelines differ from the earlier draft version. While the differences between the draft and final versions are discussed, this appendix does not attempt to examine the detail of public comment (including industry and agency comment) provided on the draft, or examine possible reasons for the changes.

The appendix concludes that a comparison between the draft and final versions indicates substantial (possibly critical) weakening of the strategic ability of the guidelines to promote sustainable approaches to fishery management.

A3.2 Background:

Australia, at the international level, signalled its commitment to the precautionary principle when it supported the UN General Assembly resolution *The World Charter for Nature* in 1982. Australia signalled its commitment to fostering ecologically sustainable development when it supported the *Rio Declaration* in 1992.

The *Environmental Protection and Biodiversity Conservation Act* (EPBC Act) was passed in 1999 and came into effect in July 2000. At that time, all Commonwealth managed fisheries which had not been assessed under the *Environmental Protection (Impact of Proposals) Act* 1974 (the *EP(IP) Act*) were required to be assessed under the strategic assessment provisions of the EPBC Act. A central object of the EPBC Act is to promote ecologically sustainable development, an objective already listed in the Commonwealth's *Fisheries Management Act 1991* through amendments introduced in 1997.

Prior to the passage of the EPBC Act, commercial fisheries had been granted a general exemption from the assessment requirements of the *Wildlife Protection (Regulation of Imports and Exports) Act 1982* (the *WP(RIE) Act*). This exemption was removed just before that Act was subsumed by the EPBC Act, which has similar powers to restrict exports of wildlife, including fish. The effect of these provisions resulted in a requirement that a fishery under State or Territory management which needed export approval had to undergo an EPBC Act assessment to demonstrate ecological sustainability.

Guidelines were required to assist in developing and reviewing assessments which would demonstrate that a particular fisheries was ecologically sustainable. Draft guidelines were developed by the two Commonwealth departments responsible for environment and fisheries (DEH²⁶³ and AFFA²⁶⁴), and were made available for public comment in July 1999 (Commonwealth of Australia 1999). The guidelines were finalised in June 2000 (Commonwealth of Australia 2000). These two documents (the draft and the final) are compared below.

An interesting feature of the revisions discussed below is that they introduce the word "endangered" as complimentary to "threatened" - a clear misunderstanding of the way the terms are used within the EPBC Act - where 'endangered' is one of six categories within 'threatened'. This suggests, somewhat surprisingly, that the authors of the final guidelines were in fact not familiar with the details of the EPBC Act - even though the Act was the primary driver of the guidelines.

Instances where the original wording of the draft criteria has been substantially weakened in the final version are highlighted in yellow. Areas where there has been strengthening of the criteria are highlighted in green.

Table A3.1 A comparison between draft and final versions.

Draft 1999	Final 2000	Comments
PRINCIPLE 1 - A fishery must be conducted in a manner that does not lead to over-fishing, or for those stocks that are over-fished, the fishery must be conducted in a manner that demonstrably leads to their recovery.	PRINCIPLE 1 - A fishery must be conducted in a manner that does not lead to over-fishing, or for those stocks that are over-fished, the fishery must be conducted such that there is a high degree of probability the stock(s) will recover.	The change raises a question as to how the 'degree of probability' would be calculated. The initial wording allows outcomes to be audited, while the revision does not.
Objective 1.1 - The fishery shall be conducted at catch levels that continually maintain the natural productivity of the target stock(s).	Objective 1.1 - The fishery shall be conducted at catch levels that maintain ecologically viable stock levels at an agreed point or range, with acceptable levels of probability.	Maintaining 'natural productivity' has been removed as a management target.
<i>Criteria 1.1.1</i> - There is a reliable data collection and assessment process based on an appropriate level of research in place for the species / fishery.	<i>Criteria 1.1.1</i> - There is a reliable information collection system in place appropriate to the scale of the fishery. The level of data collection should be based upon an appropriate mix of fishery independent and dependent research and monitoring.	Useful additional detail does however raise the question as to what constitutes an "appropriate mix".
1.1.2 - There is a robust assessment and periodic review of the stock dynamics and status for the target species, including the age and sex composition of the stock.	1.1.2 - There is a robust assessment of the dynamics and status of the species/fishery and periodic review of the process and the data collected. Assessment should include a process to identify any reduction in biological diversity and /or reproductive capacity. Review should take place at regular intervals but at least every three years.	The emphasis on target species has changed.
1.1.3 - The distribution range of the stock has been established, including whether the stock(s) have separate genetic identities.	1.1.3 - The distribution and spatial structure of the stock(s) has been established and factored into management responses.	The explicit reference to genetic identities has been removed.
1.1.4 - There are reliable estimates of removals from the fished stock.	1.1.4 There are reliable estimates of all removals, including commercial (landings and discards), and recreational and indigenous, from the fished stock. These estimates have been factored into stock assessments and target species catch levels.	The scope of the estimates is now more clearly defined.
1.1.5 - There is a sound estimate of the potential productivity (maximum safe long-term yield) of the fished stock/s.	1.1.5 - There is a sound estimate of the potential productivity of the fished stock/s and the proportion that could be harvested.	Reference to a 'safe' or a 'sustainable' harvesting level is absent from the revised wording.
1.1.6 - There are target reference point(s) (biological and/or effort) based on the stock assessment that defines target levels of fishing.	1.1.6 - There are reference points (target and/or limit), that trigger management actions including a biological bottom line and/or a catch or effort upper limit beyond which the stock should not be taken.	The revised wording combines draft criteria 1.1.6 and 1.1.7.
1.1.7 - There is a limit reference point, which is the biological and/or effort bottom line beyond which the stock should not be targeted.	1.1.7 - There are management strategies in place capable of controlling the level of take.	The new wording highlights an omission: management strategies need to be both capable and effective.
1.1.8 - Fishing is conducted in a manner that does not threaten stocks of by-product species. ²⁶⁵	1.1.8 - Fishing is conducted in a manner that does not threaten stocks of by-product species. (Guidelines 1.1.1 to 1.1.7 should be applied to by-product species to an appropriate level).	The new wording adds useful detail.
1.1.9 - All removals, including recreational and indigenous take and discards, from the stock have been factored into stock assessments and target species catch levels.	1.1.9 - The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.	The new wording contains a weak implicit expectation that precautionary actions will be included in management regimes.

Draft 1999	Final 2000	Comments
Objective 1.2 - Where the fished stock(s) are below the target reference point, the fishery will be conducted such that recovery is allowed to occur to a specified level consistent with the precautionary approach and the ability of the stock(s) to produce long-term potential yields within a specified time frame.	Objective 1.2 - Where the fished stock(s) are below a defined reference point, the fishery will be managed to promote recovery to ecologically viable stock levels within nominated timeframes.	Two important elements have been removed in the revision: reference to the precautionary approach, and reference to 'potential yields'.
1.2.1 - A precautionary recovery strategy is implemented specifying management actions, or staged management responses, which are linked to the target reference points and that will lead to the recovery of the stock within a specified period of time.	1.2.1 - A precautionary recovery strategy is in place specifying management actions, or staged management responses, which are linked to reference points. The recovery strategy should apply until the stock recovers, and should aim for recovery within a specific time period appropriate to the biology of the stock.	The initial wording required the recovery strategy to be 'implemented'. The revised wording requires only that the recovery strategy be 'in place'. No guidance is provided on what constitutes 'stock recovery'.
1.2.2 - If the stock is estimated as being below the limit reference point, a zero targeted catch or temporary fishery closure is implemented.	1.2.2 - If the stock is estimated as being at or below the biological and / or effort bottom line, management responses such as a zero targeted catch, temporary fishery closure or a 'whole of fishery' effort or quota reduction are implemented.	The revised wording represents a substantial degradation of the intent of the original wording. Fishing reductions should be implemented well before hitting the bottom reference point - which should signal an 'emergency' situation requiring the cessation of fishing effort. The revised wording is a major breach of precautionary and sustainable management approaches.
Objective 1.3 - Fishing is conducted in a manner that does not alter the age or sex composition of the fished stock to a degree that impairs reproductive capacity nor reduces biological diversity.	Removed in the revision.	The selective removal of larger adults, especially larger females, is (in some fisheries) likely to 'impair reproductive capacity'.
1.3.1 - Management actions have been agreed where analysis of age and sex composition or genetic structure of the stock(s) indicates there are significant changes or shifts such that reproductive capacity may be impaired or genetic diversity threatened.	Removed in the revision.	No explanation is provided for the removal of 1.3 and 1.3.1 in the revised guidelines.
PRINCIPLE 2 - Fishing operations should safeguard the structure, productivity, function and diversity of the ecosystem (including habitat and associated dependent and ecologically related species).	PRINCIPLE 2 - Fishing operations should be managed to minimise their impact on the structure, productivity, function and biological diversity of the ecosystem.	The word 'safeguard' is a lot stronger, and more auditable, than the word 'minimise'. For this reason, and also with respect to references to ecosystem impacts, the revised wording is much weaker.
Objective 2.1 - The fishery is conducted in a manner that does not threaten biological diversity at the genetic, species or stock levels.	Objective 2.1 - The fishery is conducted in a manner that does not threaten bycatch species.	'Biological diversity' has been replaced by 'bycatch' - a major weakening of the original wording.
2.1.1 - Measures are in place to avoid capture and mortality of bycatch ²⁶⁶ species unless it is determined that that catch is sustainable.	2.1.3 - Measures are in place to avoid capture and mortality of bycatch species unless it is determined that the level of catch is sustainable (except in relation to endangered, threatened or protected species). Steps must be taken to develop suitable technology if none is available.	Both original and final wording are weak when compared to the view, which had already become accepted by 2000, that there is a general responsibility to minimise bycatch and reduce waste ²⁶⁷ .
2.1.2 - There is a reliable data collection process, as part of fishing operations, of the species composition and abundance of bycatch.	2.1.1 - Reliable information, appropriate to the scale of the fishery, is collected on the composition and abundance of bycatch.	Wording "as part of fishing operations" has been removed.

Draft 1999	Final 2000	Comments
2.1.3 - There is an analysis of the composition and abundance of bycatch species with respect to vulnerability to fishing and a representative group is selected from those assessed to be most at risk from the fishing method to be used as indicator species.	2.1.2 - There is a risk analysis of the bycatch with respect to its vulnerability to fishing.	No significant change.
2.1.4 - The indicator group of bycatch species is monitored.	2.1.4 - An indicator group of bycatch species is monitored.	No significant change.
2.1.5 - There are decision rules that trigger additional management measures when there are significant perturbations in the bycatch indicator species numbers.	2.1.5 - There are decision rules that trigger additional management measures when there are significant perturbations in the indicator species numbers.	No significant change.
	2.1.6 - The management response, considering uncertainties in the assessment, and precautionary management actions, has a high chance of achieving the objective	Addition of a new criteria adds some weight to the use of the precautionary principle.
Objective 2.2 - The fishery is conducted in a way that maintains natural functional relationships among species, and does not lead to trophic cascades or benthic damage that leads to significant ecosystem state changes.	Objective 2.3 - The fishery is conducted in a manner that minimises the impact of fishing operations on the ecosystem generally.	While maintaining the general intent of the original wording, the revision moves away from auditable outcomes towards 'minimisation' - a concept hard to quantify in either an audit or a court of law.
	2.3.1 - Information appropriate for the analysis in 2.3.2 is collated and/or collected covering the fisheries impact on the ecosystem and environment generally.	New criterion added.
2.2.1 - There is an assessment of whether the fishery has an impact on: the benthic ecosystem(s); predator/prey relationships; and [trophic relationships] ²⁶⁸ .	2.3.2 - Information is collected and a risk analysis, appropriate to the scale of the fishery and its potential impacts, is conducted into the susceptibility of each of the following ecosystem components to the fishery. 1. Impacts on ecological communities - Benthic communities - Ecologically related, associated or - Dependent species - Water column communities 2. Impacts on food chains - Structure - Productivity/flows 3. Impacts on the physical environment - Physical habitat - Water quality	The revision adds some detail.
2.2.2 - Management actions are in place to ensure significant ecosystem state changes do not arise from impacts on: the benthic ecosystem(s); predator/prey relationships; and [trophic relationships].	2.3.3 - Management actions are in place to ensure significant damage to ecosystems does not arise from the impacts described in 2.3.1.	
	2.3.4 - There are decision rules that trigger further management responses when monitoring detects impacts on selected ecosystem indicators beyond a predetermined level, or where action is indicated by application of the precautionary approach.	The new criterion is vague: what management responses? Curtailing fishing activities? What is the purpose of the management responses?
	2.3.5 - The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.	A weak criterion. The objective itself has been reworded to introduce the un-enforceable concept of harm 'minimisation'.

Draft 1999	Final 2000	Comments
Objective 2.3 - The fishery is conducted in a manner that avoids or minimises mortality of or injuries to threatened or protected species and avoids or minimises impacts on threatened ecological communities.	Objective 2.2 - The fishery is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species, and avoids or minimises impacts on threatened ecological communities.	The revised wording slightly strengthens requirements in regard to threatened species.
	2.2.1 - Reliable information is collected on the interaction with endangered, threatened or protected species, and threatened ecological communities.	New criteria
2.3.1 - There is an assessment of the impact of the fishery on protected or threatened species.	2.2.2 - There is an assessment of the impact of the fishery on endangered, threatened or protected species.	The revised wording misunderstands the meaning of "threatened" in Commonwealth legislation and policy. The word "threatened" includes "endangered" and other categories (EPBC Act).
2.3.2 - There is an assessment of the impact of the fishery on threatened ecological communities.	2.2.3 - There is an assessment of the impact of the fishery on threatened ecological communities.	No change
2.3.3 - There are measures in place to avoid or minimise capture and/or mortality of threatened or protected species.	2.2.4 - There are measures in place to avoid capture and/or mortality of endangered, threatened or protected species.	The change misunderstands the terminology of the EPBC Act (see above).
2.3.4 - There are measures in place to avoid impact on threatened ecological communities.	2.2.5 - There are measures in place to avoid impact on threatened ecological communities.	No change
	2.2.6 - The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.	An additional, rather vague criteria does add some weight to use of the precautionary principle.

Note that section 3 of the original draft was replaced with a preamble in the final version. This preamble did not identify principles, objectives or criteria. The classification below has been categorised to achieve a comparison of the draft and final versions.

Draft 1999	Final 2000	Comments
PRINCIPLE 3. The fishery is subject to an effective management system in accordance with the local, national and international laws and standards and incorporates institutional and operational frameworks that require the use of the resource to be responsible and sustainable.	To satisfy the Australian Government requirements for a demonstrably ecologically sustainable fishery, the fishery or fisheries if a species is caught in more than one fishery, must operate under a management regime that meets Principles 1 and 2. The management regime must take into account arrangements in other jurisdictions, and adhere to arrangements established under Australian laws and international agreements.	No substantial change.

Draft 1999	Final 2000	Comments
<p>Objective 3.1 - The fishery shall be subject to institutional arrangements that are in accordance with Australian laws and standards and which give effect to the principles of international agreements relating to the conservation and sustainable use of marine living resources, including the precautionary approach to management.</p>	<p>The management regime must comply with any relevant international or regional management regime to which Australia is a party. Compliance with the international or regional regime does not mean Australia cannot place upon the management of the Australian component of the fishery management controls that are more stringent than those required through the international or regional regime.</p> <p>The regime should [adhere to the criteria listed below]:</p>	<p>The final wording represents a major weakening of the intent of the original text. "Compliance with international management regimes" is very much more restricted than "give effect to the principles of international agreements".</p> <p>Given that the nature of international regimes is that they are almost always worded using general concepts rather than measurable benchmarks, strict compliance will almost never be auditable, let alone testable through a court of law. The spirit and intent of international agreements is captured in their principles, and compliance is best expressed through a requirement to 'give effect' to such principles.</p>
<p>3.1.1 - There is a documented and enforceable management plan or management arrangements ('the Plan') in place for the species or fishery.</p>	<p>The management regime does not have to be a formal statutory fishery management plan as such, and may include non-statutory management arrangements or management policies and programs.</p>	<p>Reference to a requirement that the plan should be enforceable has been lost.</p>
<p>3.1.2 - Limited access to the fishery is granted under 'the Plan'.</p>	<p>[The plan should] be capable of controlling the level of harvest in the fishery using input and/or output controls;</p>	<p>A significant weakening: "limited access" refers to current arrangements. "Capable of controlling" refers to theoretical, not actual arrangements.</p>
<p>3.1.3 - 'The Plan' contains specific management objectives relating to the long-term conservation and sustainable use of the species, stock or fishery.</p>	<p><i>Criterion deleted.</i></p>	<p>Original wording has been lost - possibly considered too general.</p>
<p>3.1.4 - 'The Plan' contains specific management strategies that give effect to the management objectives.</p>	<p><i>Criterion deleted.</i></p>	<p>Original wording has been lost - possibly considered too general.</p>
<p>3.1.5 - 'The Plan' contains specific performance criteria by which the management strategies may be measured.</p>	<p>[The plan should] be strategic, containing objectives and performance criteria by which the effectiveness of the management arrangements are measured.</p>	<p>No substantial change.</p>
<p>3.1.6 - All interested and affected parties, including the general public, have had an opportunity to be involved in a consultative process leading to the development of the 'the Plan'.</p>	<p>[The plan should] be developed through a consultative process providing opportunity to all interested and affected parties, including the general public.</p>	<p>No substantial change.</p>
<p>3.1.7 - There is broad stakeholder involvement in the stock assessment process and the process for setting target and limit reference points.</p>	<p>[The plan should] ensure that a range of expertise and community interests are involved in individual fishery management committees and during the stock assessment process.</p>	<p>No substantial change.</p>
<p>3.1.8 - 'The Plan' takes into account arrangements in other jurisdictions where the same stock is fished.</p>	<p><i>Criterion deleted.</i></p>	<p>Original wording has been lost - possibly considered repetitive.</p>
<p>3.1.9 - A surveillance and monitoring program is in place to ensure a high level of compliance with management decisions and measures.</p>	<p>[The plan should] contain the means of enforcing critical aspects of the management arrangements.</p>	<p>The new wording is much weaker. "A program is in place" (ie effective action must exist) has been replaced by a paper commitment "the plan should contain the means...".</p>
<p>3.1.10 - The management measures implemented for the fishery are linked to a strategic research plan.</p>	<p><i>Criterion deleted.</i></p>	<p>Reference to the need to gather additional information has been lost.</p>

Draft 1999	Final 2000	Comments
3.1.11 - Indicators of sustainability are developed and used as an integral part of management to assess the impacts of the fishery on the environment.	[The plan should] be capable of assessing, monitoring and avoiding, remedying or mitigating any adverse impacts on the wider marine ecosystem in which the target species lives and the fishery operates.	The new wording appears to have the same general intent as the original wording.
3.1.12 - There is a requirement for a periodic assessment of the effectiveness of the measures implemented in the fishery to ensure sustainability.	[The plan should] provide for the periodic review of the performance of the fishery management arrangements and the management strategies, objectives and criteria.	Little significant difference; however the reference to 'sustainability' has been lost.
	[The plan should] be documented, publicly available and transparent;	New criterion - a basic requirement of accountable government which may have been assumed in the original wording.
	[The plan should] require compliance with relevant threat abatement plans, recovery plans, the National Policy on Fisheries Bycatch, and bycatch action strategies developed under that policy.	New criterion. It should be noted that the National Policy on Fisheries Bycatch remains in draft form as of the time of writing (November 2004), undermining potential benefits from this requirement.

Note that the numbering system has been changed slightly in this table with respect to numbered objectives to achieve a coherent hierarchical structure.

A3.2 Discussion and conclusion:

The evolution of the guidelines (after close of public comment) indicates that both gains and losses have occurred from a sustainable management regime perspective. Gains (highlighted in green above) are generally in matters of clarification of detail. Losses (highlighted in yellow) on the other hand, are far more substantial, and three issues in particular are of considerable concern:

- A loss of auditability brought about by the replacement of *measurable* conservation targets by *general* commitments: eg: to 'minimise' harm;
- A loss of specific requirements for reference points designed to signal a situation so serious as to warrant temporary halts to fishing effort - these have been replaced by requirements simply to 'reduce fishing effort' as the critical reference point is reached; and
- The replacement of demonstrable management aspects, such as the *existence* of effective compliance and enforcement programs, with 'paper' commitments to the development of *proposals* which are likely to produce the desired effect – ie: proposals which, in this example, *could* result in effective compliance and enforcement programs. There is a major difference between a good idea and an on-ground reality (see 3.1.9 above).

The precautionary principle is one of a small number of principles fundamental to ocean management (Appendix One). Dilution of the precautionary approach is apparent in comparing the original and final guideline texts. The original wording of draft Objective 3.1 (see above) required that “*the fishery shall be subject to ... arrangements ... which give effect to ... the precautionary approach to management.*” This requirement has been removed in the final text, and replaced with vague references to the use of the precautionary approach which move well clear of establishing a requirement.

This change in wording between draft and final versions appears to contradict the apparently strong commitments made by the Australian government to the precautionary principle in international agreements, national policy statements, and in legislation (Appendix Two). The change appears to substantially diminishes the ability of the Commonwealth Government to promote the use of the precautionary principle as an operational concept.

A comparison between the discussion draft and final versions of the guidelines indicates substantial weakening of the ability of the guidelines to promote sustainable approaches to fishery management between the two versions.

