BASELINE SURVEY OF THE PORT OF DARWIN FOR INTRODUCED MARINE SPECIES

A REPORT TO THE NORTHERN TERRITORY DEPARTMENT OF TRANSPORT AND WORKS

by

DR BARRY C. RUSSELL

Museums and Art Galleries of the Northern Territory

and

DR CHAD L. HEWITT

CSIRO Marine Research

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Northern Territory Government

EXECUTIVE SUMMARY

In 1997, the Northern Territory Government recognised that with development of Darwin as a major commercial shipping hub, there was a need to provide information upon which assessment could be made of the status of the Port of Darwin as regards introduced marine pests, and committed significant funding (approximately $340,000) for a major baseline study of the port to be carried out under National Port Survey Program guidelines over two years (1998-1999).

The aims of the study were to:

- review the existing environmental and marine biological information for the Port of Darwin;
- undertake a survey of the port using the national port survey protocols, and evaluate the taxonomic composition of the biota to identify species that may have been introduced, in particular the Australian Ballast Water Management Advisory Committee (ABWMAC) designated target marine pest species;
- provide a risk assessment for the introduction of exotic marine species into the Port of Darwin.

The major finding of the study reported herein is that no ABWMAC designated marine pest species were found to be established in the Port of Darwin.

The detrimental impact of exotic species introduced into the marine environment has been recognised as a major concern in Australia in recent years, exemplified by the North Pacific seastar, algae and toxic dinoflagellates. In particular, there has been concern over the transport and introduction of marine organisms in ships' ballast water and on fouled hulls and the threat that these organisms pose to the environment, to human health, to commerce and to mariculture industries. In response to this problem, in 1995, the Australian Association of Ports and Marine Authorities (AAPMA) and the CSIRO Centre for Research on Introduced Marine Pests (CRIMP) developed terms of reference for a national port survey program. Using a nationally adopted set of sampling protocols developed by CSIRO CRIMP and endorsed by ABWMAC, this program has collected baseline data on the occurrence of exotic species in a number of Australian ports that has provided a consistent basis on which the introduced species status of individual ports can be assessed. It has also resulted in a list of target species designated by ABWMAC as marine pests or exotic organisms with the potential to become pests.

The Port of Darwin study was undertaken jointly by marine scientists from CSIRO CRIMP and the Museum and Art Gallery of the Northern Territory (MAGNT), with CRIMP having prime responsibility for the field survey; and MAGNT for sorting and identification of samples. Specialist taxonomic identification was undertaken by leading experts at MAGNT and other institutions, including the Museum of Tropical Queensland, Museum of Victoria, Queensland Museum, University of Tasmania, and the Western Australian Museum. Voucher specimens from the survey have been deposited in the MAGNT and with CSIRO.

The design and sampling protocols of the survey followed those adopted by CRIMP for introduced species port surveys under the CRIMP/AAPMA agreement. The survey was designed to maximise the likelihood that exotic species in the port would be detected. To achieve this, field sampling concentrated on habitats and sites in the port and adjacent areas that were most likely to have been colonised by the ABWMAC designated target species.

Sampling was undertaken at 30 sites within the Port of Darwin, including primary sites at Fort Hill Wharf, Stokes Hill Wharf, Iron Ore Wharf, Cullen Bay Marina, Fisherman's Wharf, Frances Bay Marina and East Arm Port. Because of strong seasonal changes in water quality in Darwin Harbour, and suspected different seasonal species assemblages, sampling was carried out for both the Dry Season (August 1998) and the Wet Season (March 1999).

The Port of Darwin Survey, resulted in the identification of some 879 species, and included a number of new species as well as species not previously recorded from northern Australia. The study, which was very comprehensive, provides a benchmark for other tropical ports in Australia.

While no ABWMAC designated marine pest species were found to be established in the Port of Darwin, during the Wet Season survey, a new marine pest, the Black-striped Mussel, *Mytilopsis sallei*, was detected at high densities in the Cullen Bay Marina and subsequently found on the hulls of small pleasure craft in other marinas. This species, representing the first record of the Zebra Mussel family (Dreissenidae) in Australia, is believed to have arrived on the fouled hull of a pleasure craft. *M. sallei* is a native of Central America that is considered to have been introduced into the Indo-Pacific via the Panama Canal attached to the hulls of ships. It is now well established throughout the Asian region where it is a major fouling pest in several ports. The species is an opportunist with very fast growth, early maturity, high fecundity and wide tolerance to salinity, oxygen and pollution levels. *M. sallei* was not detected during the Dry Season survey and had possibly only established in Cullen Bay Marina a few months prior to the Wet Season survey.

The early detection of the Black-striped Mussel during the Port of Darwin Survey led to a massive effort by the Northern Territory Government to contain and eradicate it - an effort that appears to have been successful, and a world first.

There is evidence of other past incursions of another potential marine pest species in the Port of Darwin: 40 specimens of the Asian Green-lipped Mussel (*Perna viridis*) were collected from the hull of a Vietnamese refugee vessel on 24 December 1991; and in September 1999 juveniles of this species were also found on the fouled hull of an Indonesian-based charter vessel. The Asian Green-lipped Mussel is widespread in the tropical Western Pacific and may pose a potential economic and environmental threat.

While neither the Black-striped Mussel nor Asian Green-lipped Mussel has established populations in Darwin Harbour or been detected elsewhere in the Northern Territory, the presence of both species on the hulls of newly arrived

vessels from overseas highlights both the risk of initial introduction on fouled hulls and the need for continued vigilance, and the establishment of protocols for evaluating the risk posed by and checking of all vessels arriving from 'high risk' international ports.

It also highlights the importance of ongoing monitoring and early detection in preventing the further spread of any marine pests through containment and eradication.

Because of the proximity of Darwin to Asian ports and its use as a first port of call for many visiting vessels, the risk of possible introduction of marine pests into the Port of Darwin from Asian tropical ports is considered highest. Past and recent incursions of marine pests indicate that there is a high risk of introduction of exotic organisms by hull fouling. Because at present few large bulk carriers use the Port of Darwin, the risk of introductions in ballast water into the port is considered low. However, with recent port development and the capability now of serving vessels up to 100,000 t displacement, the risk of ballast water introduction is likely to increase significantly in the future.

The majority of domestic shipping to and from the Port of Darwin occurs within the Northern Territory between ports with similar environments. Consequently, the risk of local translocation of any exotic marine species that may establish in Darwin Harbour to other ports within the Northern Territory, and vice versa, is considered high.

There is no evidence of natural range expansion to the Northern Territory of any ABWMAC designated marine pest species introduced to southern ports in Australia. It is unlikely, given the major faunal differences between tropical and temperate Australia, that the introduction of temperate exotic species through natural range extension poses a significant threat to Northern Territory ports.

However, the natural range extension of tropical introduced species from other Northern Territory ports (Gove, Groote Eylandt, Bing Bong) remains a mechanism for potential introduction of marine pests into Darwin Harbour, and vice versa. At present these ports remain unsurveyed for introduced marine pests.