Requirements for auditable and meaningful performance criteria are an essential aspect of strategic governance systems: without them the intent of the original strategy or commitment is easily diluted, or lost entirely. The loss of such measurable criteria appears as a serious, even critical, weakness in the adopted guidelines. The adopted guidelines appear deeply flawed.

Definitions: (source: Commonwealth of Australia 2000).

The following defines how certain terms will be interpreted in application of the guidelines.

Associated and/or dependent species - species associated with or dependent upon harvested species, for example species which are predator or prey of the harvested species.

Biological diversity, biodiversity - the variability among living organisms from all sources (including marine and other aquatic ecosystems and the ecological complexes of which they are part). Includes 1) diversity within species and between species; and 2) diversity of ecosystems.

Bycatch - species that are discarded from the catch or retained for scientific purposes, and that part of the "catch" that is not landed but is killed as a result of interaction with fishing gear. This includes discards of commercially valuable species.

By-product - species that are retained because they are commercially valuable but are not the main target species.

Ecologically related species - species which, while not associated with or dependent upon a harvested species, nevertheless are affected by the fishing operation.

Ecologically sustainable - use of natural resources within their capacity to sustain natural processes while maintaining the life-support systems of nature and ensuring that the benefit of the use to the present generation does not diminish the potential to meet the needs and aspirations of future generations.

Ecologically viable stock - ecological viable stock has a general rather than a specific meaning. It refers to the maintenance of the exploited population at high levels of abundance designed to maintain productivity, provide margins of safety for error and uncertainty and maintain yields over the long term in a way that conserves the stocks role and function in the ecosystem.

Ecosystem - the biotic (living) community and its abiotic (non-living) environment.

Function - relationships between components of the ecosystem, without which individuals could not survive and/or reproduce. eg protection for juveniles provided by marine plants; trophic relationships.

Management regime - In this document, refers to the policies, plans, action plans, strategic research plans, and all documentation that relates to the operations and management of the fishery.

Overfishing - can be defined in two ways which can act independently or concurrently: 1) "recruitment overfishing", where fishing activities are causing a reduction in recruitment in succeeding years and cause the mortality of too many fish in total, too many pre-productive fish, or too many fish that have only spawned a few times. The end result is that the stock can no longer replenish itself adequately. 2) "growth overfishing": where fishing activities lead to a reduction in the size of the individuals of a species, as a consequence of which few specimens grow to the size for optimum yield.

Precautionary approach - used to implement the precautionary principle. In the application of the precautionary principle, public and private decisions should be guided by: 1) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and 2) an assessment of the risk-weighted consequences of the various options.

Precautionary principle - the lack of full scientific certainty should not be used as a reason for postponing a measure to prevent degradation of the environment where there are threats of serious or irreversible environmental damage.

Precautionary recovery strategy - Management and operational strategy, designed to increase numbers within the stock, that incorporates the precautionary approach and includes mechanisms to avoid or mitigate adverse ecosystem effects.

Productivity - when applied to fish stocks the term productivity gives an indication of the birth, growth and death rates of a stock.

Reference point - an indicator level of fishing (or stock size) to be used as a benchmark for assessment or decision making.

Stock - In the strict sense, a distinct, reproductively isolated population. In practice, a group of individuals of a species in a defined spatial range which is regarded as having a relatively low rate of exchange with others of the species.

References:

- Commonwealth of Australia 1999, Criteria for assessing the ecological sustainability of commercial fisheries: draft for public comment, Department for the Environment and Heritage, Canberra.
- Commonwealth of Australia 2000, Guidelines for the ecologically sustainable management of fisheries, Department of the Environment and Heritage, Canberra.
- Costanza, R & Andrade, F 1998, 'Principles for sustainable governance of the oceans', Science, vol. 281, no. 5374, pp. 198-9.

A3 Endnotes:

²⁶³ DEH – the Department of the Environment and Heritage (Australia).

²⁶⁴ AFFA – the Department of Agriculture, Fisheries and Forestry (then known as Agriculture, Fisheries and Forestry Australia).

²⁶⁵ By-product is defined here as species that are retained because they are commercially valuable but are not the main target species and as such are taken in relatively small numbers when compared with the potential productivity of the species.

²⁶⁶ Original wording: "Bycatch is defined as species that are discarded from the catch or retained for scientific purposes".

²⁶⁷ One of the objectives of the Commonwealth Policy on Fisheries Bycatch (Commonwealth of Australia 2000) is to "reduce bycatch". See also the "fair and responsible principle" advocated by Costanza et al. 1998.

²⁶⁸ Original wording: "Feasible and practical indicators need to be developed for these criteria."

Appendix Four: Deepsea trawling: impacts and governance

Written in October 2006

A4.1 Preface

The effects of bottom trawling on the deep sea have been the subject of a variety of scientific papers, especially over the last decade. Some of the most important are listed in the bibliography below. Additionally, a considerable number of reviews, not only of the effects of bottom trawling, but also of options for international regulation of these activities, have appeared since 2001. Amongst the most important of these reviews are: the comprehensive report edited by Thiel & Koslow (2001), Butler et al. (2001), NRC (2002), Roberts (2002), Glover & Smith (2003), FAO (2003), Freiwald et al. (2004), Gianni (2004), Hain & Corcoran (2004), Currie (2004), Morato & Pauly (2004), Rogers (2004a & 2004b), Freiwald & Roberts (2005), Roberts et al. (2005), Gjerde (2006), Roberts et al. (2006), and Koslow (2007).

The purpose of the present review is to provide a brief summary of key aspects of deepsea trawling, both on the high seas and within national EEZs – focussing particularly on associated benthic damage.

The United Nations General Assembly considered proposals for regulation of these activities at its meeting in October 2006. The Australian and New Zealand Governments, along with several other nations, supported tighter controls over deep sea trawling, especially on the high seas.

This review was written just before the UNGA October 2006 meeting, which subsequently introduced a requirement for flag nations to control their high seas bottom trawling vessels in a precautionary way, requiring prior assessment of the impacts of new or exploratory trawling operations. The UNGA resolution on fisheries also called for the expansion of the jurisdiction of existing RFMOs, and the creation of new RFMOs in those high seas areas not covered by existing RFMOs, in order to expand global controls over high seas deepsea trawling. Due to lack of time this Appendix has not been brought up to date to cover subsequent events.

A4.2 Summary:

The deep sea is a major reservoir of the planet's biodiversity, most of it unknown and unstudied – the "last great frontier on Earth" (Roberts 2005). While much of the abyssal region is sparsely populated, deep sea benthic habitat around features such as seamounts, hydrothermal vents, ridges and trenches is often both rich and abundant. However, these habitats (especially seamounts) are vulnerable, particularly to bottom trawling. Bottom trawls (sometimes called demersal trawls) which come in contact with the sea floor, effectively destroy complex habitat, built over centuries or millennia by slow-growing invertebrates. Significant damage has already been done which, within the time-scale of a human life, is irreparable – and this damage continues.

Marine scientists and conservation biologists have been expressing serious concern over the continued use of bottom trawling in the deep sea for more than two decades. During this time new technology has increased the ability of fishers to work the deep sea. Major scientific reports and reviews confirm that, generally speaking, bottom trawling over complex biogenic habitat is biologically unsustainable. Several major international agreements require nations to protect ocean habitats, yet for the most part high seas bottom trawling operations continue under little or no regulation, even though, under the provisions of the UN Convention on the Law of the Sea, all vessels must obey the legal requirements of their flag States. The United Nations General Assembly commenced an examination of bottom trawl management options in 2002, and is due to reconsider the issue again in October 2006.

Under a separate UN process, options for the establishment of high seas protected areas have been under discussion since 1998.

The gravity of the issue requires involvement from the marine science community. Current management arrangements aimed at protecting deep sea biodiversity are not working. New approaches must be devised and implemented without delay. Nations must take action if continuing widespread and effectively irreversible damage over much of the deep ocean is to be prevented. This will not occur without the active involvement of the marine science community.

A4.3 The importance of deep sea biodiversity:

All life depends (directly or indirectly) on utilising energy either from sunlight or from geochemical sources. The Earth's surface is characterised by life forms utilising sunlight, and this also applies to the ocean's shallow layers, which occupy about 70% of the planet's surface. However only 1% of the energy of sunlight penetrates below 200 m, and only a few specialised plants exist below this level (Roberts et al. 2005). Below 600 m eternal darkness prevails. Here life depends on what falls, or swims, or is swept from the photic zone. Or, where hydrothermal vents or cold seeps exist, on geochemical energy.

For fish and other animals near the surface of the open ocean, life is dangerous. There is nowhere to hide. Most animals and many plants here live fast, breed fast and die fast. Many are characterised by rapid growth, rapid propagation strategies and short lives. The largest predators, and some mammalian and reptilian herbivores, provide exceptions to this rule.

However where complex physical habitat provides safety, such as coastal rocky or coral reefs, more leisurely lifestyles are possible. Lifestyles in the deep ocean are often even slower. Deepwater species (those living below 500 m) often exhibit "K-selected" life-history characteristics markedly different from most shelf species: extreme longevity, late age of maturity, slow growth, and low fecundity (Koslow et al. 2000).

Seamounts are usually the result of volcanic activity, and often occur in clusters or strings. The global count of seamounts depends upon definition. The position of about 14,000 seamounts over 1000 m. 'high' have been mapped (Kitchingman & Lai 2004), and one estimate puts the count of such seamounts in the Pacific at around 50,000 (Rogers 2004a). However, given a relaxed definition which counts hills smaller than 1000 m. in elevation, a total global count is likely to be considerably higher (perhaps >100,000). Of the 14,000 seamounts mapped by Seamounts Online (by 2004), only 3-4% had been sampled for invertebrates (Stocks 2004).

According to Stocks (2004) discussing surveys over 171 seamounts: "Crustacea is the group that has been recorded from the most seamounts (116). In part, their prevalence may be due to a sampling bias: crab and shrimp are of commercial importance and thus of particular interest in many surveys. Following the Crustacea are Anthozoa (corals and anemones), recorded from 84 seamounts. Also common (recorded on 30-45 seamounts) are gastropods, bivalves, echinoids (sea urchins), ophiuroids (brittle stars), asteroids (sea stars), polychaetes, and hexactinellids (glass and related sponges)."

Koslow et al. (2001) reported surveys of seamounts south of Tasmania:

The fauna was diverse: 262 species of invertebrates and 37 species of fishes were enumerated, compared with 598 species of invertebrates previously reported from seamounts worldwide. On seamounts that peaked at depths <1400 m and that had not been heavily fished, the invertebrate fauna was dense, diverse and dominated by suspension feeders, including a matrix-forming colonial hard coral (*Solenosmilia variabilis*) and a variety of hard and soft (gorgonian and antipatharian) corals, hydroids, sponges and suspension-feeding ophiuroids and sea stars. Of the invertebrate species, 24 to 43% were new to science, and between 16 and 33% appeared to be restricted to the seamount environment.

It is not surprising that seamounts provide support for benthic and demersal species. In abyssal environments dominated by deep sediments adjacent to slow moving water, they provide a very different environment: hard substrate in a moving water environment (supplying food and oxygen) which supports the development of a huge variety of attached filter feeders. However, due to their size seamounts also create distinctive oceanic environments around and above them. According to Rogers (2004a): “One of the most well-known oceanographic effects of seamounts with potential significance to seamount biology is the formation of eddies of water (so -called Taylor Columns) that are associated with upwellings of nutrient rich waters, leading to increased productivity in waters near the surface.” This effect is thought to partly explain the tendency of pelagic animals to aggregate in the vicinity of seamounts, thus connecting the benthic, demersal and pelagic environments.

Seamounts may play an important role in dispersal, ultimately supporting evolutionary processes in the ocean. According to Rogers (2004a): “Seamounts may also act as refugia for some marine species. Evidence also suggests that seamounts may act as stepping-stones in the transoceanic dispersal of marine species, playing an important role in the evolution of the global marine fauna.” As well, seamounts can act as “islands” in the Darwinian sense, and therefore provide the foundation for the development of new species—some unique to individual seamounts.

In summary, the deep sea contains a wealth of species, habitats and ecosystems with biologies quite different from coastal or pelagic environments. Some of these ecosystems possess exceptional species richness and endemism (Rogers 2004b). While very little of this biota has been subject to scientific investigation, enough is known to underline both its global importance and its vulnerability to disturbance.

A4.4 The impacts of bottom trawl fisheries in the deep sea:

Seabed damage from trawling has been the subject of concern since at least the 14th century (Jones 1992). Bottom trawls are large nets which are dragged along the sea floor to harvest benthic and demersal species. Deep sea bottom trawls are larger and stronger than most shallow water trawls, and can operate to around 2 km depth (although most deep sea trawling currently occurs between ~ 500-1500 m). The bottom edge of the trawl carries heavy rollers to keep the trawl base on the floor.

Modern trawls are strong enough to destroy anything weak or brittle attached to the sea floor lying in their path – such as coral. On a typical fishing trip in the NE Atlantic, a trawler sweeps ~33 km² of sea bed. A single trawl can completely destroy a cold-water coral reef which has taken thousands of years to grow (Hain & Corcoran 2004:121). One trawl net marketed in 2005 was named “the Canyon Buster” – epitomising the trawl’s effect on the sea floor.

Coral reefs or mounds may be thousands to millions of years old²⁶⁹. Deep sea coral structures damaged or destroyed by bottom trawls are often centuries or millennia old (Hall-Spencer et al. 2002²⁷⁰). Deep sea sponge communities destroyed by bottom trawls are often decades or centuries old. Bottom trawling over soft sediments disturbs plants and animals years or decades old – with the exception of some of the larger molluscs which can reach ages in excess of 200 years. Ecological recovery times may be an order of magnitude (or more) greater than the typical age of the ecosystem’s living inhabitants. The older and larger deep sea coral reefs which are currently being destroyed are likely to take several thousand years to recover, if recovery is possible²⁷¹. Increasing ocean acidity²⁷² also presents a long-term threat to such ecosystems.

The effects of bottom trawling on fish populations is exacerbated by the widely used practice of targeting breeding aggregations. Fisheries managers continue to argue that breeding aggregations can be protected by judicious controls on fishing activities, in spite of a long history of failures (see for example the discussion of the St Helens Hill spawning aggregation below). This ‘business as usual’ approach continues in spite of:

- the *FAO Code of Conduct for Responsible Fisheries* 1995 calling for States to “protect critical... nursery and spawning... habitats” (para. 6.8);

- the Johannesburg World Summit on Sustainable Development 2002 calling for States to implement “time / area closures for the protection of nursery grounds and periods...” (Plan of Implementation, para 32c);
- the Society for the Conservation of Reef Fish Aggregations 2003 calling for “... all fish spawning aggregation sites [to] be conserved” (Statement of Concern 2003); and
- the World Conservation Congress 2004 urging States to “sustain and protect reef fish and their spawning aggregations...” (Recommendation 3.100).

The most heavily fished deep sea areas have been in the North Atlantic. Catches have been maintained by a ‘mining’ approach – once one area is exhausted, fishing moves to a new location (sequential or serial depletion). Evidence is growing that many, probably most, deep sea fisheries cannot be fished sustainably using traditional fishery management approaches (Koslow & Tuck²⁷³ 2001, Morato & Pauly 2004, Bergstad et al. 2005). According to Butler et al. (2003): “... in some cases the biology and ecology of the system may be such that there is no way to fish sustainably”.

The *Working Group On The Appraisal Of Regulatory Measures For Deep-Sea Species* of the Northeast Atlantic Fisheries Commission (NEAFC), in June 2002 reported that in the Northeast Atlantic: “For the deep-water trawl fisheries the typical development is a rapid increase in catches when a new resource is discovered followed by a decrease reflecting depletion of the resource. The trends in landings and catch per unit effort (CPUE) for most deep-water fisheries currently indicate that fishing pressure is far beyond sustainability” (WGARMDS 2002). Likewise, a 2002 paper by the European Commission described the orange roughy fisheries in the Northeast Atlantic as being “consistent with a ‘mining’ approach... aggregations are located and then fished out on a sequential basis” (SGFEN 2002).

Scientists involved in assessing the sustainability of deep-sea fisheries in the New Zealand and Australian regions and in the Southwest Indian Ocean have come to similar conclusions. For example, Clark (1999) stated that an analysis of commercial catch and effort data in fisheries for orange roughy on seamounts in New Zealand waters, one of the largest deep-sea bottom trawl fisheries in the southern hemisphere, “show strong declines in catch rates over time, and a pattern of serial depletion of seamount populations, with the fishery moving progressively...to unfished seamounts.”

Bottom trawls destroy coral structures within their sweep²⁷⁴. Anderson & Clark reported one of the few observer studies of coral bycatch from a virgin seamount site – the South Tasman Rise. In the first year of the study trawls averaged around 1.5 tonne of coral per tow²⁷⁵ (about half the weight of orange roughy caught per tow), with the seasons operations harvesting around 1762 tonnes of coral bycatch. Coral catch per tow varied from less than one to a maximum of 50 tonne. The actual tonnage destroyed would be considerably higher than the weight of retrieved coral, as a substantial proportion of delicate coral falls through the trawl mesh after breaking up. Close to 100% coral cover was reported on unfished seamounts compared with only 2-3% cover on heavily fished seamounts. Not unexpectedly, coral bycatch at the site dropped dramatically over the three years of the observer study (Anderson & Clark 2003).

These estimates of coral destruction align with Koslow et al. (2001): “Trawl operations effectively removed the reef aggregate from the most heavily fished [southern Tasmanian] seamounts.” In an earlier study of 14 seamounts in this area, Koslow & Gowlett-Holmes (1998) reported sampling benthic biomass on both heavily fished and unfished or lightly-fished seamounts. Benthic biomass on the heavily fished seamounts was 83% below levels on the remaining seamounts. These results indicate that bottom trawling causes extensive damage to vulnerable benthic ecosystems. In some cases this damage extends to effective annihilation of local ecosystems.

Once a commercial trawl ground is located, the area is likely to be trawled repeatedly, while the surrounding areas are also likely to be targeted. Given the ability of bottom trawls to

almost completely remove benthic habitat, the sharp declines in catch commonly observed in deep sea trawl operations are not unexpected.

Endemism in some groups of seamounts appear to be high (from the limited data currently available). Estimates of such endemism have varied from 9% to 35% at different locations (Gianni 2004:7). According to Koslow et al. (2000): “[Seamount] fauna... is typically restricted to the seamount environment and is characterised by high levels of endemism, which suggests limited reproductive dispersal”.

Roberts concluded, in relation to seamount fisheries, “Many species, it seems, have extremely limited geographical distributions and are restricted to closely spaced ranges of underwater peaks. The potential for trawl damage to cause extinctions is high” (Roberts 2002). Rogers (2004a) shares this view: “the limited range of many seamount species means that the extinction of endemic seamount animals [as a result of bottom trawling activities] is also likely”. According to Edgar et al. (2005): “Population declines of marine species approaching extinction will generally go unnoticed because of the hidden nature of their environment and lack of quantitative data”. Morato et al. (2006) express the same concern: “... species extinctions may follow if fishing on seamounts is not reduced.” Given the global extent of deepsea bottom trawling, it seems likely that extinctions have already occurred.

What proportion of the world’s seamounts have been damaged by trawling, and what proportion have been badly damaged? What proportion are inaccessible to trawling operations, and where are these areas located? Information is not available to answer these questions accurately – either globally or for Australian waters. However, there is no doubt that a great deal of damage has already been done.

Clark & O’Driscoll (2003) reported that about 80% of known seamounts (of the appropriate depth range) in the New Zealand EEZ had been fished by 2000, and a similar figure may well be accurate in the Australian EEZ. Unfished seamounts, if they exist, should be protected as a matter of urgency. As an interim measure, bottom trawling below 400 m. should be immediately banned in Australian waters pending a scientific investigation of the extent and degree of damage, as well as identification of location and quality of remaining cold-water coral habitats.

Surveys of the Norwegian EEZ in 1997-98 indicated that between 30% to 50% of deep water coral areas had been destroyed as a result of bottom trawling (Fossa et al. 2002), and remaining coral areas were granted partial protection by Norwegian law (see below). Similar extensive surveys have not yet been undertaken in Australia. Limited surveys of Tasmania’s seamounts by the CSIRO found substantial trawl damage; however no information is available on the extent of damage in a national context. Some, but not all Tasmanian seamounts have been protected by the recently declared Huon Marine Protected Area, which extended the Tasmanian Seamounts Reserve declared in 1999.

Damage to deep sea coral habitat caused by bottom trawling is equivalent or worse than damage caused to shallow coral by blast fishing – a practice now outlawed by all effected nations. Deep sea trawling these areas is analogous to clearfelling a forest to capture a herd of deer. Moreover, instances of deliberate destruction of coral prior to trawling have been reported (Fossa et al. 2002) – a practice which may be widespread.

According to Rogers (2004b): “There is no other human activity [compared to deep-sea bottom trawling] related to the gathering of biological or mineral resources for which impacts on the environment are so poorly understood or managed.”

A4.5 Major reports and consensus statements:

As mentioned above, marine scientists and conservation biologists have been expressing concern over the continued use of bottom trawling for over two decades. Several consensus statements have been published.

In 1998 the “Troubled waters” statement (carrying 1605 signatures of marine scientists from several nations) requested governments to “ameliorate or stop fishing methods that undermine sustainability by harming the habitats of economically valuable marine species and the species they use for food and shelter.”

In 2003 the Tenth Symposium on Deep Sea Biology issued a consensus statement directed at the United Nations General Assembly, expressing concern that:

- “populations of numerous commercially important species of deep-sea fish and precious corals associated with seamounts, ridges, plateaus, continental slopes, coral reefs and sponge fields in the deep-sea have been serially depleted by fishing;
- benthic habitats and communities have been severely damaged by fishing activities; and that:
- the biological characteristics of most deep-sea species render the deep sea particularly sensitive to anthropogenic disturbance and exploitation... “

In 2004, 1136 scientists from around the world signed the statement: ‘Deep sea coral: statement of concern to the UNGA’. According to the statement:

“As marine scientists and conservation biologists, we are profoundly concerned that human activities, particularly bottom trawling, are causing unprecedented damage to the deep-sea coral and sponge communities on continental plateaus and slopes, and on seamounts and mid-ocean ridges... [we] call on the UN General Assembly to declare a moratorium on bottom trawl fishing on the high seas.”

In 2005, a statement signed by over 100 marine scientists urged the Australian Government to help negotiate a moratorium on high seas bottom trawling, and another similar letter was sent before Australia’s attendance at the UNGA in 2006. In the UK, a letter (to the same effect) directed at the UK Government, and signed by senior marine scientists, was published in England in 2005.

Several major reviews of deep sea bottom trawling effects and management options have been published in the last few years – all drawing attention to the need for urgent action by the international community (see especially: Gianni 2004, Gjerde 2006, Roberts 2006). Unsustainable fishing practices have been widely discussed and condemned. According to Glover & Smith (2003), for example: “Most (perhaps all) of [the] deep-sea fisheries are not sustainable in the long term given current management practices”.

The Millennium Task Force on Environmental Sustainability recommended: “global fisheries authorities must agree to eliminate bottom trawling on the high seas by 2006 to protect seamounts and other ecologically sensitive habitats, and to eliminate bottom trawling globally by 2010” (MEATF 2005:87).

A4.6 The role of IUU fishing:

IUU here means illegal, unreported or unregulated. Most high seas bottom trawling, until the late 1990s, was either unregulated or unreported, thus meeting the definition of IUU. Today, large areas of the high seas remain entirely without controls (through Regional Fisheries Management Organisations) over bottom trawling. Even where RFMOs have a charter to manage deep sea fisheries on the high seas, most areas remain without effective controls, due to three major failings:

- failure to apply ecosystem and precautionary approaches,
- failure to monitor and enforce agreed management regimes, and
- IUU fishing by non-member States.

Even in the CCAMLR area, which has the most effective of all RFMO high seas controls, illegal fishing in member States EEZs, and unregulated and unreported high seas fishing by non-member States remains a significant problem. The CCAMLR Commission estimated (in

2006) that around half the total annual fish catch is made by IUU fishing (pers. comm. D.Miller August 2006).

A4.7 International obligations under UNCLOS, UNFSA and the CBD:

Several major international agreements require nations to protect ocean habitats, yet for the most part bottom trawling operations continue under little or no regulation.

The *United Nations Convention on the Law of the Sea 1982* is the primary reference relating to international marine law. Articles 117-119: establish a duty for States to cooperate and take such measures as may be necessary for the conservation of the living resources of the high seas. In particular, Article 194.5: establishes a duty to “protect and preserve rare or fragile ecosystems”.

All bottom trawling over coral or sponge-dominated ecosystems breaches this requirement.

The *Convention on Biological Diversity 1992* has been endorsed by over 180 States (of a global total of 192), and is one of the most widely supported international conventions relating to environmental issues. The Convention’s Preamble emphasizes the importance of prior environmental assessment and the application of the precautionary approach.

In particular Article 3 establishes responsibilities over high seas: “[States have] the responsibility to ensure that activities within their ... control do not cause damage to ... areas beyond the limits of national jurisdiction.”

Further, the CBD Conference of Parties (CoP) meeting in 2006, in Decision VIII/21 dealing with genetic resources of the deep sea bed, stresses the need for precaution and requests “further investigation of management options” (to eliminate destructive fishing practices).

The *UN Fish Stocks Agreement 1995* requires States to “apply the precautionary and ecosystem approaches widely to the conservation and management of straddling and highly migratory fish stocks in order to protect and preserve the marine environment.” Many deep sea stocks may be categorized as “straddling and migratory”. Currently all deep sea bottom trawl fisheries breach these requirements. Moreover most nations whose nationals underwrite bottom trawling are signatories to the Agreement.

The Agreement contains other important provisions requiring States to:

- assess and minimize the impact of fishing activities on non-target and associated or dependent species and their environment [article 5(d), 5(f)];
- protect biodiversity in the marine environment [article 5(g)];
- protect habitats of special concern [article 6.3]; and
- States shall be more cautious when information is uncertain, unreliable or inadequate. The absence of adequate scientific information shall not be used as a reason for postponing or failing to take conservation and management measures [articles 6.1, 6.2].

Current bottom trawling activities breach all these requirements.

The voluntary *FAO Code of Conduct for Responsible Fisheries 1995*, formally supported by 124 nations (including Australia) in the *Rome Declaration 1999*, applies these same requirements broadly to all fishing activities.

The requirements of international law are being widely and continually breached by bottom trawl fisheries around the world, including those fisheries operating under Australia licences.

A4.8 UNGA resolutions:

Resolutions of the UNGA are the most powerful mechanism the global community has to respond quickly to urgent environmental threats.

UNGA Resolution 57/141, 2002 encouraged relevant international organizations ...
“to consider urgently ways to integrate and improve, on a scientific basis, the management of risks to marine biodiversity of seamounts and certain other underwater features within the framework of the Convention [UNCLOS].”

UNGA Resolution 58/240, 2003 reiterated:

“... its call for urgent consideration of ways to integrate and improve, on a scientific basis, the management of risks to the marine biodiversity of seamounts, cold water coral reefs and certain other underwater features” (para. 51);

The following paragraph requested States and global and regional bodies:

“to investigate urgently how to better address, on a scientific basis, including the application of precaution, the threats and risks to vulnerable and threatened marine ecosystems and biodiversity in areas beyond national jurisdiction; how existing treaties and other relevant instruments can be used in this process consistent with international law, in particular with the Convention, and with the principles of an integrated ecosystem-based approach to management, including the identification of those marine ecosystem types that warrant priority attention” (para. 52).

UNGA Resolution 59/25 2004 requested:

“States individually and RFMOs should take urgent action to protect vulnerable deep sea ecosystems (cold-water corals, seamounts, hydrothermal vents) from destructive fishing practices, including bottom trawling, consistent with international law.”

The 2004 Resolution also requested the international community to establish new RFMOs or expand existing RFMO coverage where none exists, and to consider “interim prohibitions” of bottom trawl fishing on a “case by case, scientific and precautionary basis.”

In 2005, UNGA Resolution 60/31 reaffirmed the earlier UNGA call for States and RFMOs to take urgent action to protect vulnerable deep sea ecosystems and urged “accelerated progress”.

A4.9 UN working groups on high seas marine protected areas:

Under a separate UN process, options for the establishment of high seas protected areas have been under discussion since 1998.

At this stage no agreed mechanism exists for creating and policing high seas marine protected areas.

The *Convention for the Conservation of Antarctic Living Marine Resources 1980* (CCAMLR) establishes the primary focus of the Commission as conservation (art. 2). CCAMLR inherits the Antarctic Treaty principles of peaceful cooperation and decisions based on science.

Article IX(2)g of the Convention allows the Commission to establish areas closed to exploitation, including “special areas for protection and scientific study”.

The Commission is currently taking a strategic approach to the establishment of MPAs, recognising the need to identify representative areas as well as scientific reference sites and areas for the protection of vulnerable ecosystems. A bioregionalisation is currently under development.

The *Titanic Accord* is an agreement between four nations (France, UK, Canada and USA) and establishes a protected area around the wreck of the Titanic by simple agreement. The disadvantage is that the agreement does, of course, not bind non-member States or their nationals.

A4.10 Recent restrictions on bottom trawl fisheries:

The strongest and most comprehensive restrictions are those of Palau, where all deepwater bottom trawling within the entire Palau EEZ is prohibited. In addition, Palau has prohibited its nationals and flagged vessels from engaging in deepwater bottom trawling anywhere in the world.

The Australian Government established the Tasmanian Seamounts Marine Reserve (370 km²) in 1999. In 2004, the existing area of the Great Barrier Reef Marine Park that was off-limits to bottom trawling (of about 89,000 km²) was extended to more than 115,000 km² (of mainly relatively shallow bottom) as part of the revision of protected area boundaries within the Great Barrier Reef Marine Park. The Great Australian Bight Marine Park was also extended in 2004 to place 20,000 km² off limits. When the boundaries for the Southeastern Region marine reserves were decided in 2006, bottom trawling was excluded from more than 180,000 km² including an extension of the area around the Tasmanian Seamounts reserve.

The European Union and Iceland established some protected areas targeting deep sea corals in the period 2000 to 2005. The NEAFC²⁷⁶ established interim protection over small high seas areas: four seamounts and a section of the Reykjanes Ridge (NEAFC 2004). In Norway all identified coral areas are now partially protected from bottom trawling by a 1999 regulation requiring fishers to use "caution" near reefs; in addition five reefs are fully protected with fishing excluded (Hain & Corcoran 2004:125).

The New Zealand Government, in 2006, supported by major companies within the NZ fishing industry, proposed closure of 1,200,000 km² to bottom trawling. On 12/9/2006, the New Zealand Government released a press statement which read in part: "Foreign Minister Winston Peters, Fisheries Minister Jim Anderton, and Conservation Minister Chris Carter said the government was seeking an immediate moratorium on the high seas outside areas where competent Regional Fisheries Management Organisations (RFMOs) existed or were under negotiation." Where RFMOs existed with competence to manage high seas bottom trawling, the Government advocated that: "RFMOs should institute strong conservation measures to protect vulnerable ecosystems such as seamounts by 2008."

In the USA, the Federal Government designated (by Presidential proclamation) a large protected area²⁷⁷ in the Northwestern Hawaiian Islands in June 2006 (362,000 km²) and established a 919,000 km² area specifically closed to bottom trawling in the Aleutian Islands²⁷⁸ complementing a similar area on the West Coast closed to bottom trawling (388,000 km²). In October 2006, President Bush called for "an end to destructive fishing practices, such as unregulated bottom trawling on the high seas" (Bush 2006).

The Kiribati Government (in early 2006) proposed a large marine protected area at the Phoenix Islands closed to all commercial fisheries (185,000 km²).

The General Fisheries Committee of the Mediterranean has banned bottom trawling in all areas below 1000 m. and, in 2006, established three areas offshore from Italy, Cyprus and Egypt specifically to protect deep sea ecosystems.

A4.11 Industry views:

The industry can be divided into two groups: (a) long haul 'harvesters' and (b) short haul 'miners'. The harvesters do not support a moratorium, believing that its primary effect would be to exclude them from resources while applying little effective control over the miners. The miners do not support a moratorium, fearing that increased flag state and port state controls

would inhibit their activities. However they are well aware that they stand to benefit from a poorly enforced moratorium.

The miners:

- Use flags of convenience, shelf companies and tax havens. While historically using old vessels off-loaded as a result of national fleet subsidisation, the industry is increasingly using new purpose-built vessels (Gianni & Simpson 2005).
- Avoid regulations and reporting requirements.
- No obvious use of impact minimisation gear or techniques.
- Sequential depletion of species and locations.

The harvesters:

- Use vessels flagged to nations supporting UNCLOS, UNFSA and FAO Code.
- Both private and public company structures.
- Embrace national and RFMO regulations and reporting requirements.
- Support governance regimes aimed at sustainable harvesting.
- Some have initiated voluntary closures²⁷⁹ (Sea Lord, Austral Fisheries, Bel Ocean, and TransNamibia).
- Argue that use of appropriate gear and techniques can minimise impacts.
- Argue that claims of widespread damage to benthic habitat are unsubstantiated (Clement Assoc. 2006).
- Argue that large areas of habitat are protected by terrain.

The industry argue that a moratorium which was poorly enforced could indeed exclude the harvesters from resources while applying little effective control over the miners. This could decrease deep-sea fish supply and increase market price. The IUU fishers, (the 'miners') to the extent that they were still operating, would benefit from increased prices and reduced opposition.

A4.12 Summary and recommendations:

The deep sea is a major reservoir of the planet's biodiversity, most of it unknown and unstudied – the "last great frontier on Earth" (Roberts 2005). While much of the abyssal region is sparsely populated, deep sea benthic habitat around features such as seamounts, hydrothermal vents, ridges and trenches is often both rich and abundant. However, these habitats (especially seamounts) are vulnerable, particularly to bottom trawling. Bottom trawls, or mid-water trawls which come in contact with the sea floor, effectively destroy complex habitat, built over centuries or millennia by slow-growing invertebrates. Significant damage has already been done which, within the time-scale of a human life, is irreparable – and this damage continues at an increasing rate.

Marine scientists and conservation biologists have been expressing serious concern over the continued use of bottom trawling in the deep sea for more than two decades. During this time new technology has increased the ability of fishers to work the deep sea. Major scientific reports and reviews confirm that, generally speaking, bottom trawling over complex biogenic habitat is biologically unsustainable. Several major international agreements require nations to protect ocean habitats, yet for the most part bottom trawling operations continue under little or no regulation. The United Nations General Assembly commenced an examination of bottom trawl management options in 2002, and is due to reconsider the issue again in October 2006. Under a separate UN process, options for the establishment of high seas protected areas have been under discussion since 1998.

The gravity of the issue requires involvement from the marine science community. Current management arrangements aimed at protecting deep sea biodiversity are not working. New approaches must be devised and implemented without delay.

Nations must take action if continuing, widespread and effectively irreversible damage over much of the deep ocean is to be halted. This will not occur without the active involvement of the marine science community. The current UNGA investigation, and the recent (2006) review of the UN UNFSA, provide opportunities for scientists, and scientific associations, to voice their concerns. This may be done by submissions to national governments, and by submissions directly to the Executive Secretary of the UNGA.

The *United Nations Convention on the Law of the Sea 1982* substantially modified the prior doctrine of 'freedom of the high seas', partly by the EEZ framework, and partly by defining responsibilities accompanying existing rights.

The environmental responsibilities defined by UNCLOS have, for the most part, been ignored, and continue to be ignored in spite of the provisions of the CBD, UNFSA, the resolutions of Rio and Johannesburg, and the FAO Code.

It is time now to consider further major restrictions on freedoms which are being widely abused, to the great detriment of the planet and its inhabitants.

"We must place biodiversity conservation at the center of ocean governance, build the precautionary approach into the UN Convention on the Law of the Sea and ensure that every activity in these areas beyond national jurisdiction - be it fishing, mining, transportation, tourism or research - is conducted in a sustainable manner that is fair to present and future generations" Earle & Laffoley 2006.

Recommendations:

Given the Australian Government's clear commitments to the provisions of the Law of the Sea, and to the wide application of the precautionary and ecosystem approaches, action appears necessary within short, medium and long term frameworks:

- As a short-term measure, the Australian Government could, through its delegation to the UNGA and its contributions to the United Nations General Assembly *Ad Hoc Open-ended Working Group on the Conservation and Sustainable Use of Marine Biodiversity Beyond Areas of National Jurisdiction*, support the draft 'Palau Resolution', or the somewhat stronger 'Brazil Resolution';
- As a medium-term measure, the Australian Government could support the development of an implementation agreement to further elaborate State responsibilities under the general requirements of the conservation clauses of the UNCLOS²⁸⁰. The work which Australia is now doing in conjunction with other interested States in developing a 'model framework' for Regional Fisheries Management Organisations should place Australia in a strong position to contribute to such an endeavour.
- As a long-term measure, through Australia's participation in the UNGA *Ad Hoc Working Group*, the Australian Government could support a UNGA re-examination of the 'freedom of the high seas'. While this freedom appeared essential during the UNCLOS negotiations, experience of the last two decades suggests that a new approach, and a new philosophy, will be needed in the long term if high seas biodiversity is to be protected. Australia's support for alternative philosophies already in place through existing instruments, such as the 'common heritage of mankind' under which the International Seabed Authority operates, as well as the 'peaceful cooperation' and emphasis on 'furthering science' of the Antarctic Treaty, place the Australian Government in a strong position to provide international leadership to such an endeavour.
- In regard to deep water fishing with Australia's EEZ, the current ban on exploratory deep water demersal trawling below 700 m in the SESSF should be revoked, and replaced by a precautionary ban on demersal trawling below 500 m applying to the entire Australian EEZ (including remote island and Antarctic zones). Bottom trawling would be entirely banned in all areas *in the absence of documented evidence demonstrating that bottom trawling in specific clearly delineated areas could be carried out without damage to vulnerable benthic ecosystems*. Such a measure, in

line with the precautionary approach, places the onus for proof on the licence applicant. Australia should also follow Norway's example in outlawing deliberate destruction or damage to benthic ecosystems, and Palau's example in outlawing deepwater trawling on the high seas by Australian nationals, in the absence of a precautionary approach demonstrating "no likely damage" as above. All spawning aggregations should also be protected within a similar precautionary framework.

- in regard to Australia's input to the current FAO technical consultation on deepwater fisheries, I believe Australia should be pushing for a few key points: (a) absolute protection for 100% of vulnerable ecosystems (in line with s.194 of CLOS); (b) full application of precaution to the deep sea (ie: no fishing²⁸¹ unless it can be demonstrated that any effect to target stocks or to associated ecosystems could be recovered within two decades²⁸² or less); (c) precautionary default parameters in determining fishing pressure, particularly adoption of a target reference point of 75% of original biomass²⁸³; and (d) precautionary bans on all destructive fishing – such as bottom trawling or deep sea set gillnets over vulnerable habitat. Another obvious measure, following Norway's example, is to prohibit, under extreme penalties, the deliberate destruction of vulnerable habitat (anywhere, at any depth).

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Note that a PowerPoint presentation on the subject is located under the "Australian Documents" heading at <http://www.tucs.org.au/~cnevill/marine.htm>.

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Endnotes:

- ²⁶⁹ Ferdelman et al. (2006) dated a coral mound near Ireland as Pleistocene in age.
- Ruggeberg et al. (2006) estimated the age of a carbonate mound in the Porcupine Seabight at around 5 million years.
- ²⁷⁰ Hall-Spencer et al. found coral matrix bycatch in the Northeast Atlantic was at least 4550 years old.
- ²⁷¹ According to Roberts et al. 2006: "There is global evidence that these habitats have been damaged by trawling for deep-water fish, causing severe physical damage from which recovery to former reef status will take several hundreds or thousands of years, if at all."
- ²⁷² Caused by increasing levels of atmospheric carbon dioxide.
- ²⁷³ Koslow & Tuck suggested that an additional critical factor, largely overlooked in deepwater fisheries, is decadal-scale variations in recruitment.
- ²⁷⁴ Koslow & Gowlett-Holmes (1998): "Fauna are extensively damaged by normal trawl operations..."
- ²⁷⁵ Anderson and Clark quoted a report from G. Diver giving an upper catch figure of 50 tonne of coral in one tow.
- ²⁷⁶ NEAFC: North East Atlantic Fisheries Commission.
- ²⁷⁷ NW Hawaiian Islands MPA: all commercial fishing is to be phased out by June 2011.
- ²⁷⁸ The Aleutian closure (MPA News August 2006: 96% of 957,000 km²) was designated in July 2006 by the National Marine Fisheries Service.
- ²⁷⁹ The Southern Indian Ocean Deepwater Fishers' Association (SIODFA 2006) announced the 'creation' of eleven large areas of deepwater habitat in the Southern Indian Ocean in which the Association would no longer fish. These areas total ~309,000 km².
- ²⁸⁰ The idea of a new implementation agreement is discussed and supported by Hafner (2006) speaking on behalf of the European Union.
- ²⁸¹ For example, a precautionary ban on trawling below 500 m in depth.

²⁸² See Article 3 of CCAMLR 1980, which specifies a recovery time limit of “two to three decades”.

²⁸³ See Constable 2006, where a 75% reference point is discussed. The logical of selecting this value was that a 50% reference point may be a reasonable (precautionary) value in relation to a single stock, but to allow for lack of knowledge of the intimate workings of larger associated ecosystems, particularly food chain effects, a half-way point between this and 100% (no fishing) is a reasonable value in the absence of more detailed scientific information. Obviously such precautionary parameters can be modified over time as ecosystem models develop increasing rigor and accuracy.

Appendix Five: Commonwealth assessment of the SA abalone fishery: a critique.

Supplement to Chapter 13: not intended to be read separately.

Table A5.1: Guideline component compliance analysis.

Does the Commonwealth's accreditation of the fishery require or encourage compliance with individual guideline components?