The information contained in this report fulfils the immediate data requirements of the risk assessment based Decision Support System being developed by the Australian Quarantine and Inspection Service to meet the ballast water management needs of Australia.

The report provides a clean bill of health for the Port of Darwin with respect to introduced marine pests.

CONTENTS

1. BACKGROUND

A prerequisite for any attempt to control the spread by shipping of introduced marine species in Australian waters is knowledge of the current distribution and abundance of exotic species in Australian ports. This information base has been lacking until recently and is now being gathered for most Australian ports. The current national port survey program is a joint initiative of the Australian Association of Port and Marine Authorities (AAPMA) and the CSIRO Centre for Research on Introduced Marine Pests (CRIMP) and is supported by the Australian Ballast Water Management Advisory Council (ABWMAC). The program seeks to redress the lack of knowledge about the occurrence of exotic species in Australian ports and provide a consistent basis on which the introduced species status of individual ports can be assessed.

Port surveys designed to identify all exotic species will inevitably be subject to scientific, logistic and cost constraints that will limit both their taxonomic and spatial scope. Recognition of these constraints has lead AAPMA and CRIMP to adopt a targeted approach, which concentrates on a known group of species and provides a cost-effective approach to the collection of baseline data for all ports. The surveys are designed to determine the distribution and abundance of the targeted group of species in each port. These species are listed in Appendix 1 and are made up of:

- those species listed on the Australian Ballast Water Management Advisory Council' s (ABWMAC) schedule of introduced marine pest species;
- a group of species which are major pests in overseas ports and which, on the basis of their invasive history and projected shipping movements, might be expected to colonise Australian ports; and
- those known exotic species in Australian waters that currently are not assigned pest status.

The targeted surveys will also identify species of uncertain status (endemic or introduced) that are abundant in a port. A major component of each port survey is a local public awareness program designed to collect information that might indicate the presence of introduced species in the port and adjacent areas, the approximate date of introduction, and potential impacts on native marine communities.

In 1997, the Northern Territory Government recognised that with development of Darwin as a major commercial shipping hub, there was a need to provide information upon which assessment could be made of the status of possible marine pests in the Port of Darwin, and committed significant funding (approximately $340,000) for a major baseline study of the port to be carried out under the national survey program guidelines over two years (1998-1999).

The aims of the study were to:

- review the existing environmental and marine biological information for the Port of Darwin;

- undertake a survey of the port using the national port survey protocols, and evaluate the taxonomic composition of the biota to identify species that may have been introduced, in particular the ABWMAC designated target marine pest species;
- provide a risk assessment for the introduction of exotic marine species into the Port of Darwin.

This report details the results of an introduced marine species survey of the Port of Darwin, Northern Territory, targeting ABWMAC marine pest species, carried out between 14-21 August 1998 (Dry Season survey) and 26-30 March 1999 (Wet Season survey). The survey was undertaken jointly by CSIRO CRIMP and the Museum and Art Gallery of the Northern Territory (MAGNT).

The study, funded through the Northern Territory Department of Transport and Works and the Port of Darwin Corporation, also received financial contribution from the Australian Quarantine Inspection Service (Ballast Water Research and Development Fund). The N.T. Department of Primary Industry and Fisheries, N.T. Department of Lands Planning and Environment, MAGNT and CSIRO provided in-kind support.

The NT Ballast Water Management Advisory Committee, comprising representatives from the Departments of Transport and Works; Lands, Planning and Environment; Primary Industry and Fisheries; Arts and Museums; and Port of Darwin Corporation, oversaw the study.

2. DESCRIPTION OF THE PORT

2.1 General Features

Darwin is Australia's most northern capital city and the only major population centre on 5,600 km of coastline between Perth and Cairns. It is the closest Australian city to Asia; has the ASEAN countries as its neighbours; and is strategically well placed to contribute to, and benefit from, the economic growth of the ASEAN area. The vision for Darwin is that by the year 2010 it will be a competitive and efficient multimodal transport hub connecting Australia with Asia and beyond, and acting as the transhipment port for trade between the east and west coasts of Australia.

The Port of Darwin, located at latitude 12º 28’ S, longitude 130º 50’ E on the southern shore of the Beagle Gulf in the Timor Sea (Fig. 1), is one of Australia's largest deep water harbours. The harbour encompasses approximately 1,000 km^2 of open water, with deep shipping channels, and is presently capable of accommodating ships to approximately 100,000 t displacement with up to a 14m draught.

The port has seven main regions, four of which primarily serve commercial shipping:

(i) the old port area (Plate 1) comprising a modern container and general cargo terminal and consisting of three major wharves, a 70 tonne rail mounted container crane and roll-on roll-off facility;

(ii) the new East Arm Port (Plate 2);

(iii) Frances Bay Marina, Fisherman’s Wharf and adjacent slipways;

(iv) Hudson's Creek barge landing;

and two serve mainly recreational craft:

(v) Cullen Bay, Tipperary Waters and Bayview Haven marinas;

(vi) Fannie Bay and Sadgroves Creek cruising yacht mooring areas.

In addition Darwin has a:

(vii) Naval Base;

Details of port facilities are provided in Appendix 2.