GUIDELINE COMPONENT(2000)	STATE ASSESSMENT (5/2003)	COMMONWEALTH ASSESSMENT (2004)	DISCUSSION
<p>Principle 1 objective 1. The fishery shall be conducted at catch levels that maintain ecologically viable stock levels at an agreed point or range, with acceptable levels of probability.</p>	<p>Historic and present catch levels are described. Agreed points or ranges for stock levels are not identified. See below.</p>	<p>Enhanced estimation of stock levels through the development of better assessment models is recommended; see below.</p>	<p>Although the objective has not been met, action recommended by the Commonwealth should see the situation improve over time.</p>
<p>1.1.1 There is a reliable information collection system in place appropriate to the scale of the fishery. The level of data collection should be based upon an appropriate mix of fishery independent and dependent research and monitoring.</p>	<p>Data is presented on measures in place to obtain commercial catch and effort information. Fishing location data is not currently available at map code level; GPS location data provided on a voluntary basis only. Limited fishery-independent information is collected on abundance and biology. No blacklip data is available from the Western Zone where blacklip comprise >50% of the TACC. No abundance data is available from virgin areas/periods. No recreational licence is needed. There are no reliable estimates of recreational catch or illegal catch, so no reliable estimates of total catch.</p>	<p>"DEH encourages PIRSA to further investigate the introduction of a licensing system as a means of improving the estimation of the recreational catch in the fishery" (p.15).</p>	<p>Noting implicit non-compliance with the guideline component, DEH identifies strategies to improve information collection in the future.</p>

Table A5.1 continued.

GUIDELINE COMPONENT (2000)	STATE ASSESSMENT (5/2003)	COMMONWEALTH ASSESSMENT (2004)	DISCUSSION
<p>1.1.2 There is a robust assessment of the dynamics and status of the species/fishery and periodic review of the process and the data collected. Assessment should include a process to identify any reduction in biological diversity and /or reproductive capacity. Review should take place at regular intervals but at least every three years.</p>	<p>Peer-reviewed stock assessments are prepared for two species each year in the three zones, based largely on CPUE data, which in some areas has remained stable (stable CPUE occurred in the NSW abalone fishery prior to stock collapse.) CPUE for Central blacklip shows significant decline 1989-2001. Dramatic reductions in blacklip catch in numerous Western fishing areas have not been investigated. Species-specific CPUE data is not available for the Western Zone. There are major gaps in fishery-independent data. Available data shows major declines of some metapopulations. No abundance data is presented. No fishing closures have been implemented. No reliable stock assessment model is available, but is 'under development'. No reliable monitoring of biological diversity is undertaken. No 3-year reviews are undertaken, but are intended in the future.</p>	<p>"A sound stock assessment process is in place for both blacklip and greenlip abalone, based on fishery dependent and available independent data" p.16.</p> <p>Recommendation 3: PIRSA to ensure that the new stock assessment model be developed by the end of 2005 and be used as part of the stock assessment process for 2006.</p>	<p>The guideline component is not met. The DEH assessment on p.16 appears to lack a substantial factual basis, and runs counter to argument later in the assessment supporting recommendation 3.</p>
<p>1.1.3 The distribution and spatial structure of the stock(s) has been established and factored into management responses.</p>	<p>Information on the spatial structure of the stock is variable. Some small areas are well studied, with adequate fisheries independent and dependent data. However, there are major gaps in data collection (see above). Some areas have shown dramatic declines likely to indicate serial overfishing. Temporary closures have not been implemented to allow recovery, in spite of scientific recommendations (Shepherd & Rodda 2001).</p>	<p>Recommendation 7 allows the State 3 years to develop strategies aimed at preventing serial depletion of stocks. The need for temporary closures is discussed (p. 23). Several recommendations are aimed at accurate stock evaluation.</p>	<p>The guideline component is partially met. A timeframe for the implementation of the recommended strategies is not recommended or discussed.</p>

Table A5.1 continued.

GUIDELINE COMPONENT(2000)	STATE ASSESSMENT (5/2003)	COMMONWEALTH ASSESSMENT (2004)	DISCUSSION
<p>1.1.4 There are reliable estimates of all removals, including commercial (landings and discards), recreational and indigenous, from the fished stock. These estimates have been factored into stock assessments and target species catch levels.</p>	<p>Estimates of removals due to commercial fishing are reasonably accurate at the scale of the three major fishing zones. Reporting at the scale of 'map zones' is now mandatory, and should provide catch information at the scale of the metapopulation.</p> <p>Information on recreational removals is not accurate, and has been collected from non-targeted surveys. Indigenous removals are included within recreational removals.</p> <p>No accurate information on illegal removals is available. Illegal removals may be significant, but no quantitative estimate is presented (p.34). Illegal removals are not factored into the TAC.</p>	<p>Attention is drawn to gaps in data on recreational and illegal take. It is stated that illegal take may be in the order of 10% of the TACC.</p> <p>Recommendation 4 focuses on gathering better catch data. It is recommended that illegal catch be factored in as part of the TAC.</p>	<p>Reliable estimates of removals are partly not fully available; the guideline component is not met. Estimates have not been factored into target species catch levels: again the guideline is not met.</p>
<p>1.1.5 There is a sound estimate of the potential productivity of the fished stock/s and the proportion that could be harvested.</p>	<p>A reliable stock assessment model is not yet available. No estimates of pre-harvest abundance are available, and no areas have been closed with a view to obtaining these estimates. An integrated stock assessment model needs to be developed.</p>	<p>Recommendation 3 relates to the development of a new stock assessment model. Several other recommendations relate to improving the spread and accuracy of basic model input data.</p>	<p>Although the guideline component is not met. DEH recommendations should see an improvement in stock assessment methods.</p>
<p>1.1.6 There are reference points (target and/or limit), that trigger management actions including a biological bottom line and/or a catch or effort upper limit beyond which the stock should not be taken.</p>	<p>Reference points are established (p.35) however none are linked with temporary fishing closures.</p>	<p>Recommendations 7 and 9 developing additional reference points and linking these with enhanced monitoring and recovery strategies.</p>	<p>Although the guideline component is not met, DEH recommendations should result in more careful attention to problem areas likely to be affected by serial depletion though overfishing.</p>

Table A5.1 continued.

GUIDELINE COMPONENT (2000)	STATE ASSESSMENT (5/2003)	COMMONWEALTH ASSESSMENT (2004)	DISCUSSION
1.1.7 There are management strategies in place capable of controlling the level of take.	The commercial catch is controlled largely by annual quotas (by weight). Size limits apply to both recreational and commercial catches. Although other restrictions apply to recreational take (eg: boat limit of 10 per day) no licence or reporting requirements are imposed.	The recreational take is an open and un-reported fishery. Recommendation 4 focuses on obtaining better estimates of recreational take, however licensing or reporting requirements are not discussed.	The guideline component is met in regard to the commercial fishery, but not with regard to the recreational fishery.
1.1.8 Fishing is conducted in a manner that does not threaten stocks of by-product species. (Guidelines 1.1.1 to 1.1.7 should be applied to by-product species to an appropriate level).	No by-product species have been identified.	No issue is identified – thus no recommendations are proposed.	Guideline component met. The manual and selective nature of the fishery suggests few bycatch or by-product problems; however the issue of the incidental take of other species by abalone divers could be discussed.
1.1.9 The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.	Page 39: “A constant harvest strategy in most Zones over 15 years has not resulted in reduced catches or declining catch rates in most areas”. No risk assessment is undertaken. Precautionary management is not discussed – in spite of the historic collapse of abalone fisheries. No lessons learned from overseas fishery collapses are discussed. Precautionary strategies (specific to SA) recommended by Shepard et al. (2001) are not discussed or even mentioned.	Page 26: “DEH considers that the management regime in the SA Abalone Fishery is appropriately precautionary and provides for the fishery to be conducted in a manner that does not lead to widespread overfishing.”	DEH judge that the guideline component is met, despite a complete absence of discussion on the precautionary approach in either the SA or DEH assessment documents.
Principle 1 objective 2. Where the fished stock(s) are below a defined reference point, the fishery will be managed to promote recovery to ecologically viable stock levels within nominated timeframes.	The SA assessment does not provide a general discussion of this objective. It does provide a list of possible reference points; strategies for their use are, however, not discussed.	No specific discussion of this objective is provided by the DEH assessment; however some concern is expressed in general comments that over-fishing may be affecting some areas.	Recommendations 7 and 9 both contain advice partly focussed on managing local overfishing. DEH implicitly accept the objective as met, in spite of evidence to the contrary.

Table A5.1 continued.

GUIDELINE COMPONENT(2000)	STATE ASSESSMENT (5/2003)	COMMONWEALTH ASSESSMENT	DISCUSSION
<p>1.2.1 A precautionary recovery strategy is in place specifying management actions, or staged management responses, which are linked to reference points. The recovery strategy should apply until the stock recovers, and should aim for recovery within a specific time period appropriate to the biology of the stock.</p>	<p>Page 40: “The use of two possible trigger conditions provides greater security and further enforces the use of the precautionary principle.” No logical argument or evidence is presented to support this statement. Further: “SA Fisheries regard the specified trigger points and the commercial TAC level (set below the highest recorded catches) as precautionary.” Again, no logical argument or evidence is presented to support this statement. Although reference points are discussed “there is currently no recovery strategy with associated timeframes...” (p.41).</p>	<p>The DEH assessment, like the SA assessment does not provide a discussion on the precautionary approach. However Recommendations 7 and 9 both focus on the development or stock recovery strategies.</p>	<p>Although the guideline component is not met, Recommendations 7 and 9 are likely to help to improve recovery management.</p>
<p>1.2.2 If the stock is estimated as being at or below the biological and / or effort bottom line, management responses such as a zero targeted catch, temporary fishery closure or a ‘whole of fishery’ effort or quota reduction are implemented.</p>	<p>On page 41: “For example, in response to Perkinsus infections, management responses were implemented. In the 1996 fishing season the blacklip abalone quota for the Western Zone was reduced by 12%.” However, in spite of strong evidence of serial depletion within some metapopulations (Shepherd & Rodda 2001, Shepard et al. 2001) management actions have been restricted to ‘discussion’ with no recovery closures implemented.</p>	<p>Evidence presented by Shepherd (see above) demonstrates widespread metapopulation declines which, in some locations, are severe. Extinction of some local populations appears a possibility. The DEH report notes (p.28) “There are currently no recovery strategies with timeframes linked to management responses”. However the DEH report concludes: “...overall, stocks are not currently overfished, but there is some uncertainty on the status of stocks in particular areas” (p.29).</p>	<p>No recovery strategies have been implemented at sites where metapopulations are at risk. Although the guideline component is not met, DEH’s recommendation 9 aims at improvement. The recommendations used should result at least in the development of recovery strategies, if not their implementation.</p>
<p>Principle 2 objective 1: the fishery is conducted in a manner that does not threaten bycatch species.</p>	<p>No by-catch issues are identified.</p>	<p>The DEH assessment accepts the proposition that there are no significant by-catch issues.</p>	<p>Compliance with objective.</p>

Table A5.1 continued.

GUIDELINE COMPONENT (2000)	STATE ASSESSMENT (5/2003)	COMMONWEALTH ASSESSMENT	DISCUSSION
2.1.1 Reliable information, appropriate to the scale of the fishery, is collected on the composition and abundance of bycatch.	As mentioned above, no by-catch issues are identified.	The DEH assessment accepts the proposition that there are no significant by-catch issues.	Guideline component met. No recommendations by DEH.
2.1.2 There is a risk analysis of the bycatch with respect to its vulnerability to fishing.	As mentioned above, no by-catch issues are identified.	The DEH assessment accepts the proposition that there are no significant by-catch issues.	Guideline component met. No recommendations by DEH.
2.1.3 Measures are in place to avoid capture and mortality of bycatch species unless it is determined that the level of catch is sustainable (except in relation to endangered, threatened or protected species). Steps must be taken to develop suitable technology if none is available.	As mentioned above, no by-catch issues are identified.	The DEH assessment accepts the proposition that there are no significant by-catch issues.	Guideline met. No recommendations by DEH.
2.1.4 An indicator group of bycatch species is monitored.	As mentioned above, no by-catch issues are identified.	The DEH assessment accepts the proposition that there are no significant by-catch issues.	Guideline component met. No recommendations by DEH.
2.1.5 There are decision rules that trigger additional management measures when there are significant perturbations in the indicator species numbers.	As mentioned above, no by-catch issues are identified.	The DEH assessment accepts the proposition that there are no significant by-catch issues.	Guideline component met. No recommendations by DEH.
2.1.6 The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.	As mentioned above, no by-catch issues are identified.	The DEH assessment accepts the proposition that there are no significant by-catch issues.	Guideline component met. No recommendations by DEH.

Table A5.1 continued

GUIDELINE COMPONENT(2000)	STATE ASSESSMENT (5/2003)	COMMONWEALTH ASSESSMENT	DISCUSSION
Principle 2 objective 2. The fishery is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species and avoids or minimises impacts on threatened ecological communities.	There are no reported adverse impacts between the industry and threatened species or ecological communities.	DEH accepts the low probability of adverse impacts, but recommends the development of a reporting framework, noting the possibility of adverse impacts between divers and the nationally threatened Great White Shark populations. DEH Recommendation 10 aims at the establishment of a reporting framework.	Guideline component met overall.
2.2.1 Reliable information is collected on the interaction with endangered, threatened or protected species and threatened ecological communities.	No information is collected as none is warranted.	Recommendation 10.	Guideline component not fully met. Recommendation 10 will address the issue.
2.2.2 There is an assessment of the impact of the fishery on endangered, threatened or protected species.	Assessment not warranted.	DEH agrees in general, but recommends further information collection (see above).	Guideline component met overall.
2.2.3 There is an assessment of the impact of the fishery on threatened ecological communities.	Assessment not warranted. No threatened ecological community exists in the fishing zones.	DEH agrees.	Guideline component met.
2.2.4 There are measures in place to avoid capture and/or mortality of endangered, threatened or protected species.	Assessment not warranted.	DEH agrees in general, but recommends further information collection (see above).	Guideline component met overall.
2.2.5 There are measures in place to avoid impact on threatened ecological communities.	Assessment not warranted. No threatened ecological community exists in the fishing zones.	DEH agrees.	Guideline component met.
2.2.6 The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.	Assessment not warranted. No threatened ecological community exists in the fishing zones.	DEH agrees.	Guideline component met.

Table A5.1 continued

GUIDELINE COMPONENT (2000)	STATE ASSESSMENT (5/2003)	COMMONWEALTH ASSESSMENT	DISCUSSION
<p>Principle 2 objective 3. The fishery is conducted in a manner that minimises the impact of fishing operations on the ecosystem generally.</p>	<p>Basic ecological data is not presented. For example, no pre-harvest abundance estimates are presented, nor is ecological or abundance data presented from no-take areas. Important and readily available predator-prey information is not discussed: eg: Thomas & Day 1995 (whelk <i>Haustrum bailey anum</i> (now <i>Thais</i>)) or Gorfine & Dixon 2000 (banded morwong <i>Cheilodactylus spectabilis</i>). For both these animals (and possibly others) abalone may be a major dietary component at certain life-stages. Ecological effects of diver presence are not examined.</p>	<p>Page 32: "DEH considers that the fishery is conducted in a manner that minimizes the impact of fishing operations on the ecosystem generally. A recommendation has been developed to ensure that the risk of significant impact by the fishery on the marine environment generally is minimized in the longer term."</p>	<p>Page 32: "Recommendation 11: PIRSA to give priority to further developing environmental indicators that can be reported against in future Stock Assessment Reports."</p>
<p>2.3.1 Information appropriate for the analysis in 2.3.2 is collated and/or collected covering the fisheries impact on the ecosystem and environment generally.</p>	<p>Information is not collected, but research proposals are being developed to collect the information in the future (page 44).</p>	<p>Page 31: "PIRSA acknowledges that more research needs to be carried out to determine the environmental effects of abalone fishing."</p>	<p>Although the guideline component is not met, DEH considers that Recommendation 11 (see above) will improve the situation in the future.</p>
<p>2.3.2 Information is collected and a risk analysis, appropriate to the scale of the fishery and its potential impacts, is conducted into the susceptibility of [the listed] ecosystem components to the fishery.</p>	<p>Information is presented concerning the role of protozoan disease. No substantial information or risk analysis is presented on any other aspect.</p>	<p>Page 31: "The draft Management Plan for the fishery contains ecosystem and environmental performance indicators linked to strategies that include researching the interactions between abalone and other species. However, these performance indicators are not currently reported against."</p>	<p>Although the guideline component is not met, DEH considers that Recommendation 11 (see above) will improve the situation in the future.</p>

Table A5.1 continued

GUIDELINE COMPONENT(2000)	STATE ASSESSMENT (5/2003)	COMMONWEALTH ASSESSMENT	DISCUSSION
<p>2.3.3 Management actions are in place to ensure significant damage to ecosystems does not arise from the impacts described in 2.3.1.</p>	<p>Trial environmental and ecosystem indicators have been prepared, but are currently not reported. Data collection and reporting frameworks are being developed.</p> <p>Experimental no-take areas to assist in identifying ecosystem effects are not being developed.</p>	<p>See quote above – DEH recognises that PIRSA intends to address this issue.</p> <p>No discussion of the role of no-take areas.</p>	<p>Although the guideline component is not met, DEH considers that Recommendation 11 (see above) will improve the situation in the future.</p>
<p>2.3.4 There are decision rules that trigger further management responses when monitoring detects impacts on selected ecosystem indicators beyond a predetermined level, or where action is indicated by application of the precautionary approach.</p>	<p>See above.</p>	<p>See above.</p>	<p>See above.</p>
<p>2.3.5 The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.</p>	<p>See above.</p>	<p>See above.</p>	<p>See above.</p>

Appendix Six: Impacts of recreational spearfishing in Australia:

Notes on the effects of recreational diving on shallow marine reefs in Australia.

August 2006

"In the old days (1940's and 1950s) my friends and I used to be able to go to Rottnest (Perth's holiday island) and spear a boat load of dhuies (best fish around). These days there's nothing there - I don't understand it."

85 year old veteran Western Australian spear fisherman Maurie Glazier quoted by niece Jo Buckee²⁸⁴, 2004.

A6.1 Abstract:

On the basis of anecdotal information (as little other information is available) I argue in this appendix that recreational diving (in particular spearfishing) has had devastating effects on the fish and crayfish (southern rock lobster²⁸⁵) populations of accessible shallow reef environments along much of the Australian coastline. Spearfishing in Australia is almost entirely recreational. This appendix briefly reviews the global scientific literature on the subject, providing a backdrop against which local anecdotal information may be judged. My involvement, as a teenager, in overfishing Victorian reefs is described. Overfishing of a similar nature appears to have taken place in other Australian States where reefs are within ready access (by car or boat) from population centres of all sizes. Damage to shallow reef environments along Australia's sparsely populated coastline (eg: in northern Western Australia, north-western Queensland, the Northern Territory, western South Australia and western Tasmania²⁸⁶) seems likely to be concentrated at the more accessible or attractive²⁸⁷ sites. These impacts are significant in a national context, yet appear to have been ignored or under-estimated by both spearfishers and the government agencies²⁸⁸ charged with conserving and regulating marine environments²⁸⁹. This relaxed managerial approach runs counter to the voluntary *FAO Code of Conduct for Responsible Fisheries*, which Australian governments claim to support. Current government management of the sport of spearfishing fails internationally accepted precautionary benchmarks in all Australian States. Further controls over spearfishing by State Governments are recommended, covering nine specific issues.

Keywords: spear, spearfishing, effects, impacts, Australia, recreational diving, lobster.

Citation: Nevill, Jon (2006) *The impacts of spearfishing: notes on the effects of recreational diving on shallow marine reefs in southern Australia*. OnlyOnePlanet Australia; Hampton Melbourne. Available online at <http://www.tucs.org.au/~cnevill/marine.htm>, accessed [date].

A6.2. Introduction:

Before discussing spearfishing in detail, it is important to note that 'passive' recreational diving and snorkelling (while important in developing an informed public voice for marine conservation) can also result in damage to marine habitats. Ponder et al. provide a review which highlights the need for awareness instruction, particularly for novice divers, as well as management limits on the number of divers at popular sites (Ponder et al. 2002:381-382).

Commercial spearfishing is banned in all Australian States, and illegal commercial spearfishing has been rare for over two decades. Relatively little use of spearfishing is made within Australia's small artisanal fisheries. The bulk of spearfishing in Australia is recreational.

Spearfishing is one of the few fishing techniques where each target is individually selected, so bycatch should be zero – a positive feature. It should also be acknowledged immediately that far more Australians go angling than go spearfishing (Henry and Lyle 2003²⁹⁰) and that recreational gill-netting is still permitted in Western Australia and Tasmania^{291, 292}. The effects of these activities are widespread and significant²⁹³. However, while spearfishing has the potential to be one of the most environmentally-sound fishing activities, it is a mistake to believe that the effects of the sport have not been important – and in many cases disastrous. Spearfishing activities are often concentrated at particular sites, and the activity is, in the right conditions, an extremely effective and efficient method of harvesting target fish – being far more time-efficient than angling in many situations.

Where reef species are heavily targeted, local populations of adult fish can be completely removed, and recruitment from deeper reefs may be low or non-existent. These locations are particularly vulnerable, and anecdotal evidence indicates local extinctions have occurred. A significant regional extinction is approaching²⁹⁴ (the grey nurse shark: see below).

The Australian situation, where recreational spearfishing predominates, is different from the situation in many Pacific island States. Here substantial commercial and artisanal spearfisheries operate under little effective control. According to Gillett & Moy (2006):

The ten most important spearfishing difficulties [in Pacific island States] appear to be the contribution of spearfishing to inshore over-fishing, the use of scuba in spearfishing, night spearfishing, industrial spearfishing, negative interaction with line fishing, poaching and difficulties of surveillance, devastation of certain species, devastation of spawning aggregations, incompatibility of spearfishing with marine tourism, and increased [detrimental] algal growth due to the removal of herbivores.