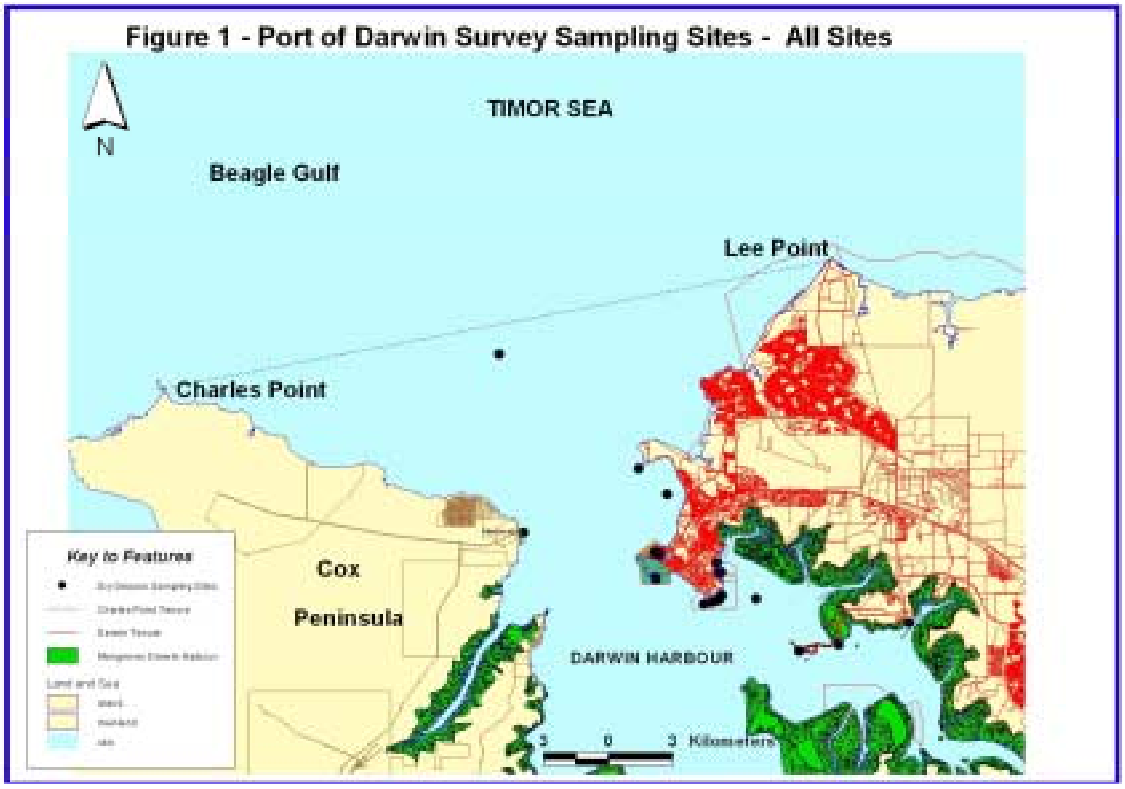

Plate 1. Port of Darwin – old port area (foreground). From left to right: Iron Ore Wharf to, Roll-on/Roll off pontoon, Fort Hill Wharf, Stokes Hill Wharf. Breakwater in upper left of photograph encloses Naval Base. Cullen Bay Marina basin is to upper right of Naval Base. East Point with Fannie Bay yacht club mooring area is in upper/centre of photograph. Frances Bay with slipways, Fisherman's Wharf and Frances Bay Marina are in centre right of photograph. (Photo: Department of Lands Planning and Environment)

Plate 2. East Arm Port (Photo: Department of Lands Planning and Environment)

2.2 Shipping Activities

The Port of Darwin received 3,515 ship visits in 1997-99: 1,838 from domestic ports and 1,677 from international last ports of call. Shipping movements in the port include all vessels using the commercial wharfs operated by the Darwin Port Corporation (excluding naval vessels, and fishing vessels using the Frances Bay Marina) and are summarised in Appendix 3.

The last port of call and next port of call for about one third of vessels visiting the Port of Darwin in 1997-99 are not recorded. Of the remainder, more than 60% of all international vessels that visited the Port of Darwin arrived from South-east Asian ports, with the majority of vessels from Indonesia (27%) or the Philippines (16.1%) (Appendix 3). Many international vessels that visit the port are scheduled services and arrive several times per year (Table 1). The majority of domestic shipping movements (about 79%) are within the N.T. or to oilrigs offshore in the Timor Sea, with the greatest number of domestic arrivals from Western Australia (13.9%) and Queensland (6.6%) and a similar number of domestic departures (Western Australia – 15.4%, Queensland – 3.7%). Less than 1% of the total domestic vessel visits are to or from southern ports in New South Wales, Victoria, Tasmania or South Australia.

The major overseas export commodities for the port are cattle; metal manufactures; copper ores and concentrates; zinc ores; lead ores; cement; hay, chaff and fodder; uranium and thorium; and metal waste with a total overseas export tonnage of 306,612 t. Domestic exports include metal manufactures and machinery to a total of 4,744 t. Overseas import commodities through the port include petroleum products, cement clinker, metal manufactures and sulphur with a total import tonnage of 338,707 t, while domestic imports included beverages, petroleum products and cement clinker to a total of 431,996 t (1998/99 figures; Darwin Port Authority 1999).

Shipping activity in the port in terms of vessel visits by type, is dominated by Fishing/Supply/Prawning vessels, followed by pleasure/yachts, rig tenders, livestock carriers, pearling, liquid bulk/petroleum carriers and charter vessels (1997/98, 1998/99 figures; Darwin Port Authority 1999). More than 20 major cruise vessels visit each year, and the port also receives visits of naval vessels from many countries. At present the number of bulk cargo vessels arriving in the port in ballast is low.

Table 1. Scheduled shipping services for Port of Darwin (As At 05.10.99)

Operator	**Vessels**	**Port Rotation**	**Frequency**
New Guinea Pacific line (NGPL) (N.T. Shipping)	Changsha Chekiang Chengtu Chenan	Auckland, Tauranga, Sydney, Newcastle, Brisbane, Gladstone, Townsville, Darwin, Surabaya, Port Klang, Singapore, Jakarta, Darwin, PNG (Port Moresby, Alotou*, Oro Bay*, Lae, Madang*, Kimbe*, Rabaul*), Solomon Islands (Noro, Honiara) Newcastle	14 Day Rotation (* alternate voyages)
Norwest Shipping (Borzi International)	MV Sina	Fremantle, Dampier*, Port Hedland*, Broome, Wyndham/Kununurra, Darwin, Port Hedland*, Dampier*, Fremantle	17 Day Rotation (* on inducement)
PT Karuna Kusan (Elses Trading)	Fajar Kanguru	E.Indonesia Port(s), Kupang, Darwin.	Monthly
Australian Shipping Consultants (Barwil)	Arktis Fantasy	Newcastle, Townsville*, Darwin*, Amamapare (West Papua), Newcastle	6 week Rotation (* Subject to Inducement)
The Bankline (Adsteam)	Fleet	Rotterdam, Hamburg, Hull, Pacific Islands, PNG, Philippines, Darwin*, Indonesia, Singapore, Europe.	Every 2 months * subject to inducement (carries up to 12 passengers)
Asia World (N.T. Shipping)	Splietohff	Yokohama, Kobe, Wakayama, Pohang, Taichung, Darwin, Dampier, Fremantle	Call Subject to Inducement
Perkins Shipping	Arktis Grace	Singapore, Bintulu*, Kalimantan **,** Darwin, Port Hedland, Dampier, Singapore. (Also inducible into any port in S E Asia & North Australia – e.g. Jakarta, Surabaya, Balikpapan, Kota Kinabalu, Weipa)	14 Day Rotation (*on inducement)
	Arktis Atlantic	Darwin, Dili, Darwin	Weekly
	Coastal	Darwin, Gove, Groote Eylandt	Weekly
Rooney Shipping and Trading	MV Camira &	Darwin, General Santos City	Every 2 months
	MV Carabao	Darwin, Dili, Darwin	Weekly
	MV Temberong	Darwin, Amamapare	Every 6 weeks
		Darwin, Brunei	Every 6 weeks
		Darwin, Kota Kinabalu	Every 2 months
		Darwin, Bintulu	Every 2 months
	MV's Levin, Dealco, Janet, Liz E, Aya 3.	Tramping	As required

2.3 History of the Port

Darwin has a long maritime history. On 9 September 1839, Lieutenant John Stokes sailed into the harbour on the HMS *Beagle* and named it "Port Darwin" in honour of his old shipmate Charles Darwin.

The Port of Darwin was first used for modern commerce in 1869 when it was used to supply the new settlement of Palmerston. In those early days, and before the advent of modern rail, road and air travel, the port was the communication link with the outside world. All stores, mail, passengers and exports were shipped through the port. Initially, the passengers and goods aboard vessels were ferried to and from the port area in small boats.

The first wharf, actually a causeway, was built in 1874 on the site of a wrecked ship the *Gulnare*, and was named Gulnare Wharf. In 1885-86 the Railway Jetty was built of timber construction in the same general position as today's Stokes Hill Wharf but considerably smaller in size. As the railway (Palmerston to Pine Creek) ran onto the wharf it enabled direct transhipment from ship to rail. In 1886 the first freezer ship the *Changsha* carried a sample cargo of N.T. beef to Melbourne. The steam railway locomotive "Sandfly" arrived in the port in 1886 on the vessel *Armistice*, for operations in the port and saw service from 1887 to 1950.

In 1891 the first live cattle were exported to Asia through the port, the start of a trade which is still operating today with the majority of Australia's live cattle shipped out of Darwin.

The original railway wharf of 1885 was destroyed by termites and was replaced by a new wharf that became known as Town Wharf, on virtually the same Stokes Hill site in 1904. Its poor design, allowing only five railway wagons on the wharf at one time and no access for a locomotive, was criticised continually throughout its life, and much of the high cost of goods in Darwin was attributed to it. Nevertheless it gave the Port of Darwin good service until it was severely damaged in the Japanese bombing raids of 1942. During the period of 1903-1942 it was Darwin's only wharf, and handled all cargo and passengers. Some repairs and reconstruction were carried out during World War II but the sunken wrecks were not finally removed until 1961.

To replace the damaged Town Wharf a new timber wharf was built at Fort Hill during World War II. Originally 270m long, it fell victim of the teredo-worm and some 180m of it collapsed. The remainder was partially reconstructed with steel piles and became what is known today as Old Fort Hill Wharf.

Another two wharves, the Navy Boom Wharf and Navy Repair Wharf, were built in 1941 to handle the boom defence net for Darwin Harbour, and repairs to navy vessels. They were situated at Fort Hill and parts of the Boom Wharf construction are still visible in the approaches to the Iron Ore Wharf and adjacent to the western approach of New Fort Hill Wharf. The Boom Shed, which accompanied it, is still in service.

Stokes Hill Wharf, as we know it today, was commenced in 1953, completed in 1956 and continually modified until 1972. Up until the commissioning of the New Fort Hill Wharf in 1981, it was the main general cargo wharf for the port.

In 1967 the Iron Ore Wharf was completed and saw continuous service exporting iron ore until 1974, when Cyclone Tracy played a role in the cessation of this trade. Subsequently, after serving as the home for the emergency accommodation vessel *Patris*, the Iron Ore Wharf has been put to many uses and regularly handles oil, gas and acid imports, and until 1990 had a livestock race for exporting cattle and buffalo. More recently it has been used as a berth for some vessels using the roll-on roll-off facility, and has accommodated many visiting naval craft. The ore loading equipment was refurbished in 1985 to accommodate exports of lead and zinc concentrates.

The most recently built wharf in the old port area, New Fort Hill Wharf, is a modern container terminal.

2.4 Port Development

Current developments within the port include development of the Stokes Hill Wharf and adjacent area as a tourist precinct, as well as Stage Two of Darwin's new East Arm Port development, including (Stage 2A):

(i) provision of a dedicated bulk liquids berth off South Shell Island;

(ii) extension of the Stage One general purpose wharf by 110m to provide a total of 600 m;

(iii) construction of a railway access embankment; and

(iv) construction of a 220m container wharf and intermodal terminal.

and (Stage 2B):

(v) extension of the container intermodal wharf to 300m and the storage area behind it;

(vi) Reclamation of a further 2 hectares behind the general purpose wharf; and

(vii) Provision of bulk solids exports facilities.

The second stage of East Arm will also include a high-capacity container handling facility. The facility will ultimately have the capacity to handle up to 500,000 containers each year. The bulk products wharf will be able to accommodate large vessels with 15m of water available at the lowest tide. The ultimate development masterplan provides for ship repair and maintenance facilities, oil and gas supply services and bulk ore exports. Areas at the East Arm Port have also been identified for the growing naval presence in northern Australia and for the construction of offshore modules for oil and gas production.

In addition to the development of commercial shipping facilities, Darwin Harbour has seen unprecedented development of marina basins, catering mainly for recreational vessels. Subsequent to the Port of Darwin survey a new marina has opened at Bayview. Like the existing marinas at Cullen Bay, Tipperary Waters and Frances Bay, this marina has lock gates and is in effect an artificial environment not affected by tidal movements and is subject to hyposaline conditions over the Wet Season.

The Darwin Naval Base, originally designed to supply and service fast patrol boats, also has recently undergone dredging and expansion to accommodate larger vessels.

3. REVIEW OF EXISTING ENVIRONMENTAL AND MARINE BIOLOGICAL INFORMATION

3.1 Physical Description

Darwin Harbour extends immediately to the west and south of the city of Darwin as a large indented embayment whose mouth is defined as a line between Lee Point and Charles Point (Fig. 1). The harbour itself is a drowned river valley that consists of several elongated arms: West Arm; Middle Arm, which receives the Darwin/Berry Rivers; and East Arm, which receives the Elizabeth River. At mean high tide the harbour covers an area of about 1,000 km^2, and at mean sea level occupies a volume of 2.46 x 10^9 m^3 (Dames and Moore 1985). The harbour is macrotidal: maximum tidal range is 7.8 m; mean spring range is 5.5m and mean neap range 1.9m. Two high and two low water levels are experienced every 24 hours, and the tidal range fluctuates over a 28 day cycle. Water depth in the main channel at the mouth of the harbour ranges from 20-30 m, and attains a depth of about 5-10m in the middle reaches of the arms (RAN Hydrographic Service 1973).

The harbour experiences a seasonal monsoonal climate. In Darwin mean minimum and maximum temperatures are 19.2°C and 30.3°C in July and 25.2°C and 33.1°C in November respectively (Love *et al.* 1988). Mean sea surface temperatures range from 24.5°C (July - August) to 28.9°C (November – February) (Reynolds 1983). Mean annual rainfall is 1661 mm, most of which (80%) falls in the Wet Season from December to March (Love *et al.* 1988). Rainfall is reliable from year to year, but variable in amount (Taylor and Tulloch 1985). Annual evaporation exceeds rainfall in most years by at least 600 mm. The area is subject to tropical cyclones (Love *et al.* 1988). Salinity in the main harbour averages 30.5 ppt in March and 35 ppt in September. Salinity is dependent upon site location in the harbour, in particular, proximity to river mouths. In East Arm, for example, salinities can range from 6 ppt to 41 ppt (Woodroffe and Bardsley 1988).