Johannes (1978) discussing the demise of traditional fish conservation in Oceania, refers to damage to fish populations by spearfishing, and cites examples of formal and informal bans on spearfishing in certain locations.

Judging by information presented by Gillett & Moy (2006) viewed in conjunction with local studies, heavy spearfishing pressures across the tropical Pacific have caused, and continue to cause severe declines and local extinctions of reef fish. Local extinctions, and possible regional extinctions of the giant humphead parrotfish (*Bolbometopon muricatum*) have been documented by Dulvy & Polunin (2004). Many less prominent fish than the humphead have, without doubt, suffered in a similar way. Dulvy & Polunin identify spearfishing as a primary threat to these reef fish.

Fisheries managers can ignore important anecdotal information which looks “unscientific”. Pauly (1995) refers to a ‘shifting baseline’ which has in part resulted from an apparent inability of fisheries science to use anecdotes to establish historical baselines²⁹⁵. Johannes et al. (2000) stressed the importance of considering fishers’ ecological knowledge. Saenz-Arroyo et al. (2005) after a detailed examination of historical evidence on the abundance of the Gulf Grouper in the Gulf of California, concluded:

We should start rethinking our criteria for assessing marine species at risk, not just in the context of the shifting baseline, but also with respect to the type of information we require for these assessments. By only trusting the evidence that we are trained to use as ecologists or fisheries scientists we continue to run the risk of failing to adequately protect species that have been depleted without our noticing.

Discounting anecdotal information, even when no scientific²⁹⁶ information is available, may be one of the reasons behind the failure of many fisheries management programs. This appendix rests largely on fishers’ knowledge. It deals with the environmental impacts of recreational diving, focussing principally on spearfishing. Recreational harvesting of crayfish and abalone are also briefly discussed.

By way of background, it is important to note that, globally, the importance of recreational fishing has been consistently understated and under-reported (Cooke & Cowx 2004) and that recreational fishing can cause ecosystem degradation of similar scales and types compared with commercial fishing (Cooke & Cowx 2006). These authors provide examples of declines caused by recreational fishing that “were largely unnoticed by fisheries managers, a characteristic that may be widespread in recreational fisheries.” (2006:94). This comment certainly applies to the management of spearfishing in all Australian States.

Spearfishing on SCUBA (self-contained underwater breathing apparatus) while banned in Queensland, New South Wales, and South Australia, is still permitted in Western Australia, Victoria, Tasmania and the Northern Territory. As far as I am aware, night spearfishing is still permitted in all Australian States. In my view this situation needs urgent review, and displays an absence of understanding (on the part of the agencies charged with regulating fishing activities) of the potential damage the sport can do to reef environments. Again, in my view, massive increases in marine no-take areas are needed to provide adequate protection for marine ecosystems, and spearfishing should not only be excluded from these areas, but from buffer zones around these areas as well.

A6.3. International benchmarks:

The cavalier attitude to spearfishing common amongst Australia’s fishery management authorities is underlined by a comparison of existing management frameworks with FAO²⁹⁷ fishery guidelines. The voluntary *FAO Code of Conduct for Responsible Fisheries 1995*, echoing the *Rio Declaration 1992* (both endorsed by the Australian Government), requires all compliant States to apply the precautionary principle. The FAO precautionary principle guideline (the Lysekil Statement²⁹⁸) advocates (paragraph 7) that:

- (a) all fishing activities have environmental impacts, and it is not appropriate to assume that these are negligible until proved otherwise,

and that:

- (c) the precautionary approach to fisheries requires that all fishing activities be subject to prior review and authorization; that a management plan be in place that clearly specifies management objectives and how impacts of fishing are to be assessed, monitored and addressed; and that specified interim management measures should apply to all fishing activities until such time as a management plan is in place.

The failure of all Australian State fishery agencies to develop management plans for spearfishing, or to monitor effects and publish findings, places these agencies in clear contravention of the precautionary elements of the *Rio Declaration* and the *Code of Conduct* in this respect.

The Lysekil Statement contains a number of other recommendations which are relevant to the management of spearfishing:

Para.	Recommendation	State fishing agency response
6b	Prior identification of undesirable outcomes and of measures that will avoid them or correct them promptly.	Recommendation ignored.
6c	Any necessary corrective measures are initiated without delay.	Recommendation ignored.
6d	Where the likely impact of resource use is uncertain, priority should be given to conserving the productive capacity of the resource.	Recommendation ignored.

Para.	Recommendation	State fishing agency response
25	For all fisheries, plans should be developed or revised to incorporate precautionary elements.	Recommendation ignored.
28	To be precautionary, priority should be accorded to restoration of overfished stocks, avoidance of overfishing, and avoidance of excessive harvesting capacity.	Ignored – with the partial exception of the GBRMPA ²⁹⁹ .
41	Precautionary monitoring of fishing should seek to detect and observe a variety of ancillary impacts, eg: environmental changes, fish habitat degradation...	Ignored – with the partial exception of the GBRMPA.

To comply with the FAO Code of Conduct, a fishery must be precautionary. The Lysekil Statement presents accepted benchmarks which together define precautionary fishery management. No Australian State or Territory currently manages spearfishing in accordance with the precautionary approach.

A6.4. Back in the old days ...

Humans have been spearing fish for thousands of years. However spearfishing as a popular sport is a post World War II phenomenon, underpinned by the technical innovations of SCUBA and neoprene wetsuits reaching the consumer marketplace. Spearfishing as a popular sport in Australia began in Queensland and New South Wales in the mid-1940s, and in my home State of Victoria (where water temperatures were lower) in the late-1940s. Neoprene wetsuits had, however, not yet reached the consumer market at this time, seriously limiting diver time in the cool waters of southern Australia.

When my father and I started spearfishing in 1959 (I was 13 years old) my first spear was a home-made affair, a length of bamboo with a steel barb at the tip and two straps of rubber cut from a car inner-tube fixed to the rear. Mass-produced masks, snorkels and fins had been available for about fifteen years. Wetsuits had only recently appeared in shops selling sporting equipment, although these early suits had no linings, with the disadvantage that a lot of talcum powder was needed to don the suit, and the neoprene foam was easily damaged by contact with rocks. Within a year we had replaced our sling spears with home-made trigger-mechanism spearguns constructed from broom handles and rubber straps, with 5/16 inch stainless steel spears. Although mass-produced spearguns were available, they were expensive. The popularity of the sport at that time was increasing rapidly.

My family lived in Hampton, a suburb of Melbourne, on the eastern shore of Port Phillip Bay. Close by a 300 m breakwater had been constructed from basalt boulders to provide a small harbour for a number of swing-moorings. The breakwater was built over shallow sand, but joined a section of natural sandstone reef at the point where it met the shore. Our house was only five minutes walk from the Bay. In those days, snorkelling beside the Hampton breakwater, I could count on catching enough fish in 20 minutes to feed five people – generally 3 to 5 fish between 0.35 and 1.0 kg in weight each. Leather jackets³⁰⁰ and luderick³⁰¹ were abundant, as were several other species of reef dwelling fish. Large flathead³⁰² and flounder³⁰³ could be easily caught on the sand beside the breakwater. Like most others spearing fish, we simply assumed that the fish we took would be replaced by fish moving in from deeper reefs. We were wrong.

There is no doubt in my mind that spearfishing in reef environments is hugely more effective as a harvesting mechanism compared to angling. Angling had taken place along the breakwater since it was built decades earlier. Although flathead and snapper were the primary angling target (fishing on the sand beside the artificial reef formed by the boulder breakwater) a few anglers targeted reef species, using floats to keep baits above the rocks. I participated in both angling and spearfishing at that location over several years.

Within five years of my first observation in 1959, the populations of reef fish along the breakwater were decimated. I undertook a visual census in 1964, and reconstructed 1959 population levels from memory³⁰⁴. Within about ten years the species targeted by spearfishers were gone, for all intents and purposes. Even the marblefish³⁰⁵, easy to catch but poor eating, were gone. Several fish species, by my observation, were entirely eliminated from this site. During this period there was no noticeable increase in recreational angling pressures, which remained almost non-existent in relation to reef fish. No commercial harvesting or recreational netting of reef fish took place at this site before, during or after the period in question. Because I lived with the breakwater so close by, during my childhood I was there almost every day (usually accompanied by my dog) and I can remember no changes – pollution episodes or dramatic weather events³⁰⁶, for example, which could account for the decline I witnessed. There is no river or creek nearby which might have effected the site. I believe that spearfishing pressure was the single cause of the decline in fish populations in the 1960s³⁰⁷. A rapid increase in spearfishing pressures, starting during the late 1950s, coincided with a rapid decrease in fish numbers. Aquatic vegetation at the breakwater did change, but this change followed rather than preceded the decline in fish numbers.



Figure A6.1 Hampton breakwater and marina, 2009.

Source: Google Earth 23/3/2009.

Later on, about 1990, the swing moorings were removed and a marina was constructed inside the breakwater to protect mainly recreational yachts and motor vessels. This would have resulted in an increase in local pollution by anti-fouling agents; however no site-specific water quality data is available. I estimate that the wetted-hull area after the marina was constructed increased by around a factor of 10^{308} . It should be noted that this expansion post-dates the demise of the species in question by many years.

Ten years later still, creation of an artificial beach (just visible at the top of Figure 1) released millions of tonnes of sand into the immediate vicinity of the breakwater (discussed below). In an attempt to maintain depth in the marina, sand was pumped by the Sandringham Yacht Club (owner of the marina) to the outside edge of the breakwater, substantially reducing the water depth, and smothering the rock habitat at the foot of the breakwater. However, well before this had happened, fish populations on the outside breakwater wall had collapsed.

With the rapid decline of shore-based reef spearfishing in Port Phillip Bay, I switched my attention to ocean locations. One of my favourite spearfishing sites was Flinders back-beach, near the entrance to Westernport Bay, a little over one hour's drive from my home in the suburbs of Melbourne. Flinders probably has the most extensive accessible shallow ocean reefs of any site along the Victorian coastline. Other easily accessible ocean sites were the rocky shores at Inverloch, Eagles Nest and Cape Liptrap, and shallow reefs near Tidal River at Wilson's Promontory.



Figure A6.2 Flinders shallow reef, 2009.

Source: Google Earth 23/3/2009.

As I have said, spearfishing became a popular weekend pastime at Victorian ocean locations at the close of the 1950s. In the early 1960s, the shallow (2-6 m) reef ledges at Flinders³⁰⁹ were still so packed with fish that a spear shot into a ledge would often take two fish with the one shot. Large crayfish and abalone were abundant. At Eagles Nest, I can remember – along with two friends – filling a 50 kg flour-sack with crayfish in under one hour, snorkelling in water only 2-4 metres deep. By the time I started studying at university (1966) I had noticed a dramatic decline in both fish and crayfish in these shallow ocean reefs.

The crayfish populations in shallow water, although prolific in the early 1960s, were without doubt already well below pristine abundance. According to O'Hara (2000) the first European settlers on the Mornington Peninsula³¹⁰ in 1802 "reported catching up to 500 crayfish in a single evening from the shoreline of Point Nepean"³¹¹. It is clear that the abundance of

crayfish in very shallow water, prior to the onset of fishing, was extremely high. Today adult crayfish have been (for all intents and purposes) entirely removed from these near-intertidal waters.

In Tasmania, when James Kelly called at Port Davey in 1815 he traded swans he had shot for crayfish; the local aborigines quickly collected over 1000 crayfish by hand from the water's edge. In 1905, James Rattenbury caught 480 crayfish from his ship the Rachel Thompson in six hours using only six 'cray rings' in Wineglass Bay (Gardner et al. 2005). I snorkelled the shallow reefs on each side of Wineglass Bay in 2003, without finding a single crayfish.

Others were also concerned at the rapid decline of Australia's shallow water fauna. In 1966 Pollard and Scott wrote:

In many parts of the world, particularly along the coasts of Spain, Southern France, Italy, Jamaica and the Bahamas, spear fishermen have decimated populations of edible reef fishes. The same is now happening in parts of Australia. The inshore reefs for more than twenty miles each side of Sydney Harbour have been almost denuded of edible fish, and much of the remaining New South Wales coastline is also beginning to suffer (Pollard and Scott 1966:106 – see Attachment One for further details).

Similar damage to reef environments from spearfishing was observed in the USA. According to Hale & De Sylva (1992): "In 1957, extensive spearfishing and coral dynamiting aroused conservationists, resulting in the establishment of the first aquatic preserve in the US – the John Pennekamp Coral Reef State Park, off Key Largo."

I wrote, with some alarm, to the Victorian Minister for Fisheries, suggesting that urgent controls needed to be implemented to reduce the impact of the sport. I suggested that spearfishing on SCUBA needed to be banned³¹², and that licences should be introduced for spearguns, conditional on a display of knowledge concerning fishing regulations such as legal bag and size limits³¹³.

The Minister wrote back, politely replying that he was advised that there was no scientific evidence to justify my concerns. His response left me with the sense that no action would be taken by the Department to investigate the matter further. At that time Victoria had no fully protected marine reserves³¹⁴ other than a tiny circle of 100m radius at Pope's Eye near the entrance to Port Phillip Bay. The Pope's Eye reserve protects an artificial reef environment which has grown up around the foundations of a navigational marker.

As no scientific data appear to exist which would indicate natural abundance levels for reef fish, crayfish or abalone, historical anecdotes are important sources of information on 'natural' ecosystem levels. In the shallow reef ledges along Victoria's coastline in the late 1950s, my own experience suggests that it was common to see layers of abalone two-deep in places, as well as groups of six to twelve crayfish in the deeper ledges. Most of these shallow ledges are empty today. When commercial abalone fishing started in Australia in the 1960s, it was not uncommon for divers to harvest a full boat-load without moving their anchor. Local abalone clusters were estimated by divers at more than 100/m². These and similar anecdotes (compared with modern abundances) indicate a precipitous decline in both abalone and crayfish populations along Australia's eastern seaboard. Accurate declines are impossible to calculate, but it is not unreasonable to believe overall abundance levels for both these groups are now between 5% and 1% of their un-fished levels, and certainly lower still in many local areas where they are all but absent.

Anecdotes from temperate reef environments in other parts of the world support this view. According to Dayton et al. (1998) along the Californian coast:

Both abalones (*Haliotis* spp.) and spiny lobsters (*Panulirus interruptus*) were extremely abundant before diving and effective trap fisheries. Divers of the 1950s reported green abalones stacked on top of each other in shallow water and

describe the Point Loma kelp forest as “paved with red abalones”. Abalones are now so scarce that all five species fished in southern California have been closed to both sport and commercial harvest, and there is good reason to believe that one, *H. sorenseni*, will become the first marine invertebrate known to become biologically extinct as a result of human fishing. Probably because the spiny lobster source population has yet to be rendered ecologically extinct in Mexico, the lobster fishery has persisted, but abundance and size distributions are clearly different from historical patterns. In 1888, 260 traps yielded 104,807 kg of lobsters. By 1975, 19,000 traps were required to harvest almost the same mass, 105,768 kg.

In the summers of 1982 and 1983 I was able to re-visit most of my old spearfishing locations. I wished to ascertain what changes had taken place at sites I was familiar with, as I was considering the preparation of a short article dealing with shallow reef environments³¹⁵. In Port Phillip Bay, I found that several species appeared to have been entirely eliminated from accessible shallow reefs. Even tiny juveniles had disappeared. Abalone were still reasonably abundant³¹⁶ in a few locations, but they were small, and generally below the legal size limit – and were being harvested illegally at unprecedented levels. On weekends I saw families removing large plastic rubbish bins (around 70 L capacity) overflowing with undersize abalone. At that time there was a bag limit for recreational abalone of 10 per person per day as well as a size limit. Each bin would have held around 200 abalone, in my estimation. There were no bay-side information signs relating to fishing regulations in those days – multi-lingual signs were to appear a few years later. I never saw a fisheries enforcement officer, nor did I hear or see relevant information on radio, television or through newspapers, aimed at educating the public about fishing restrictions.

Clearly, fishers like myself (as well as government experts) had under-estimated the ability of these reefs to recruit stock from deeper, less accessible habitats³¹⁷. We had over-estimated reproductive capabilities, and under-estimated fishing pressures. Are similar mistakes still being made today?

I was also surprised by a dramatic decline in large specimens of flathead and flounder – a matter I still fail to fully understand. They certainly were heavily harvested by both anglers and spearfishers, but there are huge areas of sandy habitat in the Bay. Commercial fishers did (and still do) target these fish, and I have not attempted to obtain further information on commercial harvesting pressures. Perhaps these bottom-dwelling fish are more territorial, or less mobile than I had imagined. These observations were made long before the very recent reports of major declines in fish populations of the Bay³¹⁸, thought to be the result of major ecosystem changes brought about by introduced invertebrate pest species.

As an aside, during the 1950s I had watched huge schools of ‘whitebait’ (a schooling fish 70 – 100 mm in length) streaming past the end of the breakwater. These schools were so large they would take around a whole day to move past – a stunning sight of great areas of sea turned silver. I have never seen such schools again.

My survey of shallow reefs in 1982/83 revealed that the situation was a little better at ocean locations. Although crayfish had disappeared completely from the shallow ledges, vestiges of the former populations of reef dwelling fish remained – however the fish were generally much smaller and fewer compared with populations I had observed 10 years earlier. It was particularly sad to see the ledges at Flinders, which had been so thick with fish and crayfish, now virtually deserted.

A6.5. The decline of two spearfishing target species in New South Wales.

Many reef-dwelling fishes have attributes which make their populations vulnerable to overharvesting – they are large, territorial, highly edible and have slow reproductive strategies³¹⁹. Those that have restricted ranges are especially vulnerable. Apart from the

three species discussed in this section, Pogonoski et al. (2002) implicated spearfishing in the decline of a number of other vulnerable species: the camouflage grouper (*Epinephelus polyphkadion*) – also targeted in the Pacific for the Asian life fish trade; the potato cod (*Epinephelus tukula*) – spearfishing is banned in Natal, South Africa; the western blue grouper (*Achoerodus gouldii*) – spearfishing is banned in South Australia; and the double-header (*Coris bulbi*) – restricted to Lord Howe Island and the NSW coast.

This section focuses on two species which were heavily targeted by spearfishers until they were protected by legislation – the black rockcod and the grey nurse shark. Unfortunately, populations have not recovered, and the eastern seaboard population of the grey nurse appears to be moving towards extinction. The resurgence of eastern blue groper³²⁰ populations, however, provides a different story from the same general area: this animal too was heavily harvested by spearfishers prior to protection, and populations have recovered well in some areas³²¹.

The **black rockcod**, *Epinephelus daemeli*, has been a protected species in New South Wales (NSW) waters since 1983, and was listed as a ‘vulnerable species’ under the NSW *Fisheries Management Act 1994* in 1999. It is also listed under section 15 of the Commonwealth *Fisheries Management Act 1991*, making its take in fishing operations illegal unless covered by a scientific permit. The Australian Society for Fish Biology (ASFB) lists the species as potentially threatened (ASFB 2004).

Roughley (1916) reported specimens to 100 pound in weight, and that “at one time it was fairly plentiful in the vicinity of Port Jackson, but has become very scarce in recent years, owing to the havoc wrought by fishermen...” McCulloch (1922) reported that *E. daemeli* was “a valuable food fish” in NSW, indicating that the species was still reasonably common in the State at that time. Today, according to the ASFB, “abundance is low, and large males are considered to be rare.” (ASFB 2004).

The overfishing reported by Roughley would not, presumably, have included spearfishing, as the sport did not achieve widespread popularity for another 40 years. However, the inquisitive and territorial nature of the animal, as well as its size, make it highly vulnerable to spearfishing (Leadbitter 1992). The total fishing ban in NSW was initiated after substantial anecdotal evidence of continued and major decline in population numbers; spearfishing was identified as a major threat (ASFB 2004).

The **grey nurse shark** *Carcharias taurus* was once relatively common along Australia’s east and southeast coasts, with the largest adults reaching over 4 m in length. According to Roughley (1951:261) “the most prevalent shark at Port Stephens (NSW) was the whaler, followed by the grey nurse...”. The shark, which is neither fast nor aggressive, became a spearfishing trophy target in the 1960s, with its territorial nature and its fondness for shallow reefs making it particularly vulnerable. At that time explosive spearheads were both readily available and unrestricted by government regulation, and were routinely used to kill the larger adults.

The grey nurse is now listed as an endangered species under the NSW *Fisheries Management Act 1994*, and listed as a threatened species under the Queensland *Nature Conservation Act 1992*. The east coast population of the shark is listed as critically endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. This shark was the first shark protected by legislation in the world when the NSW government initiated a fishing ban in 1984, following a dramatic decline in numbers credited to line and spearfishing (Fisheries NSW 2003). An overview of conservation issues is provided by Pollard et al. (1996) who identify spearfishing as a primary driver of decline.

Rather than recovering, population numbers have continued to decline. Numbers are now so low (probably 300-400 adults) that serious concerns must be held for the survival of the east coast population (Otway et al. 2004). Limited habitat protection has been provided

through marine protected areas, however these protected areas are comparatively small and not regularly policed, and illegal line and spearfishing continue³²². Accidental kills are continuing to occur from beach shark meshing programs in NSW, which are designed to reduce the incidence of shark attacks on swimmers. The grey nurse has not been implicated in such attacks in Australia.

A6.6. Fisher experience:

Ron and Valerie Taylor are amongst Australia's best known underwater photographers, and have had a long association with both fishing and conservation. They have dived extensively in all Australian States. According to Valerie³²³:

We were both Australian Spearfishing Champions several times and Ron was world champion once. We however would know better than most the detrimental effects of spearfishing, specially competitions where an entire reef system is decimated, and from our 50 years of experience never ever returns to how it was or how nature intended it to be. I have seen a beautiful rich coral reef denuded of all the big fish in just 3 days. (off Maroochydore) during the Australian Spearfishing Championships.

The spearo who swims out and takes a selected fish or two to eat does less harm than a line fisherman, but a bunch of up to 60 or 70 good freedivers with guns shooting everything in sight can cause irreparable damage. We know, we used to do it. We used to believe that there were so many fish off the coast that no amount of harvesting could make a difference. It took us over a decade to really see the damage we in our ignorance were doing to life in our coastal waters.

As for wanting scientific evidence, in the 1960s there were no scientists monitoring what was happening off the coast. We know very well how quickly a species of reef fish can be wiped out in a large area. Ron and myself did all our spearfishing holding our breath.

When good eating fish in the shallows became scarce, many spearos began using SCUBA to hunt commercially in deeper water, which was a disaster for our reef dwelling fish who all have a territory in which they live. Many species do not live below say 200 feet and were extremely vulnerable to SCUBA divers with guns.

In 1970 Ron and myself along with the NSW politician Eric Willis had the practice of taking fish and crayfish using any form of self contained breathing apparatus banned in NSW. The uproar from the spearfishing clubs was enormous, but we were at the time Australia's two top spearfishing champions so there was little to argue about. We were out there and we knew first-hand what we were doing and we knew it was wrong. This made us very unpopular in spearfishing circles, although today many of the old timers now agree with us.

Valerie Taylor's experiences fit exactly with my own experiences, and are, I believe, typical of accessible reef areas around Australia.

In South Australia, for example, an unpublished report by Shepherd (1967) suggested that excessive spearfishing was responsible for the denudation of inshore reefs along the South Australian coast.

Another unpublished report from South Australia (Ottaway et al. 1980) commented "Whether or not spearfishing could kill off all the larger fish of particular species on particular reefs has not been studied rigorously, but it is the personal opinion of three of us who did spearfish in South Australia some 15 years ago that it was happening then and it is still happening now on reefs further and further away from the main areas of population". The three giving this opinion, based on their personal observations, were John Ottaway, then a Queen's Fellow in Marine Science at Flinders University, Igor Oak, then the President of the South Australian Underwater Photographic Society, and R.B. Gardiner, then the Chairman of the SCUBA

Divers Association of South Australia. These three highly experienced divers were among the first spearfishers and SCUBA-divers in South Australia.

According to John Ottaway more recently (personal communication, 2005):

I have no doubt that the popularity of spearfishing in the 1960s, and no controls (when scuba gear became readily available) on spearfishing on scuba in the mid to late 1960s, was the major factor in the staggering decline in near-shore fish populations along the South Australian coastline, starting with the reef areas near Adelaide, and then radiating away from Adelaide as the nearer reefs became depleted.

There were many reefs along the Hallett Cove to Port Stanvac area where during the early 1960s I always saw many hundreds of fish, and commonly saw reef and pelagic specimens that would have been 5 kg plus and occasionally 10 kg plus. We left those big fish alone because the smaller fish were abundant, better eating, and we thought the big fish were probably important breeding stock. We also saw sharks reasonably often, ranging from 60 cm wobbegongs (frequently) to 4-5 metre white pointers (rarely).

In 1978, I went back to that same area on several occasions to have a look around, and was shocked to find the whole area where I used to spearfish was now a 'wasteland' with not a single fish over a couple of hundred grams to be seen. Even the big schools of pelagics were absent.³²⁴

It seems surprising that government regulatory agencies could turn a blind eye to the major changes that spearfishing was creating in accessible coastal ecosystems – yet this happened consistently not just in Australia but around the world.

Describing the situation at Goat Island (once a popular spearfishing location, then newly declared as the Leigh Marine Reserve) in New Zealand, Russell – writing twenty years after the start of recreational spearfishing – wrote:

Although reef areas support large numbers of fishes and high standing crops, they are very vulnerable to exploitation. Most reef fishes are non-migratory, many species spend their whole lives on the same small patch of reef, and they are thus more susceptible to fishing pressures than stocks of pelagic or wandering demersal species. The problem is especially severe for small isolated reefs, and there are numerous examples where reef fish populations have suffered marked local depletion through overfishing (e.g. Clutter 1971; Johannes 1975).

Certain methods of exploitation such as spearfishing may be particularly damaging. At Goat Island, the effects of spearfishing were evident in two areas (Areas D and E), both of which are within easy swimming distance of Goat Island Beach and are heavily spearfished during summer. Compared with less accessible reef areas (e.g., Area A) there was a notable scarcity of larger fishes such as *Cheilodactylus spectabilis* (red moki) and *Navodon convexirostris* (leatherjacket). These species are commonly taken by skindivers and, like most reef fishes, can be virtually eliminated from an area by indiscriminate spearfishing. The long-term effects of removal of these larger fishes from reef communities is difficult to assess, but possible consequences include reduced stocks, depressed age-size structure of the populations, and, by removal of the larger predators, alteration of the reef community as a whole. For some species (e.g. *Coris sandageri*, Sandager's wrasse) which occur only in small localised populations at Goat Island and other coastal areas of northern New Zealand, the threat of local extinction also is very real.

The establishment of marine national parks provides protection for fishes in some areas, but there remains the need for many species to be protected from spearfishing outside these areas. The recognition of marine fishes as native wildlife and according legal protection similar to other endangered wildlife might be a first

step. Because the majority of reef fishes can be classified as residents and are therefore endangered by spearfishing, a large list of protected species is likely to be impracticable and from a management point of view, a declared list of fishable species is probably more feasible. As a basis it might include only transient species (Russell 1977).

More information on the Leigh Marine Reserve is contained in Attachment Two below.

Alan Curley started spearfishing the central coast of New South Wales in 1970, at least a decade after the sport gained popularity. At that time abalone were still common, with densities of 10-20 per m² in caves and 30-40 per m² in ledges around The Entrance. Abalone have all but disappeared from this area today, which Alan explains largely in terms of professional harvesting pressures. Fin-fish abundance today shows a precipitous decline since the early 1970s. According to Alan (pers. comm. 2/6/06):

Toowoan Bay³²⁵ (southern headland and deep hole) is a common spear and line fishing site even today. Thirty years ago the hole was full of pelagic fish, Silver Sweep, Silver Trevally, large Silver Drummer, Port Jackson sharks, Baitfish including Yellowtail and the occasional Kingfish and Snapper. Red Morwong and Rock Blackfish³²⁶ were abundant together with Bream, Leatherjackets, Grouper and Luderick. I can remember lying on the bottom waiting for a 400 mm Grouper (a protected species) to clear the end of my gun to enable me to shoot a 400 mm Red Morwong, with a 900 mm Kingfish swimming in the background. Large Red Morwong lived in families of 4 to 8 per hole, and at least 2 individuals could be found within any 100m stretch of reef which had weed, boulders or ledges for cover.

My daughter and I surveyed the same area in 2004-2005. The pelagic fish were non-existent and Red Morwong were rare despite the fact we were using SCUBA tanks and could search the reef thoroughly. There were also few large Rock Blackfish of any size and numbers of Luderick were well down. An estimate of around 50 Luderick per 100 meters of shallow reef would have been conservative for 30 years ago. The Groupers and Leatherjackets were almost non-existent. The reef is almost barren compared to when I speared there 30 years ago.

Such changes are dramatic but unfortunately typical. While angling and commercial fishing have undoubtedly played a part, the decline in the sedentary reef species, especially the Luderick which generally do not take a bait, are in my opinion principally due to spearfishing pressure.

A6.7. Removal of larger fish – is it important?

Spearfishing is a selective sport, and spearfishers tend to harvest larger individuals within a species – partly driven by the ‘trophy status’ of the larger fish. In some cases the larger individuals are less timid and are easier to spear.

Birkeland and Dayton (2005) have reviewed the effects of removing larger individuals from populations. At least as far as long-lived reef fish are concerned, the available data indicate a variety of important effects:

- larger females are proportionately more fecund, yielding more eggs per gram of body weight;
- the larvae of larger females of some species have better survival rates;
- larger females spawn over an extended period, thus providing more resilience to changing environmental conditions;
- larger fishes can be more experienced and more successful in spawning;

- larger fishes of some species provide leadership in migrations to spawning aggregation sites;
- reduction of larger fishes may reduce genetic heterogeneity; “potentially leading to reduced adaptability, population productivity and persistence”;
- for sequential hermaphrodites, where all the larger individuals may be of the same sex, significant removal of large fishes may prejudice spawning success of the metapopulation; and
- larger fishes can have different and important ecological effects; Birkeland & Dayton quote studies showing larger parrot-fish create important erosive effects which smaller individuals do not.

Birkeland & Dayton conclude that: “the selective removal of larger individuals probably contributes significantly to the impact of recreational fisheries, and to the difficulty that some populations experience in recovering from overfishing”.

Birkeland & Dayton suggest that “spearfishermen could also be encouraged to take intermediate-sized fishes” rather than larger individuals. Speaking from my personal experience as a spearfisher, I believe such “encouragement” would undoubtedly fall on deaf ears – this approach is likely to be completely useless. In my view, the only way to protect larger individuals is through two strategies: either ban the spearing of the species in question, or create large networks of marine no-take areas.

It is sometimes suggested that the culture of recreational spearfishing in Australia has changed over the years, to embody more thoughtful and more environmentally-conscious ideas. A perusal of Australia’s spearfishing magazines (see for example www.spearfishingdownunder.com.au) in July 2006 found no evidence to support this suggestion. In fact letters to the editor and editorials were dominated by “more and bigger catches are better” ideas, coupled with outright antagonism to any form of restriction on the so-called sport. The Underwater Federation of Australia’s policy statement on spearfishing, published in July 2006, contains little evidence of any awareness of the ecological impacts which the activity can cause³²⁷.

A6.8. Site and specie risk factors:

There is not enough information in the available literature to make definitive statements about risk factors; however these are my suggestions for identifying species and sites at high risk:

Specie:

Obligate reef dweller; seeks shelter in caves and ledges; preferred habitat in shallow water (<20 m depth); territorial; edible flesh; edible size (over 20 cm fork length) or trophy target size; low reproductive rate; sequential hermaphrodite; forms breeding aggregations; active during the day.

Site:

Accessible (within an hour’s travel by boat or car from a population centre); window of visibility (>5 m visibility for at least 20 days per year); easy to locate (presence of rocks above low water mark identifies reef location); isolated from adjacent reef habitat (by >1 km of different habitat (eg: sand, seagrass)); relatively safe (regular currents < 0.3 m/sec); relatively comfortable (water temperature > 10 Celsius).

A6.9. Spearfishing impacts – the literature:

Should I have been surprised by the destruction of fish populations at my favourite reefs? With hindsight, no. The pelagic environment is a dangerous place, there’s really nowhere to hide. Pelagic fish need high-powered reproductive strategies. The reef environment is

different, and it seems likely that much slower reproductive strategies might generally apply to sedentary reef-dwellers. The reef environment used to be a comparatively safe place...

Degrading reef environments³²⁸ have not, of course, escaped the attention of the diving community – although many spearfishermen do not wish to acknowledge the decline or their part in it (Recfishwest 2003). Grovermann (1982) described changes to reef fauna in Western Australia and South Australia. Local groups lobbied to have particular sites declared speargun free (eg: Bail 1983), and competition spearfishing was the target of strident criticism from some divers (eg. Cahill 1979). Andrewartha (1972, 1981) drew attention to the dramatic decline of reef fish and crayfish around Wilsons Promontory in Victoria, as did McCallum (1982).

Although the effects of spearfishing have been so dramatic at those localities where fishing pressure has been focused, both fishing management agencies and marine scientists have generally ignored the issue. Only a handful of papers have appeared in the scientific literature over the last few years dealing with the effects of spearfishing on reef-dwelling fish. The usual research method involves a comparison of population density and size structure of spearfishing target species at similar protected and unprotected sites. Generally speaking, these investigations have all found the same thing: that spearfishing has a marked effect on target fish populations, reducing both the size of the population and the proportion of large animals³²⁹. Depending on the study site, the size of the effect varies from the significant to the severe (Bohnsack 1982, Bohnsack 1983, Oakley 1984, Harmelin et al. 1995, Chapman & Kramer 1999, Jouvenel & Pollard 2001). Other studies, while comparing abundance data inside and out of protected areas, do not attempt to discriminate between spearfishing and other forms of fishing (eg: Buxton & Smale 1989).

Jouvenel & Pollard (2001) examined abundance and size structure of populations of two highly sought-after spearfishing target species in the north-western Mediterranean, inside and outside a protected area. Abundances were consistently higher inside the marine reserve: with *Dicentrarchus labrax* (European sea bass) averaging 3.92 individuals per 400 m transect compared with 0.69 outside, and *Sparus aurata* (guilt-head sea bream) averaging 0.68 inside and 0.05 outside the reserve. The average length of *D. labrax* inside the reserve was almost twice that outside the reserve. These results show a massive difference in biomass between fished and unfished areas.

Harmelin et al. (1995) in a similar study of fished and unfished areas, selected two target groups of fish – the first group of 16 species ('type A') were highly targeted by spearfishing, while the second group of two species ('type B') was highly targeted by angling. The unfished reserve was only 85 ha in size; nevertheless significant differences were found in the visual census surveys, which were carried out on 24 occasions over 3 years. Of the 16 spearfishing target species, eight were not detected in fished areas, supporting arguments that local extinction is possible. According to the authors: "the missing species are top carnivores, particularly threatened by spearfishing." Overall, abundance and biomass of both types (A and B) were significantly greater within the reserve, with average abundance in the reserve around twice that of the unprotected site. When only type A fishes were considered, "the mean number of individuals was 3-fold higher in the reserve than in the fished site" with this difference increasing to 10-fold when only large individuals were considered. Within the type A group, sargo bream populations (*Diplodus* spp.) were found to be particularly damaged by spearfishing, with abundance ratios inside/outside the reserve varying between about 4:1 to 30:1. That such large differences can be found within such a small reserve is a testament to the destructive power of spearfishing as a harvesting technique.

Dayton et al. (1998) discussing the disappearance of large fish from kelp forests in California, remark: "...for broomtail groupers [*Mycteroperca xenarcha*, large territorial fish], mortality caused by a few spearfishermen may easily explain their loss from the ecosystem". The authors continue: "... historical comparisons of spearfishing contest results with present

populations suggests major changes in abundance and size distribution of species such as California sheephead, *Semicossyphus pulcher*.”

Oakley (1984) reports an investigation of the effect of spearfishing on grouper in the eastern Red Sea, through a short visual survey. Census sites of similar habitat were graded according to fishing pressure, and grouper abundance and size recorded. Large grouper were six times as abundant, and medium sized grouper (200-400 mm length) three times as abundant in the low pressure sites compared to the high pressure sites. Small grouper, however, were more than twice as abundant in the high pressure sites – an effect which Oakley attributed to reduced competition with larger animals. Oakley concluded that spearfishing pressure had a significant affect on grouper populations in this area. It would be interesting to revisit Oakley’s census sites after twenty years. I suspect his ‘low pressure’ site average abundance figure of 6 large grouper per 250 m transect could not be repeated today.

Chapman and Kramer (1999) examined fish density and size within and outside the Barbados Marine Reserve – a small reserve protecting 2.2 km of coast to around 500 m offshore. The reserve was, at the time of the study, subject to illegal fishing. Given the small size of the reserve and the acknowledged enforcement difficulties, it would not be surprising to find little difference between sites inside and outside the protected area. Nevertheless, the authors found evidence of more large individuals (of species targeted by spearfishing) within the reserve, an effect which they attributed principally to spearfishing mortality.

Data from spearfishing competitions provides unreliable evidence on Catch per Unit Effort (CPUE) changes over time, for the reasons discussed elsewhere in this appendix. Very few studies have tracked spearfisher CPUE over time in a reliable way. Harper et al. (2000) is one such study, which surveyed recreational fisheries in Biscayne Bay National Park (Florida) between 1976 and 1991.

Unfortunately the study start date is around 25 years after the commencement of spearfishing as a popular recreation – so the initial impact has undoubtedly been lost. Nevertheless the study produces some interesting information. Spearfishers, in comparison to anglers, accounted for about 10% of all fish caught, although anglers spent comparatively more time catching each fish – a not unexpected finding, and one which, in my view, is likely to apply over substantial areas of Australia’s eastern seaboard. Species information is also informative. Nassau groupers, targeted by both spearfishers and anglers, showed a steeply declining CPUE, from around 22 to 1 (number landed per 100 trips) over the 15 years of the study. Hogfish, targeted principally by spearfishers, declined more slowly, with CPUE dropping from 65 to 32. These findings suggest that spearfishing has had a major impact on this area, in combination with other pressures. It is also worth noting that reef fish in the Florida Keys are known to have undergone intense exploitation (overfishing) during the twentieth century (Ault et al. 1998).

In a marine protected area at Looe Key, Florida USA, all 15 species that were spearfishing targets increased in abundance after spearfishing was banned: snappers (*Lutjanus spp.*) by 93%, grunts (*Haemulon spp.*) by 439% (Clark et al. 1989). Looe Key Reef was the site of an earlier study (Bohnsack 1982) which found significant depletion of spearfishing target species in the period before the site was protected in 1981. So far I have not been able to obtain the full version of Bohnsack 1983, however the summary states: “In particular, the observed frequency of grey snapper (*Lutjanus griseus*) increased dramatically [following the spearfishing ban in 1981] although population levels remain well below those on the control reefs [fully protected since 1960].” Clearly spearfishing had a major impact on local populations of this target fish. The summary continues: “*Thalassoma bifasciatum*, the most abundant prey species, showed a drop in abundance correlated with increased predator populations. *T. bifasciatum* population levels at Looe Key Reef prior to sanctuary establishment had been double those on control reefs.”

At a marine protected area in Banyuls-Cerbere, France (on the Mediterranean) six years after the implementation of a spearfishing ban, target reef fish abundance within the MPA increased to approximately twice that outside. Amongst target fishes, differences in

abundance of 'small' individuals were marginal or non-significant, while for medium and large fishes the differences were highly significant. No difference in diversity or species richness was detected. (Bell 1983 quoted by Charton et al. 2000).

Sluka and Sullivan (1998) examined the effects of spearfishing on grouper populations in the Florida Keys. They surveyed two sets of similar habitats; all areas were open to line-fishing, but one set was closed to spearfishing in 1960 while the other remained open. They suggest that line fishing effort was roughly 10 times spearfishing effort, and they assume that line fishing effort was uniformly distributed across all areas. The Nassau grouper, resident at all locations, is a protected species, banned from take by both line and spear fishers.

The key findings of their report relate to abundance and size distribution. The abundance of the most commonly targeted groupers did not differ significantly between open and closed areas, although the abundance of the Nassau grouper was significantly reduced at sites open to spearfishing. The authors suggest that illegal spearfishing may be taking place for the Nassau, and may account for this effect. A significant difference between closed and open areas related to the presence of large fish, with generally smaller individuals present in the open areas. The authors conclude that: "the ban on spear fishing in the upper Florida Keys has significantly benefited the size distribution of groupers. However, it appears that a ban on spear fishing alone has not resulted in recovering population levels of grouper in this region." The authors recommend that, if grouper recovery is a management aim, all forms of fishing need to be excluded.

The difficulty with this study is the lack of information on line-fishing pressure. It seems highly likely that line-fishers will select areas where they know they are not competing with spear-fishers – yet the study assumes a constant high level of line-fishing pressure across both closed and open zones (closed and open to spear-fishers). If line-fishers are preferentially selecting closed areas, this is likely to compensate for the lack of spear-fishing pressure.

An Australian study by Lowry and Suthers (2004) provides limited information on the ability of a species to recolonise local depletion, indicating that, at two sites studied in NSW, red morwong (*Cheilodactylus fuscus*) successfully recolonised small reef areas depleted by high levels of experimental spearfishing. This paper is discussed in more detail below.

An electronic search of refereed scientific journals (August 2004) failed to locate any Australian publications dealing with the impacts of spearfishing, other than the papers by Lincoln-Smith et al. (1989) and Lowry and Suthers (2004).

Lowry and Suthers obtained population estimates at reef sites for red morwong, a common reef fish found along the NSW and southern Queensland coast. According to Lowry and Suthers: "Fish re-colonized the same location 2 to 4 months after a summer and a winter experiment removed >70% of the adults by intense spear fishing." This finding demonstrates that (at least for red morwong) recolonisation can occur fairly quickly where small sites undergo intense fishing pressure for a limited period of time. As the authors acknowledge, the study has several limitations. The two experimental sites were small – a total of 68 fish were removed from the two sites. Adjacent habitat was unaffected, supplying accessible areas to support recruitment. The authors did not conduct (or did not report) an observational study to determine 'background' levels of spearfishing pressure at the sites. The authors conclude that more information is needed to determine the effects of spearfishing on the species. They note: "spearfishing may have a significant impact on such a long-lived resident population. There is evidence that spearing is responsible for the localised depletion of cheilodactylid populations in New Zealand (Cole et al. 1990)".