Currey (1988), Wrigley *et al.* (1990) and Padovan (1997) have studied the quality of water in Darwin Harbour. The harbour is a reasonably well mixed homogenous water body that is naturally turbid and carries high nutrient loads (Currey 1988). Water quality in the harbour is affected by seasonal, spatial and tidal factors: the concentration of silica, an essential nutrient for the growth of diatoms and sponges varies with season, location in the harbour and tidal movements; nitrate/nitrite levels are affected by Wet Season rains and flow of water from the Elizabeth and Blackmore Rivers. Turbidity, total suspended solids (TSS), euphotic depth and chlorophyll-a do not exhibit seasonal changes but are affected by location in the harbour and tidal movements; turbidity, TSS and chlorophyll-a are highest in the upper reaches of the harbour which are in closest proximity to the tidal mud flats and shallower waters. Tidal action is important in re-suspending material from the harbour floor into the water column, and euphotic depth, a measure of water clarity, is greatest in deeper water nearest the open sea. Total phosphorus and volatile suspended

solids are not affected by season or location in the harbour but are subject to tidal variability. Other measures of water quality (pH, total nitrogen, organic nitrogen, ammonium, colour, dissolved oxygen and soluble phosphorus) remain at relatively constant levels throughout the year (Padovan 1997).

The harbour is largely unaffected by industrial development, despite some evidence to the contrary (Peerzada 1988). Heavy metal concentrations are low compared to other Australian harbour systems and pesticides, hydrocarbons and PCBs in the water are very low (Currey 1988).

3.2 Marine Fauna

Semeniuk (1985) has divided the harbour into three regions: an open oceanic region, an embayment region and a riverine channel region. The first region is more properly regarded as an outer embayment as it lies in a relatively protected body of shallow water between the mainland and Bathurst and Melville Islands (Hanley 1988). Within the estuary of Port Darwin the predominant feature of the intertidal zone is expansive mudflats backed by mangroves. There are also areas of sandy beaches, and outcrops of rock are common both on the foreshore and as small islets at low water (Hanley 1988). The riverine channel region is composed of deeper channels with beds of coarse sand and gravel that are in turn successively fringed by sands, fine sands and extensive mudflats in the sub-tidal and inter-tidal environments (Michie 1988). These mudflats support substantial mangrove communities extending over an area of 250 km^2 (Woodroffe *et al.* 1988).

Studies on the marine biology of Darwin Harbour are relatively recent and date back mainly to the early 1980s. The earliest general work is that of Pope (1967) who surveyed the community of marine invertebrates common to the shore reefs in the Darwin region and provided a list of the better known and conspicuous species together with a description of the zonation of the fauna. While many of the scientific names Pope used for taxa are now out of date, this work is still a useful introduction to the intertidal reefs in the harbour. Hanley (1988) summarised much of the knowledge on the invertebrate fauna of marine habitats in Darwin Harbour. More recent information on the marine flora and fauna of Darwin Harbour was brought together in the proceedings of the Sixth International Marine Biological Workshop held in Darwin in 1993 (Hanley *et al.* 1997) Additionally, there is considerable unpublished information on the harbour's fauna held in the collections of MAGNT. Based on these collections and on published records, it is estimated that the total number of species in Darwin Harbour will exceed 3,000 species. The following is an updated summary of the marine fauna of the harbour.

3.2.1 Foraminifera

Michie (1987) studied the distribution of foraminifera in Port Darwin. He listed 86 species and recognised 3 distinct biotopes in the harbour: a coralline biotope, represented by small reef areas at Lee Point and East Point reefs and at Nightcliff, with a maximum of 52 species; a more extensive tidal flat biotope, including East Arm of the harbour, with a low diversity of 5 species; and a large subtidal biotope consisting of reworked sediments in channels, shallow subtidal areas and the offshore, with 29 species. Diversity is variable, usually higher than the tidal flat biotope but lower than the coralline biotope.

3.2.2 Sponges

The first sponge from Darwin Harbour was described by Barnard (1879) and subsequently identified by Carter (1879) as a new genus and species. As a result of collecting by HMS *Alert*, Ridley (1884) recorded 21 species, including 11 new species, most of which (17 species) are still recognised today. Bergquist and Tizard (1967) published a list of 19 species, with several new species described. Since 1967 there have been 37 additional species in 16 genera described from Darwin Harbour (Hooper 1984, 1986a, 1986b, 1987, 1991, 1997). Significantly, Darwin Harbour is the type locality for 22 species of sponge. Nevertheless, the described fauna probably represents less than 10% of the known sponges of the region (Hooper 1997).

3.2.3 Cnidaria

Utinomi (1971) published the first species list with some descriptions of alcyonarian corals. Darwin Harbour has a relatively low diversity of soft corals and gorgonians. Of over 90 genera of octocorals known from Australian coastal waters, only 29 genera are recorded from Darwin Harbour. Soft corals are poorly represented with 11 genera and about 20-25 species. The gorgonians are better represented with 18 genera and 30-40 species. The reason for the low diversity is probably the turbidity of water in the harbour.

The shallow water reefs of the harbour are surprisingly rich in species of hard corals, with 123 species of scleractinian and non-scleractinian corals belonging to 17 families and 47 genera recorded (Wolstenholme *et al.* 1997). The major coral beds in this region are sparsely distributed across the extensive intertidal reef flats, to a depth of 10m in the harbour, and to greater depths in subtidal regions outside the harbour (Hooper 1987). The increasing depth of the distribution of corals is probably related to the increasing depth of the photic zone as water moves through the middle harbour to the ocean (Wrigley *et al.* 1990). The low levels of light penetration through the turbid waters (Hooper 1987) restrict the distribution of deep-water hermatypic corals.

Recent work on the athecate Hydrozoa (hydroids) has boosted the number of genera of this group to 7 with 9 species (Watson 1999), including 1 new species.

Records of Scyphozoa (jelly-fish) are poor, possibly reflecting a lack of taxonomic attention on this difficult group. Several species of Cubozoan (box jellyfish) appear to be seasonally abundant in Darwin Harbour, amongst them the box jellyfish, *Chironex fleckeri*. Southcott (1956, 1974) and Grey (1978) provide references to the box jellyfish, which is common in the harbour during the Wet Season.

3.2.4 Nematoda

Members of this group are very abundant worldwide and tropical marine substrates are known to harbour large numbers of individuals and species of these worms. Hodda and Nicholas (1987) recorded 22 genera from small samples of mangrove mud on a tidal creek at East Arm.

3.2.5 Polychaeta

The literature on polychaete worms from Darwin Harbour is sparse. Straughan (1967) gave notes on a small collection from Darwin, and Hanley (1984) described a commensal polychaete and new records of hosts. Hanley (1985) examined the distribution of polychaetes in mangrove habitats in the N.T. including several sites in the harbour, and provided a species list. Other records of polychaete fauna are included in Hutchings and Glasby (1987), Consulting Environmental Engineers (1986) and Hutchings (1997). It is estimated that there are probably 600 species of polychaetes in Darwin Harbour, with the greatest diversity on subtidal reefs (Hanley 1988).