Belinda Curley also studied red morwong in NSW: "One of the MPA's I studied was Gordons Bay near Sydney. The MPA covers 0.1 km² and fish have been protected from spearfishing since 1992. Line fishing is still permitted. I found that the abundance and size of red morwong (*Cheilodactylus fuscus*) was greater inside Gordons Bay when compared to three ecologically similar control areas. Given that red morwong are relatively sedentary and heavily spearfished in NSW this provides strong evidence that spearfishing does effect local

populations of this species.” (pers. comm. 10/5/06). I concur with Ms Curley’s view, particularly given the small size of the reserve. To demonstrate an effect in such a small area requires very strong pressure on the animals concerned.

Papers such as Edgar & Barrett (1999) referring to the Tasmanian situation, do not attempt to separate spearfishing impacts from other harvesting activities – although confirming significant differences in fish populations across marine reserve boundaries. Not surprisingly, Edgar and Barrett note that small marine protected areas are relatively ineffective³³⁰. My personal observations of areas near their study site at Maria Island suggest that recreational gill-netting as well as spearfishing and crayfish collection pressures are significant immediately beyond the boundaries of the protected area. Between the declaration of the Maria Island protected area in 1992 and their 1997 survey, crayfish biomass increased by over an order of magnitude, and biomass of legal-size crayfish increased by over 20 times.

Catch per unit effort (CPUE) data in relation to the capture of reef fish is available from spearfishing competitions; however this data means little in itself, as the selection of competition site and prior access by spearfishers to this site are critical in establishing logical conclusions. The data, moreover, is prone to certain inaccuracies stemming from the way it is reported.

Competition data can be used in two ways: (a) if a site is under constant spearfishing pressure, competitions held, say, at 10-year intervals can provide surrogate measures of changes to the health of reef populations over time, or (b) if large competitions are held regularly at the same site, and spearfishing pressure between competitions is low, the impact of the competitions themselves can be measured.

Competition CPUE data are most useful if the first data come from fishing a virgin site (thus establishing a baseline) and where that site then becomes subject to significant and ongoing spearfishing pressure. In this case, the next time a competition is held at that site the CPUE data (provided other aspects like competition rules and weather remain more or less unchanged) can provide a measure of the effect of that regular pressure on the site. Here the competition itself is not the pressure measured, it is the yardstick - as it provides a surrogate measure of species density and the presence of large individual fish.

Papers by Johnson (1985a, 1985b) highlight difficulties in using competition CPUE data in an attempt to measure changes in fish populations. Spearfishing competitions in South Australia were documented in 1977/78 and again in 1983/84. Comparing data across these two events, catch rates decreased (effort increased) and the proportion of reef-dwelling fish caught decreased (compared with open-water species). However, no conclusions could be drawn as the competitions used different rules (eg: for ineligible and eligible species) and were held at differently defined sites, under different access conditions. It is also worth noting that the organisers “estimated” diver water time by guessing an overall figure averaged across all competitors – a technique prone to considerable inaccuracy.

The discussion of competition data by Lincoln-Smith et al. (1989) highlights other problems in using competition data: for example where rules allow only one or two fish per species to be weighed-in, discarded fish go unreported in both number and weight, and in fact unobserved by competition officials³³¹. Competition catches are heavily influenced by competition rules, and may bear little relation to regular spearfisher catches in both species and weight per unit effort; thus comparisons between spearfisher impacts and angler impacts cannot be reliably based on competition data.

Problems with the use of competition statistics can be illustrated by examining the coral trout (*Plectropomus leopardus*) CPUE data from Smith and Nakaya (2003). Their Great Barrier Reef CPUE data (p.20) indicate that, over the 1980-2000 period, fish per diver hour CPUE declined by about 30% while the average weight of each fish caught declined by about 25%. While these figures suggest a steady decline in abundance commensurate with unsustainable fishing rates, they are moderate over the timescale, and perhaps do not

support the sense of alarm which I am expressing. The actual situation, however, is that these figures disguise the fact that there has been a major decline in coral trout abundance due to fishing pressures on the Great Barrier Reef, particularly the heavily fished reefs of the inner South. The rigorous abundance surveys reported by Hughes (2004) “found a 4-5 fold depletion of the biomass of this targeted fish in fished areas [compared to adjacent no-take areas].”³³²

And what about fishing pressure? It’s sometimes said that the spearfishing participation rate is low, and rocky reefs are often protected by weather, or difficulty of access. The NSW Fisheries Department, while dismissing claims of overfishing as “anecdotal”, did not seek to even investigate the environmental impacts of spearfishing until 1997 (Minister for Fisheries NSW 1997). As far as I can ascertain, the studies promised by the Minister in 1997 have either not been undertaken, or not been published. Other State Fisheries agencies have generally followed the same lines in turning a blind eye to the impacts of spearfishing.

Fisher lobby groups tend to underplay the effects of spearfishing – arguing both lack of ‘scientific evidence’ and, paradoxically, recommending continued access to marine reserves by spearfishers (Recfishwest 2003). The Australian Underwater Federation (AUF) has produced a number of reports on spearfishing and its effects (Saenger and Lowe 1975, Hyde 1986). The AUF’s paper by Smith & Nakaya (2003) presents data on spearfishing CPUE (catch per unit effort) out of the necessary spatial, temporal and pressure context, thus failing to establish any logical conclusion other than a general inference. No information is presented indicating that the competitions in question were held at the same or systematically comparable locations, at the same time of year, under the same rules, and under similar weather conditions.

In commenting on the bad press received by spearfishing competitions, Schmeissing (1997:58) pointed out that “on land the suggestion to kill native fauna for competition points would undoubtedly be met with public outcry”. Schmeissing also noted that angling competitions had received better press coverage following the introduction of tag and release rules, but that tag and release would never be possible for spearfishing competitions.

Schmeissing’s thesis (1997:59) noted that “catch records from the 1996 NSW State Spearfishing Titles indicate that 82% of species caught during the competition were sedentary reef species”. His central recommendations at the close of his study included the removal of sedentary reef species from competition eligibility rules, after highlighting concerns that spearfishing pressures, both within competitions and more generally, were widely unsustainable.

A6.10. Spearfishing: a sport out of control?

Have the impacts of spearfishing on accessible shallow reefs been underestimated? I believe they have been grossly underestimated – partly perhaps because fishery agency staff tend to focus on issues which they see as more important, particularly commercial fishery issues. Partly also because conservation lobby groups in Australia tend to be preoccupied with issues which they perceive to have wider public support – such as forest conservation or wilderness protection, for example.

A cursory examination of spearfishing pressures suggests that severe local impacts are predictable. As no reliable historical information on participation rates in the sport exists, it is necessary to make some assumptions^{333, 334}. Given that the population of Victoria in the early 1980s was around four million, an assumption of a participation rate of point one percent actively engaged in spearfishing over the summer months would yield a spearfisher population of 4,000 people. During one Saturday morning in February 1982, I counted 8 spearfishers on the Hampton breakwater³³⁵, and by my experience that would have been typical for a summers day at the weekend. The remaining 3,992 spearfishers were presumably somewhere else at the time (there are perhaps 100 similarly attractive

spearfishing sites along the shore of the Bay and the nearby ocean coast). An assumption that the breakwater received 32 fishing visits per week, taking into account bad weather and a lower rate of participation during the week, seems realistic. My catch rate at that site in the early days was around 5 fish in half an hour, decreasing as the fish population dropped. So it's likely that spearfishing pressure on the virgin site *could* remove around 160 fish each week over the warmer half of the year, or around 4000 fish per year, conservatively. Effort to remove those fish would have been a minimum of around 800 hours. The breakwater site itself has only one open side, so the artificial reef in question forms a strip about 300 metres long by 6-12 metres wide (average 10). Visibility on the inside of the breakwater was, and remains, too poor to either spearfish or survey. If we assume a virgin resident population density of 2 edible fish per metre of length, that's 600 mature fish resident on the site (prior to the onset of spearfishing pressure). It's clear that the pressure imposed by recreational spearfishing is considerable - easily enough to remove all the breeding stock from the site over a period of three or four years - and, even taking recruitment from deeper reefs into account, that's exactly what happened.

In terms of access, as one site goes downhill, spearfishing pressure turns to less accessible sites. Easy access to small boats and SCUBA gear compound these pressures. Controls on spearfishing, where they exist, are seldom enforced - partly due to obvious difficulties related to enforcement effort.

In my estimation, most of Victoria's accessible shallow reefs were decimated between 1960 and 1985. They have not recovered. Without a knowledge of historical accounts, those entering the sport over the last twenty years can have no conception of the environment which existed forty years ago. This is the 'shifting baselines' effect referred to by Dayton (1998) where (due to pervasive environmental degradation) successive generations lose track of the meaning of a pristine environment.

A6.11. Precautionary management of spearfishing:

After a detailed examination of the effects of fishing on the marine environment, the UK Blundell Report (RCEP 2004:Summary:10) stated:

The precautionary approach needs to be applied comprehensively to fisheries management. Currently, the marine environment is regulated on the basis of a presumption in favour of fishing. Unless harm to ecosystems or habitats can be demonstrated by whatever organisation regulates fisheries, then it is usually acceptable for activities to continue. This approach has not prevented marine ecosystems from being severely damaged.

Therefore, we recommend that the presumption should be reversed; applicants for fishing rights (or aquaculture operations in the marine environment) should have to demonstrate that the effects of their activity will not harm the sea's long-term environmental sustainability. This change would place the burden of justification on those seeking fishing rights and make both the industry and its regulator focus much more on the biological state of the marine environment. The new approach could operate through a system of licensing and marine planning. There will be areas that need to be entirely protected in order to fulfill the precautionary principle and achieve recovery of ecosystems.

This reversal of the burden of proof is being partially implemented in Commonwealth fisheries through the Australian Government's assessment program under the *Environment Protection and Biodiversity Conservation Act 1999* - with regard to some sections of the commercial fishing industry.

It is time to introduce the concept of precautionary management to recreational fishing, including spearfishing. First, the steps outlined above (section A6.3) should be put in place as a matter of urgency. Secondly, a longer-term and more wide-ranging strategy is needed, and a national taskforce should be convened by the Australian Government to plan the introduction of a precautionary approach to all recreational fisheries over the coming decade.

The taskforce would lay the policy foundation for an exercise which would essentially rest with State fishery management agencies to implement. Implementation should include an extensive community education and consultation program which might span the best part of ten years.

In my view, State governments, acting in unison, should announce that *all* waters will be closed to recreational fishing on a target date some years in the future, with the exception of waters which are being fished under an agreed sustainable regime. Studies would need to be undertaken to demonstrate that particular local fishing regimes are in fact sustainable. Such studies should be funded in equal shares by recreational fishing organisations, the relevant State government, and the Commonwealth government. The target date, given the magnitude of the education and consultation task, should in my view be 2020.

A6.12. Conclusions and recommendations:

While the above recommendations on introducing a precautionary approach to the management of recreational fishing would involve a massive shift in consciousness by both the fishing public and politicians (which could only take place over a period of several years) there are urgent short and medium term issues which need to be addressed immediately.

Australian agencies responsible for regulating marine harvesting activities have been lulled into a false sense of security in relation to spearfishing in particular. While participation rates related to harvesting by recreational divers and snorkellers are low (in the order of perhaps 1 in 1000), and bycatch from such harvesting activities is also close to zero, there is strong anecdotal evidence that the concentration of harvesting activities on shallow reef environments has caused major damage. Extensive local extinctions have almost certainly occurred, and entire reef ecosystems have been degraded. A significant regional extinction (the eastern coast grey nurse shark population) is approaching, brought on in large part by historical spearfishing pressures.

Harvesting activities by recreational divers and snorkellers need much tighter control – as a matter of urgency. The current management of these activities by the States breaches the Food and Agriculture Organisation *Code of Conduct for Responsible Fisheries 1995* – particularly article 7.5 which requires the adoption of a precautionary approach to fisheries management. Australia has endorsed the FAO code, although it should be noted that compliance with the code is voluntary.

No national voluntary code of conduct exists to guide the sport of spearfishing. Such a code is needed and should be developed. While spearfishing is almost solely under the control of Australian States and Territories, national coordination is required. Initially, discussions need to be held between the Commonwealth Departments of the Environment, Water, Heritage and the Arts (DEWHA) and Agriculture, Fisheries and Forestry (DAFF) with a view to devising a program to engage both fisheries agencies and stakeholders from the States. The next step would be to expand these discussions to include State fisheries and environment agencies, as well as environment and fishing stakeholders. The list of stakeholders should include the Australian Underwater Federation, large State spearfishing and diving clubs, the Australian Marine Conservation Society, the Australian Society for Fish Biology, WWF Australia and the Australian Marine Science Association. The ultimate aim of the program would be to create, through a stakeholder-driven consensus process, a code of conduct which would (a) emphasize the vulnerability of reef ecosystems and their permanent residents, (b) encourage responsible fishing behaviours, and (c) initiate stakeholder-driven monitoring and reporting programs designed to track changes in reef ecosystems.

State fishery management agencies should develop management plans for spearfishing, in line with FAO recommendations (see above). Generally speaking, I believe nine key actions are urgently required to control spearfishing activities in Australia, and these issues need to be addressed within State fishery management frameworks:

1. There is an urgent need for a massive expansion of permanent marine no-take areas – principally to address biodiversity conservation and benchmarking concerns. Spearfishing activities should of course be banned in such areas. However, where buffer zones are established around such areas, spearfishing activities should be excluded from these zones as well, in order to increase the level of protection of ecosystems inside the no-take areas from harvesting edge effects. At the very least, in States where spearing on SCUBA and night spearfishing are still legal, these activities need to be totally excluded from buffer zones around no-take zones.
2. Temporary no-take areas, of substantial size, should be established specifically for the purposes of re-building fish stocks. The experimental use of such no-take areas should begin immediately, with closures of both 5 and 10 years. A selection of heavily-fished reefs should be immediately protected across Australia. The entire reef, plus lateral and longitudinal buffer zones, should be protected. Other significant habitats, such as seagrass areas, should also receive similar temporary protection for the same purpose.
3. The FAO Code advocates the use of ‘interim’ measures while a fishery management plan is being developed and finalised. One of the key areas where more knowledge is needed relates to the relative effect of angling compared with the potentially more effective (and more damaging) techniques of spearfishing and gill-netting. Quite apart from MPA programs, fishery agencies should institute partial closures of a variety of reef types (and locations) to netting and spearfishing in an experimental impact monitoring program. Such closures need to be for periods of at least a decade in order for reef populations to stabilise, and, for the same reason, they need to be substantial (> 10 km²) in extent. Natural variations are high in marine systems.
4. Spearfishing on compressed air³³⁶, and night spearfishing should be banned immediately in all Australian waters, including all of the Australian EEZ. These techniques increase the vulnerability of reef fish, or open water aggregations, already under severe pressure. Spearfishing on SCUBA is currently banned in Queensland, New South Wales, and South Australia.
5. The sale of speared or damaged fish should be banned outright in all Australian jurisdictions. Such sales are currently banned in Queensland, New South Wales, Victoria and South Australia. Coherent fishery management requires a general regulation prohibiting the sale of fish by anyone not possessing a professional fishing licence, and this is the case on Australia’s eastern seaboard. Due to the small chance of apprehension, high penalties should apply as a deterrent, even though in some cases the offence will appear trivial.
6. According to the FAO Lysekil Statement: “an open access fishery is not precautionary”³³⁷. The sport of spearfishing should be permitted conditional on the participant holding a current recreational fishing licence issued by a State government fisheries agency³³⁸. The costs of providing and administering the licence should be recouped via a licence fee. The licence should be provided after the fee has been paid, and the applicant has demonstrated knowledge both of relevant State statutory controls, as well as familiarity with the voluntary code of conduct (see below). Licences could be issued on an annual basis. Re-issue of a licence should be conditional on the applicant making annual internet-based catch reports at least one a year, even if catch has been zero.
7. There are obvious issues in enforcing compliance across fisheries generally. For this reason punishments for breaching regulations must have strong deterrent elements: punishments where the chance of apprehension is remote need to be severe. Breaches of regulations need to be categorised as minor or major. Those convicted of two major breaches should be banned from holding a fishing licence of any kind again. This should be a *requirement* of the relevant legislation.
8. Spearfishing competitions should be phased out over a 5-year period. Immediate bans should be placed, Australia-wide, on competitions which allow the catch of species which are substantially dependent on reef environments.
9. A voluntary *national code of responsible conduct for spearfishing* should be developed by a joint State/Commonwealth working party, in consultation with

spearfishing, fishing and marine conservation groups. Existing club codes are not widely circulated or used, and have not been prepared in consultation with government or conservation stakeholders³³⁹. State regulations should be introduced requiring that all sales of spearguns, and the issue of all spearfishing licences, should be accompanied by distribution of copies of the code of conduct.

A6.13. Acknowledgements:

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Endnotes:

²⁸⁴ Jo Buckee, pers. comm. 8 September 2004.

²⁸⁵ *Jasus edwardsii*.

²⁸⁶ The relatively unrestrained recreational use of gill nets in Tasmania (see endnote below) has been responsible for major impacts on reef fish populations, making it difficult to untangle the various effects of gill net, line and spear fishing – all of which are probably significant in reducing reef fish populations in this State. Schaap & Green conducted limited visual surveys of matched lightly fished and heavily fished reefs, and found "...a consistent trend towards decreased diversity, species richness and number of individuals at the more heavily fished sites". Although the limited nature of the surveys made definitive conclusions difficult, the authors remarked: "the trend is consistent with the removal of vulnerable species by gill netting and other fishing activities such as spear fishing and line fishing" (1988:39). They concluded that there was "circumstantial evidence that fishing activities have had a major impact on reef fish communities in areas which have been subjected to relatively heavy fishing pressure" (1988:40).

²⁸⁷ The coral patches of Shark Bay in Western Australia are not readily accessible sites, but they are attractive. Shark Bay is a full day drive north of Perth (although the regional cities of Geraldton and Carnarvon are closer) and a small boat is required to access the patches. I spent three weeks in Shark Bay in 1984, researching a paper (Nevill and Lawrence 1985). Shark Bay is predominated by seagrass and sand habitats, with coral making up a tiny fraction (probably less than 0.01%) of the total area. My interviews with Denham locals indicated that all the coral patches had been heavily fished by commercial or semi-commercial spearfishers, as well as anglers, during the 1970s. By the early 1980s they were denuded of fish and all had suffered substantial anchor-damage to corals.

²⁸⁸ Australia has a three-tiered government structure. The Australian Government (also called Federal or Commonwealth) is responsible for taxation, defence, economic regulation and international affairs, including Exclusive Economic Zone (EEZ) fisheries. Six States and two territories form the second layer, and are responsible for most health, education, law

enforcement, social services, and resource management functions – including fisheries management (sole jurisdiction to the 3 nm boundary). Local governments form the third tier.

²⁸⁹ Three recent publications of the Department of Fisheries Western Australia (2003a, 2003b and 2004) do not even contain the word “spearfishing”.

²⁹⁰ According to the 2001 recreational fishing survey: “Line fishing (including the use of bait, artificial lures and jigs as well as set-lines) accounted for 19.7 million fishing events, i.e. nearly 85% of the overall annual fishing effort. Fishing with pots and traps (7%), harvesting bait with pumps, rakes and spades (4%), fishing with nets (3%) and diving with spears or hand collecting (1%) followed in importance. Diving (using spears or underwater hand collection) contributed 266,000 events or just 1% of the overall effort. SCUBA/surface air and snorkel diving (hand collection) was the primary activity (55% of dive events) although spearfishing (36%) was also significant. Spearing fish from the surface accounted for the balance of the ‘dive’ effort (9%). Tasmania and Western Australia reported above average levels of dive effort (3-4%) (Figure 5.19, Appendix 5.8). In Tasmania, Western Australia, Victoria and South Australia dive (hand) collection (mainly for rock lobster and abalone) using snorkel, scuba or surface air supply accounted for the bulk of the dive effort. Spearfishing was the main dive activity in New South Wales and Queensland but was also of significance in Western Australia. Dive effort accounted for about 582,000 hours nationally or less than 1% of the total. Event duration for dive activity ranged from an average of 2.7 hours for spearfishing to slightly less than 2 hours for hand dive collection”. The survey figures for South Australia and Tasmania both recorded total annual fishing effort at under 2000 hours for each State, with a figure for the Northern Territory of under 300 hours total effort (Appendix 5.9, p.158). Australia’s population in 2001 was just under 20 million. Population by State/Territory (2001): New South Wales 6,580k, Victoria 4,800k, Queensland 3,630k, Western Australia 1,900k, South Australia 1,510k, Tasmania 471k, Aust Capital Territory 319k, Northern Territory 198k.

²⁹¹ Baker et al. 2002:83-84.

²⁹² Brothers et al. 1996.

²⁹³ According to Rees 1995: “Recreational fishing using gill nets is comparatively unregulated in Tasmania...”. “[T]his practice has been recognised as decimating reef fish stocks and is banned or heavily controlled in all other States and Territories in Australia”. “The Division of Sea Fisheries estimates net numbers at between 15,000 and 45,000, each up to 50 m long.”