3.2.6 Sipunculida

The only published records of sipunculid worms from Northern Territory waters, including Darwin Harbour, are Edmonds (1980, 1986) who recorded a total of 6 species for the region, reflecting probably more a lack of serious collecting rather than a depauperate fauna. Sipunculans are burrowers in sand, mud, limestone and coral and representatives of this phylum are likely to be much more common in most marine habitats in the harbour.

3.2.7 Crustacea

Most interest in the crustaceans of northern Australia has centred on the decapods – the crabs, prawns, shrimps and lobsters, and little is known of other diverse and important components of the crustacean fauna of Darwin Harbour such as copepods, amphipods, isopods, cirripedes, mysids and tanaids (Hanley 1988).

The earliest record of crustaceans is that of Miers (1884) who provided a list of species collected by HMS *Erebus* and HMS *Terror*. Banner and Banner (1973, 1975, 1981) published on the alpheid shrimps of Australia and included 23 species of shrimps from Darwin Harbour. Bruce (1983) listed additions to the shrimp fauna of the N.T., including 13 species from habitats in the harbour. Bruce (1987a) included new records of palaemonid shrimps from the harbour, and Bruce (1987b) described a new species of alpheid shrimp from northern Australia, including Darwin Harbour. Bruce (1988) listed 65 shrimp species from East Point, while Bruce and Coombes (1997) listed 121 species of caridean shrimp from the harbour. As a result of collections made during a workshop on the marine fauna and flora of Darwin Harbour, Keable (1997) reported 24 cirolanid isopods from Darwin harbour, increasing the previously known number of species to 26, while Edgar (1997) described a new genus and 3 new species of tanadacean crustaceans.

LeProvost *et al.* (1982) recorded 32 species of decapod crustaceans from mangroves in Darwin Harbour. George and Jones (1982) published a taxonomic revision of the Australian fiddler crabs which includes descriptions of species collected in the harbour and elsewhere in the Northern Territory. Morgan (1987) described species of hermit crabs from Darwin Harbour and Port Essington, including several new species, and listed 11 species from the harbour. Davie (1985) recorded 60 species of crab associated with mangroves in northwestern Australia. It is estimated that there are probably 40-60 mangrove associated crabs in Darwin Harbour and an overall estimate of about 1,000 crustacean species probably is not unreasonable (Hanley 1988).

3.2.8 Echinodermata

Only two publications (Clark 1938, 1946) deal with the echinoderm fauna of Darwin Harbour. It is estimated that there are approximately 60 species of echinoderms (Hanley 1988) including sea urchins, holothurians, starfishes, featherstars, brittlestars and crinoids. The absence of significant numbers of echinoderms in Darwin Harbour is probably the result of the high turbidity of harbour waters. An exception is the brittlestars which are often associated with muddy habitats and which are the dominant component of the echinoderm fauna of the harbour (Hanley 1988).

3.2.9 Mollusca

Darwin Harbour is the best-collected locality for marine molluscs in northern Australia. Many professional and amateur shell collectors have gathered specimens during visits to Darwin, and Laseron (1957, 1958, 1959) has published a series of papers describing many new micromolluscs from the harbour. Blackburn (1977) published a guide to more than 100 species of molluscs, mainly gastropods. LeProvost *et al.* (1982) recorded 31 species, mainly gastropods, in the harbour. A list compiled by Dr R Willan has a total of 924 species, including 75 mangrove species (Willan in press). None of the molluscs recorded by Willan includes species introduced prior to the Port of Darwin Survey being undertaken (R. Willan pers. comm.).

3.2.10 Fishes

The first fishes from Darwin Harbour were described by Richardson (1842, 1843a, 1843b) based on paintings of fishes collected at Talc Head in 1839 by Lt James Emery of HMS *Beagle*. Subsequent records of fishes from the harbour are provided by Macleay (1878), Klunzinger (1879), Paradice and Whitley (1927), Taylor (1964), Larson (1988) and Larson and Williams (1997). The most recent checklist of the fishes of Darwin Harbour (Larson and Williams 1997) recorded a total of 415 species, which included 31 new records for the Northern Territory.

4. SURVEY METHODS

4.1 Sampling Strategy

The survey which follows the protocols outlined in Hewitt and Martin (1996) and ratified by the Australian Ballast Water Management Advisory Committee (ABWMAC) was designed to maximise the likelihood that exotic species in the port would be detected. To achieve this, sampling concentrated on habitats and sites in the port and adjacent areas that were most likely to have been colonised by the target species (see Appendix 1).

The areas sampled (in priority order) were:

(i) active wharves;

(ii) marina areas;

(iii) mooring areas;

(iv) slipways;

(v) artificial reefs

Sampling methods were selected to ensure comprehensive coverage of habitats and were intended to provide presence/absence information and/or semi-quantitative indices of abundance only. As many of the target species were likely to be rare, sampling concentrated on maximising coverage within a site with minimal sample replication. Replicate sampling was only undertaken in situations were small scale heterogeneity was likely to influence detection of target species (e.g. coring for dinoflagellate cysts). The sampling methods used, habitats sampled and target taxa are summarised in Table 2.

Table 2. Summary of sampling methods, habitats sampled and target taxa, Port of Darwin survey, Dry Season (August 1998) and Wet Season (March 1999).

Sampling Methods	Habitat(s) Sampled	Target Taxa
Non-targeted surveys		
Qualitative surveys:		
diver searches	piles, reefs, soft bottoms	invertebrates; fish; algae
video/still photography	piles, reefs, soft bottoms	invertebrates; fish; algae
Quantitative surveys:		
quadrat sampling	piles, channel markers	invertebrates, algae
transects	reefs	invertebrates; algae
video/still photography	reefs, soft bottoms	invertebrates; algae
large cores	soft bottoms	invertebrate infauna; mobile epifauna; fish
Targeted surveys		
diver searches	piles, reefs, soft bottoms	Tubeworms, starfish, crabs
traps	piles, soft bottoms	crabs
small cores	mud/silt bottoms	dinoflagellate cysts
poison stations	piles, reefs	fish

Detailed descriptions of sampling procedures are given in Appendix 4. As shore surveys and beach seine collecting has been extensively carried out in Darwin Harbour by the MAGNT, these methods were not repeated during the present survey program. Similarly, other methods such as traps and poison stations also were not employed intensively during the present survey as both methods have been previously used by MAGNT to obtain data on the harbour fauna.

4.2 Sampling Methods

Sampling was distributed over 30 sites (see Figures 2-5) including the commercially active areas:

(i) Fort Hill Wharf

(ii) Stokes Hill Wharf

(iii) Iron Ore Wharf

(iv) Cullen Bay Marina

(v) Frances Bay Marina

(vi) Fisherman's Wharf

(vii) East Arm Port

Sampling methods employed in each of these areas are summarised in Table 3 and details of sampling sites are given in Appendix 5. Sampling was most intense in the old port area and focused on habitats on and around wharf piles, and the adjacent soft bottoms. Visual surveys, video transects, still photography and coring were undertaken by divers; trapping and plankton sampling were carried out from research vessels or wharves.