²⁹⁴ Although spearfishing played a major role in the dramatic decline of the grey nurse shark, it seems unlikely to be a major current threat, even though illegal spearfishing of the shark is continuing at a low level. The key issue here is that the east coast population is now so small (2003 estimate: 400-500 adults), due mainly to historic fishing, that the animal may not be able to recover. Adult females usually produce 2 pups every second year. Many other sharks have similarly low reproductive capacities.

²⁹⁵ According to Pauly (1995): “Essentially, this syndrome has arisen because each generation of fisheries scientists accepts as a baseline the stock size and species composition that occurred at the beginning of their careers, and uses this to evaluate changes. When the next generation starts its career, the stocks have further declined, but it is the stocks at that time that serve as a new baseline. The result is a gradual shift of the baseline, a gradual accommodation of the creeping disappearance of resource species, and inappropriate reference points for evaluating economic losses resulting from overfishing...” An exception to this general rule is the study by MacIntyre F, Estep KW and Noji TT (1995) NAGA (the ICLARM Quarterly) 18(3)7-8, which used anecdotes from Mowat F (1984) *Sea of slaughter*. Atlantic Monthly Press.

²⁹⁶ ‘Scientific’ is usually interpreted in this context as meaning ‘obtained and presented in an objective, verifiable and systematic manner’.

²⁹⁷ Food and Agriculture Organisation of the United Nations, Rome.

²⁹⁸ See reference list under “Technical Consultation...”

²⁹⁹ In 2004 the Great Barrier Reef Marine Park Authority established no-take reserves over 33% of the Authority’s area, partly to allow recovery of natural ecosystems from fishing pressures – including spearfishing amongst other fishing pressures.

³⁰⁰ *Aluteridae* family.

³⁰¹ *Girella tricuspidata*.

³⁰² *Platycephalus* spp.

³⁰³ *Rhombosolea tapirina*.

³⁰⁴ In my view, these figures are accurate to plus or minus 10%.

³⁰⁵ *Dactylosargus arctidens*.

³⁰⁶ An examination of Bureau of Meteorology records (www.bom.gov.au) shows no climate or weather abnormalities or changes which might account for a decline in fish populations.

³⁰⁷ Although, with hindsight, I regret it, I was originally one of the most active participants in this sport at this site.

³⁰⁸ The construction of the marina replacing the original swing moorings resulted in about a six-fold increase in stored boats, and these boats over the last decade have increased in size, reflecting the increasing affluence of the nearby suburbs.

³⁰⁹ Flinders is a small township slightly over an hour's drive from the south side of suburban Melbourne.

³¹⁰ The Mornington Peninsula forms the eastern side of Port Phillip Bay.

³¹¹ Pers. comm. T. O'Hara 15/8/05: "The 500 rock lobster abundance figure is from the short-lived Collins settlement at Sorrento in 1802. I have never seen the original, only heard it referred to verbally (by Tim Allen). Early sailors also noted the abundance of osysters in Western Port (abundant enough to be able to reach down and collect them by the handful from a rowboat".

³¹² Spearfishing on SCUBA is now banned in Victoria, although still legal in the Northern Territory, Western Australia and Tasmania.

³¹³ Schmeissing (1997) reported that (in 1997) "there are no conditions or restrictions on the purchase of spearguns in NSW". His study recommended that the NSW government introduce regulations requiring retailers to include an information brochure (covering both government regulations as well as guidance on good spearfishing practice) with the sale of every speargun (Schmeissing 1997:65).

³¹⁴ Victorian marine waters extend 3 nautical miles from the shore. Today, over 5% of these waters are within protected areas meeting the IUCN protected area class I and II criteria.

³¹⁵ Later published as Nevill 1984.

³¹⁶ A quick check I made of these areas in January 2003 suggested that abalone abundance had declined by about two orders of magnitude in the preceding 20-year period.

³¹⁷ According to Valerie Taylor (pers. comm. 10/9/04: "Most rocky reefs off the coast of NSW that we fished (and we fished most of them) hit sand between 150 and 250 feet, some much shallower at say 30 to 80 feet so there appears to be little deep water reef habitat out of scuba range for the animals to trickle up from and repopulate the shallower water".

³¹⁸ A 40% drop in populations of some commercial species in the period 2000-2003. Fyfe (2003).

³¹⁹ Groper, for example, have been identified as particularly vulnerable to spearfishing pressures (Oakley 1984, Morris et al. 2000).

³²⁰ *Achoerodus viridis* – Eastern blue grouper. Spearfishing for EBG banned in NSW in 1969, and commercial fishing in NSW was banned following a continued population decline in 1980.

³²¹ According to Bruce Wallner (pers. comm. 22/9/04): "With respect to the [decline of the grey nurse shark] it would [be] good to compare the spectacular recovery of blue groper in recent decades since the application of spearing bans as another case study. Blue groper are an excellent example of the impact that spearing can have on reef populations, but why have they bounced back when others have not? It might well be that blue groper have been less available to other forms of fishing like recreational angling. That is anglers find them hard to catch – they are selective feeders both in terms of prey type and time of day and because they are powerful reef dwellers they more often break off the lines of the casual generalist angler. It might be that their niche is more plastic, or social structuring and sex-changing has allowed them to increase, or it just might be that stringent bag limits applied to the recreational anglers have actually worked. Whatever the reason, my point is that reef ecology is mostly pretty complex and the interactions between nature and human forms of mortality can be hard to predict."

³²² AUF website accessed 22 August 2004 www.auf-inc.com.au.

³²³ Personal communication, 8 September 2004.

³²⁴ John Ottaway, Assistant Director, Western Australia Department of the Environment, pers. comm. 10/2/2005.

³²⁵ Toowoomb Bay lies between Sydney and Newcastle, on Australia's heavily-populated east coast.

³²⁶ *Girella tephraeops* -rock blackfish.

³²⁷ Although extremely weak in the environmental area, the AUF policy statement does acknowledge that spearfishing in marine protected areas *on SCUBA* is not a good idea – hardly indicating progressive or thoughtful attitudes.

³²⁸ In temperate environments such as those found across southern Australia, physical damage by recreational divers does not appear to be a major problem, although it is noteworthy that a study of a Spanish marine protected area in a temperate environment found significant local damage to colonial bryozoans, with slow recovery (Garrabou et al. 1998). In coral environments, anchor damage, trampling and fin damage to fragile coral structures are issues of concern (Hawkins & Roberts 1992, Harriott et al. 1997, Roupheal & Inglis 2001, Tratalos & Austin 2001).

³²⁹ The large fish are comparatively more fecund than smaller individuals, and therefore more effective as individuals for maintaining populations (see review of this effect in Gell & Roberts 2003b:449).

³³⁰ A view now widely held: see for example Bellwood et al. (2003) who also present evidence suggesting that the overfishing of a spearfishing target species, the giant coral-eating parrot fish (*Bolbometopon muricatum*) is likely to have major effects on coral ecosystem structure and function. This large and mobile reef-dweller is unlikely to receive significant protection from small sanctuaries.

³³¹ According to Valerie Taylor (pers. comm. 10/9/04): "In our day during competition spearfishing we could weigh in 2 fish of each edible species (they are nearly all edible) over a certain weight. The heavier the fish the more points it is worth. In competitions we would spear the first fish of each species we saw then the second if it was larger, then a third if it was larger than the other 2 dumping the smallest and so it went. The number of dumped fish was usually quite extensive. I do not know if the rules have changed since then but the discarding of the smallest and replacing it with a larger specimen worth more points I am sure is still the practice. This would make it almost impossible to judge the number of fish killed in a spearfishing competition".

³³² Coral trout (members of the genus *Plectropomus*) are the most heavily targetted finfish species on the GBR. Of the *Plectropomus* group, the common coral trout, *Plectropomus leopardus*, is the most heavily fished. It is targetted (generally at different intensities at different places) by commercial line fishing, by recreational angling, and by recreational spearfishing. A detailed examination of fish size/abundance data supports the view that fishing can have a major impact on coral trout populations. In several areas coral trout are no longer 'abundant' when compared with levels in the early 1990s. Sweatman et al. 2003, for example, state in relation to Border Island: "Numbers of most fish taxa were relatively stable. Although numbers have fluctuated over the 9-year study period there has been little tendency for prolonged increases or decreases. One exception may be the commercially important coral trout (*Plectropomus leopardus*). Numbers have declined since 1994 and are currently stable but low. Evidence of fishing activity has been noted (presence of snagged lures and hooks) even though this reef has protected status."

Comparative (closed / open zone) data for southerly inner-reef areas in fact reveals a substantial difference between fished and unfished areas for coral trout. This difference is reduced for northerly and outer-reef areas, where both fishing pressures and compliance/enforcement are likely to be lower. Evans & Russ 2004 report: "The biomasses of *Plectropomus* spp. and *L. utjanus carponotatus* were significantly greater (3.9 and 2.6 times respectively) in the protected zones than fished zones at all three island groups [Palm, Whitsunday and Keppel]. Using before-reserve and after-reserve creation data, Williamson et al. 2004 report: "Density and biomass of coral trout increased significantly (by factors of 5.9 and 6.3 in the Palm Islands, and 4.0 and 6.2 in the Whitsunday Islands) in the reserve sites, but not the [control] fished sites..."

³³³ Schmeissing 1997:56 made comparable assumption for NSW: 10,000 participants, on average fishing on 26 days per year, catching around 6 fish averaging about 1 kg each.

³³⁴ These assumptions are not unrealistic compared to participation rates in the only available national study: Henry and Lyle 2003.

³³⁵ Taken from notes prepared during the preparation of a small article for the *Environment Victoria* newsletter (Nevill 1984).

³³⁶ Spearfishing on compressed air includes the use of SCUBA and air delivered by hose.

³³⁷ Paragraph 47. See references under "Technical Consultation...".

³³⁸ The Victorian Government currently requires that spearfishers, like any other recreational fisher, hold a recreational fishing licence (RFL). This licence carries no reporting obligations, although the government does facilitate the submission of voluntary recreational fishing reports through the internet – see for example

http://www.fishvictoria.com/pyoursay/reports/port_albert_sthgipp.php, accessed 20/3/06.

³³⁹ Existing club codes are extremely weak concerning environmental matters. None warn against the possible ecological effects of night or SCUBA spearfishing (see Gillett & Moy 2006) and none carry information about the ecological dangers of targetting the biggest fish (see discussion above). The Australian Underwater Federation *Spearfishing Code of Conduct* for example, contains only one sentence in environmental issues: "Respect our marine life by never taking more game than for your immediate personal needs".

Recfishwest have a *Policy on Compressed Air Spearfishing* which, far from carrying warnings, attempts to justify the activity.

A6.16. Attachment One: Extract from Pollard and Scott 1966:

Spearfishing has undoubtedly had a marked effect upon populations of certain species. Spearfishing started in Sydney about twenty years ago, and today there are more than 1000 spear fishermen in New South Wales. The pastime is developing rapidly in all other Australian States. Gear has improved greatly, and today compressed air and carbon dioxide powered spearguns, underwater breathing apparatus, and rubber suits allow the spearfisherman to tackle bigger fish at greater depths and in every sort of weather.

In many parts of the world, particularly along the coasts of Spain, Southern France, Italy, Jamaica and the Bahamas, spear fishermen have decimated populations of edible reef fishes. The same is now happening in parts of Australia. The inshore reefs for more than twenty miles each side of Sydney Harbour have been almost denuded of edible fish, and much of the remaining New South Wales coastline is also beginning to suffer.

The species commonly taken by spear-fishermen are blue groper, black bream, southern bream, strongfish, Queensland groper, kingfish, luderick, red morwong, mulloway, black drummer, silver drummer, flatheads and leatherjackets. The reef-living species among these are particularly vulnerable because of their sedentary habits and slow growth rates.

The populations of most of these fish have declined to some extent in different areas, but the blue groper of the NSW coast has suffered most. This large member of the parrot-fish family grows to over 100 lb. in weight, and is relatively easy to spear because it is so slow. The blue groper is much easier to spear than to land, however, because when speared it dives into the nearest cave or crevice and is very difficult to dislodge. In such cases, the spear often tears out and the fish is lost. These injured fish usually die. Blue groper have been slaughtered in NSW to such an extent that a bag limit of two per day has now been imposed.

In southern waters the strongfish or dusky morwong is suffering in a similar manner. The Port Noarlunga reef near Adelaide has been proclaimed a fish sanctuary in order to give this and other depleted species a chance to recover. In many countries the spearfishing of fish while using an aqualung is illegal. This regulation, if adopted in Australia, would help prevent the denudation of inshore reefs that has occurred along the northern Mediterranean.

In the past, when points were allotted on weight of fish caught, spearfishing competitions have denuded large areas of reef. In NSW points are now allotted according to both weight and the difficulty of capture of each species. Only one fish of each species may be taken and these must be at least 25% above the minimum legal size.

A6.17. Attachment Two: the Leigh Marine Reserve, New Zealand

Source: Gell & Roberts 2003b.

The Leigh Marine Reserve encompasses 5km of coast, extending 800m seaward on the north-east coast of New Zealand. The reserve was gazetted in 1975 after a 10-year process of application and consultation. The initial motivation for its establishment was the concern of scientists from the Leigh Marine Laboratory of the University of Auckland over the level of exploitation of the shores and coastal waters, particularly from spearfishing. Its main aims were conservation of the marine environment and scientific research. The reserve became actively managed in 1977 and is enforced by marine rangers and by community enforcement via the Department of Conservation. Although not initially established for fisheries management, the fishing community have come to support the reserve, as have members of the wider community who have seen benefits through the increases in visitor numbers and associated revenue (Walls 1998).

In a survey after 10 years of management (Crouch & Hackman 1986, in Ballantine 1991) 78% of commercial fishers said they were in favour of more reserves, 78% said they would actively prevent poaching in the Leigh reserve and 40% said that their catches were higher because of the existence of the reserve. A second survey was conducted at Leigh in 1992 (after 15 years of active reserve management), focusing on three user groups – visitors, local residents and local businesses and this demonstrated almost total support.

Significantly, the survey confirmed the reserve had the support of commercial and recreational fishers, and that many fishers believed that fishing in the adjacent fishing grounds had improved. The role of fishers in enforcement of the reserve regulations was also found to be important in the day-to-day management (Cocklin et al. 1998).

Public participation and support is not currently a statutory requirement in the designation of marine reserves in New Zealand, but is now included in the application process (Department of Conservation 1994, in Cocklin et al. 1998). In the case of Leigh, Cocklin et al. (1998) identify a problem in defining the “local community” in that all consultation focused on one community. Another nearby community felt they too should have been involved. The importance of including visitors in consultation is also raised here.

The history of Leigh Marine Reserve shows that even when there has been long-term consultation, full agreement might not be reached at the outset. However, one encouraging characteristic of Leigh is that support has increased over time and now few people have objections. In a socio-economic study many local people believed that the community had benefited economically from the presence of the reserve, mainly through visitors buying food (Cocklin and Flood 1992, in Walls 1998). The indigenous people were not specifically included as a group in the initial consultation, although individual Maori people were involved. New reserves in New Zealand now specifically consult indigenous people under the Treaty of Waitangi (Walls 1998).

Effects on lobsters and the lobster fishery

In the Leigh Marine Reserve, Kelly (1999) found that experimental catch rates of lobsters showed strong seasonal variability. However, catch rates close to the reserve boundary were high compared with areas further away. Local lobster and fin fishers also choose to fish close to the boundary implying that the public perceive that the reserve has increased the abundance of fishery species (Kelly 1999).

Kelly et al. (2000) assessed recovery of the spiny lobster *Jasus edwardsii* in four marine reserves in north eastern New Zealand and compared this with similar non-reserve sites. They included Leigh Marine Reserve (protected for 21 years), Tawharanui Marine Park (protected for 14 years), Cathedral Cove Marine Reserve and Tuhua Marine Reserve (both protected for 3 years). They found higher lobster biomass inside the marine reserves than outside and they were also able to look at the extent of lobster recovery in relation to time since protection.

Lobster densities inside reserves increased by nearly 4% per year in shallow sites (less than 10m) and by 9.5% in sites deeper than 10m. Mean carapace length of lobsters increased by 1.14mm per year of protection, and lobster biomass was estimated to have expanded by 5.4% per year of protection in shallow sites and by 10.9% per year in deep sites. Estimated egg production increased by 4.8% (shallow) and 9.1% (deep) per year of protection.

In 1985/6 lobster fishers began setting their pots around the boundary of the Leigh reserve. Fishers reported very large catches with large male lobsters filling pots (Kelly et al. 1997, in Walls 1998). More recently, Kelly et al. (2002) looked at the value of the spillover fishery around the Leigh Marine Reserve. They compared catch per unit effort at the reserve boundary with a fishing site 0.3-2km from the reserve and another site 22-30km from the reserve. They found no significant difference in CPUE (in kg per trap haul) among the sites.

However, catches from the reserve boundary could only be made in the deeper offshore habitat as fishers could not use the inshore reefs favoured by lobsters at certain times.

Catches from the reserve boundary contained fewer but larger lobsters, and were more variable than those from the other two sites. However, the amount of money made per trap haul was similar at each site because the occurrence of empty pots was offset by pots containing large numbers of lobsters. For instance, in 1995 nearly 21.6% of revenue earned by the study fishers came from just 4.4% of trap hauls. High variability in catches is not something that is usually predicted for reserves and in this case is a consequence of the aggregation behaviour of lobsters near the reserve. Because of the seasonal nature of offshore aggregation, high catch rates were only possible during 7-8 months of the year and outside these months catches were likely to be low.

Jasus edwardsii supports one of New Zealand's most valuable inshore fisheries and is managed through a quota scheme that is perceived by fishers to work fairly well. The lobster fishing industry therefore opposes marine reserves, arguing that the quota system is a conservation tool and that marine reserves are not an effective management tool (S. Kelly pers. comm.). No detailed information was available on how the fishing community in general responded to the presence of reserves. However, the study fishers from whom Kelly et al. (2002) collected the CPUE data, responded to the loss of inshore reef sites and reduction of fishing area at the marine reserve by increasing the density of traps set around the reserve boundary. Evidence from New Zealand's reserves suggest that while they are presently small and acting principally as conservation tools, they could play a useful role in supporting other lobster fishery management measures.

Effects on commercial and recreational fish

Cole et al. (1990) studied densities of a variety of fish species in the Leigh Marine Reserve using underwater visual census in 1982 and found that only one species, the red moki (*Cheilodactylus spectabilis*) increased in abundance over the initial 6 years of management. Abundance of five other species, the snapper (*Pagrus auratus*), goatfish (*Upeneichthys lineatus*), spotty (*Notolabrus celidotus*), blue cod (*Parapercis colias*) and leatherjacket (*Parika scaber*) did not change significantly in these initial years. A subsequent survey in 1988 showed increasing abundance of snapper, blue cod, red moki and rock lobsters, but no trend in the abundance of sea urchin (*Evechinus chloroticus*).

Babcock et al. (1999a) studied the most common demersal predatory fish, the snapper (*Pagrus auratus*), in the Leigh Marine Reserve and Tawharanui Marine Park and found that adults were 5.8 and 8.7 times more abundant inside the reserves than in adjacent fished areas. Individuals were also significantly larger with mean lengths of 316mm inside protected areas compared to 186mm in fished areas. Babcock et al. (1999a) found significant differences in abundance of non-target species such as sea urchins (*Evechinus chloroticus*) which declined to less than a third of their former abundance in one of the marine reserves over 20 years of protection. They also found that kelp beds were more extensive in one of the reserves.

This suggests fishing pressure has changed not only the mean size and abundance of target species, but also the wider ecosystem. Snappers and lobster prey on urchins which in turn graze on kelp. In a study using tethering experiments, Shears and Babcock (2002) found that predation of sea urchins was 7 times higher inside the Leigh Marine Reserve and the Tawharanui Marine Park than in unprotected areas. Growing snapper and lobster populations in reserves have helped reduce urchin densities and facilitated an increase in algal cover. Urchin barrens covered 40% of available reef in unprotected areas but only 14% in reserves. Babcock et al. (1999a) estimate that primary productivity from macroalgae like kelp has increased by 58% from what it was before the Leigh Marine Reserve was established. Benthic primary productivity was also found to be much lower outside the reserves than before intensive fishing began. Overall this study reveals some of the complex interactions that influence recovery of protected ecosystems from previously high levels of fishing.

Willis et al. (in review) studied density and size of snapper inside and outside three marine reserves in northern New Zealand: Leigh Marine Reserve, Hahai Marine Reserve and Tawharanui Marine Park. Snapper is the most important species for recreational fishing in

upper North Island and one of the most important commercial fishery species (see Annala and Sullivan 1996, in Millar and Willis 1999). The abundance of snapper larger than the minimum legal size was 14 times greater in protected compared to fished areas, and egg production an estimated 18 times higher. In the Leigh Marine Reserve, legal-sized snapper were larger than legal-sized snapper in fished areas, but size differences were not significant. Snapper abundance, like that of lobsters, was highly seasonal with higher densities in autumn than in spring.

Willis et al. (2001) explored movement of snapper in the Leigh Marine Reserve by tagging fish. They found that some show site fidelity to areas only a few metres wide and can occupy the same area for a number of years in the absence of fishing. Some snapper may move long distances but in the light of the large increases in their abundance inside the reserve it seems likely that some are permanently resident in the reserve (Willis et al. 2001). It is possible that some snappers can be mobile or site-attached and that reserves select for the site-attached snapper.