Because of strong seasonal changes in water quality in Darwin Harbour, and suspected different seasonal species assemblages, sampling was carried out for both the Dry Season (August 1998) and the Wet Season (March 1999). For reasons of time and cost, only the primary sites (sites i-v above) were sampled again during the Wet Season survey. Although it was intended also to resurvey the East Arm Port site during the Wet Season, sampling was unable to be carried because of construction works along the sea wall.

Initial rough sorting and initial preservation was carried out immediately after sampling by the MAGNT/CSIRO CRIMP team. Further rough sorting to the level of class was carried out at the MAGNT, followed by fine sorting and analysis of samples.

Figure 2 - Port of Darwin Survey Sampling Sites - Cullen Bay & Fanny Bay

Figure 3 - Port of Darwin Survey Sampling Sites - Darwin Wharf Precinct Area

Figure 4 - Port of Darwin Survey Sampling Sites - East Arm Port

Figure 5 - Port of Darwin Survey Sampling Sites - Outer Darwin Harbour

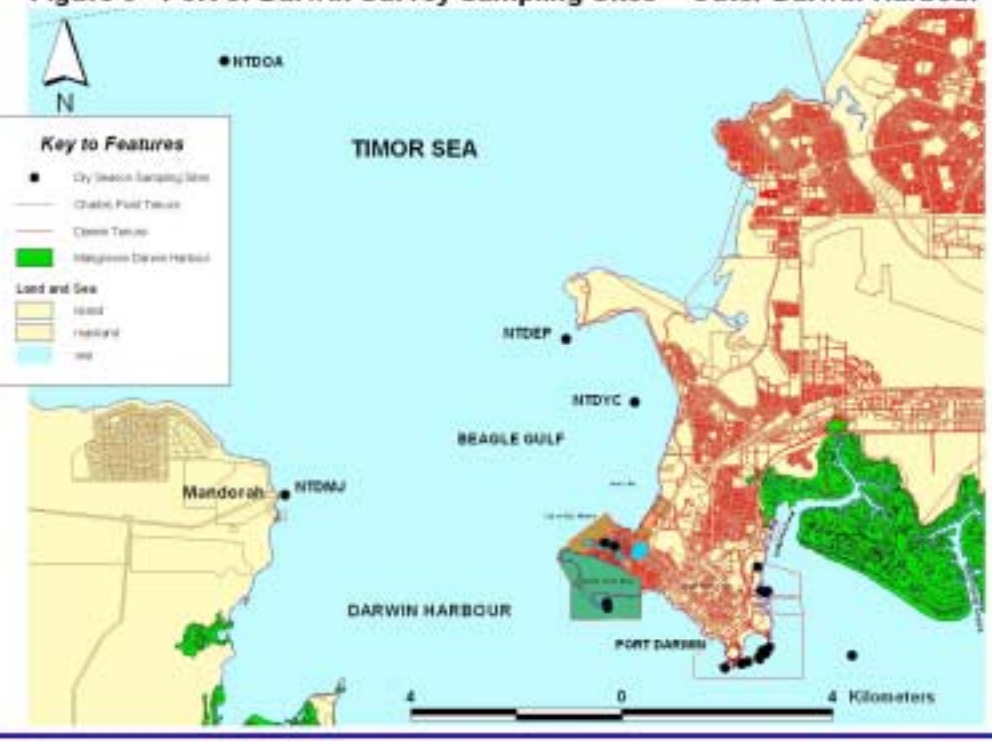

Table 3. Summary of the distribution of sampling methods by site, Port of Darwin Survey,

Dry Season

SITE NAME	SITE CODE	DATE	LAT AND LONG	TIDAL HEIGHT	MAX DEPTH	SECCHI DISK	SAMPLES TAKEN
Artificial Reef (Stokes Hill)	NTDAR	17/08/1998	12° 28.13'S 130° 51.04'E		14.3 m		QUAL; QUAL PHOTO NIK III
Barge off Perkins Wharf	NTDPWB	15/08/1998	12º 27.60'S 130º 50.95'E		1.5 m		3 Quadrats - Oyster Zone; Red Algae Zone; Underside - Barnacle Zone
Catalina Landing	NTDCL	19/08/1998	12º 29.3'S 130º 53.9'E				QUAL
Cullen Bay Marina	NTDCBM		12º 27.16'S 130º 49.30'E				P1-0, P1-3; P2 HORIZONTAL #2, P2 QUAL, P2-0, P2-3; P3-0, P3-3; QUAL; C1-0; C2-0; C3-0; CT1, CT2
Cullen Bay Marina Outer	NTDCBMO	20/08/1998	12º 27.12'S 130º 49.24'E		2.2 m		Rotenone R1; Crab Traps (CT); Seine Nets (ST)
Cullen Bay Marina Outer	NTDCBMO	18/08/1998	12º 27.12'S 130º 49.24'E				QUAL
East Arm 1	NTDEA1	18/08/1998	12º 29.507'S 130º 52.983'E	~3 m	16.9 m	3 3/4 m	P1-0, P1-3, P1-7; P2-0, P2-3, P2-7; P3-0, P3-3, P3-7; C1-0, C2-0,C3-0; DC-0; TC-15, TC-30, TC-50 (3)
East Arm 2	NTDEA2	20/08/1998	12º 29.507'S 130º 52.983'E	3 m			P1-0, P1-3, P1-7; P2-0, P2-3, P2-7; P3-0, P3-3, P3-7; Cores; QUAL
East Arm 2	NTDEA2	19/08/1998	12º 29.507'S 130º 52.983'E		12.0 m		QUAL
East Arm Wharf Breakwater	NTDEAB	19/08/1998	12º 29.507'S 130º 52.983'E				QUAL
East Point Sponge Garden	NTDEP	17/08/1998	12º 25.00'S 130º 48.40'E		8 m		QUAL

Fisherman's Wharf	NTDFW	15/08/1998	12º 27.58'S 130º 50.90'E		6.2 m	1 3/4 m	P1-0, P1-3; P2-0, P2-3; P3-0, P3-3; C1-0, C2-0, C3-0; DC-0
Fisherman's Wharf Rock Wall	NTDFWR	17/08/1998	12º 27.58'S 130º 50.92'E		4.5 m		QUAL
Fort Hill Wharf	NTDFHW	19/08/1998	12º 28.29'S 130º 50.80'E	4 m	16 m		P1-0, P1-3, P1-7; P2-0, P2-3, P2-7; P3-0, P3-3, P3-7; C1-0, C2-0,C3-0; DC-0
Fort Hill Wharf	NTDFHW	20/08/1998	12º 28.29'S 130º 50.80'E				C1-50 (3); DC-50 (3); QUAL
Fort Hill Wharf Inner	NTDFHI	15/08/1998	12º 28.32'S 130º 50.83'E	~ 4.5 m		2.2 m	FULL QUALITATIVE - P1-0, P1-3 P1+2m; P2-0, P2-3, P2+2m; P3-0, P3-3, P3+2m; C1-0, C2-0, C3-0
Fort Hill Wharf Inner	NTDFHI R1	20/08/1998	12º 28.32'S 130º 50.83'E		12.3 m		Rotenone R1
Frances Bay Marina	NTDFM	19/08/1998	12º 27.30'S 130º 50.85'E		3.4 m		QUALS; C1-0, C2-0, C3-0; DC-0
Frances Bay Marina	NTDFM	20/08/1998	12º 27.30'S 130º 50.85'E				Crab Trap; Seine nets
Hudson Creek	NTDHC	17/08/1998	12º 28.75'S 130º 55.75'E			1.1 m	QUAL; C1-0; DC-0; SS-0 (2)
Iron Ore Berth	NTDIOB	16/08/1998	12º 28.35'S 130º 50.57'E	3m (ebbing)	15.5m		P1-0, P1-3, P1-7; P2-0, P2-3, P2-7; P3-0, P3-3, P3-7. C1-0, C2-0, C3-0; DC-0.
Mandorah Jetty	NTDMJ	19/08/1998	12º 26.583'S 130º 46.104'E		8 m		QUAL SUBTIDAL, INTERTIDAL
Naval Base	NTDNB	19/08/1998	12º 27.70'S 130º 49.40'E	5 m	9 m	2.5 m	QUAL SAMPLES; C1, C2, C3 DC-0
Naval Base - Outside Breakwater	NTDNBO	18/08/1998	12º 27.75'S 130º 49.40'E		12.0 m		QUAL

Offshore Anchorage	NTDOA	19/08/1998	12º 10.251'S 130º 40.595'E		28 m		QUAL PHOTO NIK V AND NIK III; QUAL
Quarantine Anchorage	NTDQA	18/08/1998	12º 28.342'S 130º 51.412'E			3.2 m	S3 QUAL NIK III; S4 QUAL NIK V; QUAL; C1-3; DC-3;
Stokes Hill Facing	NTDSHF	20/08/1998	12º 28.24'S 130º 50.93'E		7.0 m		Rotenone R1
Stokes Hill Wharf	NTDSHW	15/08/1998	12º 28.30'S 130º 50.95'E		12 m	2 1/4 m	P1-0, P1-3, P1-7; P2-0, P2-3, P2-7; P3-0, P3-3, P3-7. C1-50, C2-50, C3-50; ,DC-50.
Stokes Hill Wharf Inner	NTDSHI	16/08/1998	12º 28.22'S 130º 51.00'E	2 m	6 m	2.12 m	P1-0, P1-3, P1+2m; P2-0, P2-3, P2+2m; P3-0, P3-3, P3+2m; C1-0, C2-0, C3-0; , DC-0
Stokes Hill Wharf Near	NTDSHN	18/08/1998	12º 28.20'S 130º 50.90'E		11.0 m		QUAL
Yacht Club Moorings	NTDYC	17/08/1998	12° 26'S 130°49'E		5 m		QUAL M1; QUAL M2

Key: P = Quantitative samples; C = Core samples; Qual = Qualitative samples; DC = Dinoflagellate cores; TC = Transect core; CT = Crab Traps; S (and ST) = Seine Net

Wet Season

SITE NAME	SITE CODE	DATE	LAT AND LONG	TIDAL HEIGHT	MAX DEPTH	SECCHI DISK	SAMPLES TAKEN
Cullen Bay Marina	NTDCBM	27/03/1999	12º 27.05' 130º 49.40'			1.5 m	P1-0; P1-3; P2-0; P2-3; P3-0; P3-3; C1-0
Cullen Bay Marina Outer	NTDCBMO	30/03/1999	12° 27.093' 130° 49.197'	5.0 m	7.2 m	1.5 m	P1-0, P1-3; P2-0, P2-3; C1, C2, C3; FD-1, FD-2, FD-3; QUAL1, QUAL2, QUAL3

East Point	NTDEP	28/03/1999	12º 25.13' 130º 48.70'	2.5 m	4.7 m	<1 m	Qual (4 Quads);sediment cores
Fort Hill Wharf	NTDFHW	27/03/1999	12º 28.29' 130º 50.80'	2.5 m	14.0 m	2.2 m	P1-0; P1-3; P1-7; P2-0; P2-3; P2-7; P3-0; P3-3; P3-7; QUALS; 2 core C1-0; Crab Traps and Seine Trap
Frances Bay Marina	NTDFM	26/03/1999	12º 27.30' 130º 50.85'	n/a	4.5 m	3.3 m	P1-0; P1-3; P2-0; P2-3; P3-0; P3-3; C1
Iron Ore Berth	NTDIOB	28/03/1999	12º 28.35' 130º 50.57'	2.5 m	14.8 m	4.2 m	P1-0; P1-3; P1-7; P2-0; P2-3; P2-7; P3-0; P3-3; P3-7; ; Crab Traps and Seine Traps
Stokes Hill Wharf	NTDSHW	26/03/1999	12º 28.30' 130º 50.95'	3 m	8.5 m	3.5 m	P1-0; P1-3; P2-0; P2-3; P3-0; P3-3;

Key: P = Quantitative samples; C = Core samples; Qual = Qualitative samples

4.3 Public Awareness Program

A public awareness program was initiated in the week prior to the commencement of the Dry Season survey and continued during the survey period. The program involved a press release (see Appendix 7) distributed to locally based media and subsequent radio, television and newspaper interviews. Groups or individuals were encouraged to contact CSIRO or the MAGNT with any observations or information that they felt would assist identify exotic species in the port area, assess their impact and indicate the possible time of introduction. MAGNT and CSIRO staffs were available to follow up and assess any responses during the survey period so that observations could be investigated while the survey team was in the area.

5. SURVEY RESULTS

5.1 Port Environment

The Port of Darwin is a natural drowned river system with a large tidal range, strong tidal currents regime and seasonal changes in water quality.

Examination of the wharf pile communities indicates a significant influence of tidal water movements, currents and sediment loads in all commercial areas of the port. The majority of piles carried developed communities, dominated intertidally by barnacles and tubeworms. The maximum tidal range in the port is 7.8m. Below the tidal range, the communities were dominated by sponges, ascidians, and bryozoans, to within 1m of the bottom. Thinning near the base of piles is likely to be associated with siltation.

Surface sediment adjacent to piles at most berths was a combination of fine mud and silt (Table 4). In regions where there is significant flow (e.g., Iron Ore Wharf) the fine material was replaced by sand or coarse shell grit. Total organic content of these sediments also tends to be lower (Table 4).

Table 4 Relative proportions of sand and silt/mud fractions in selected sediment samples (after Nielsen and Dorairaj 1999) and total organic content (unpublished data).

Sample	Cullen Bay Marina	Fort Hill Wharf	Frances Bay Marina	Stokes Hill Wharf	Iron Ore Wharf	East Point	Mandorah	East Arm Port (1)	East Arm Port (2)	Hudson Creek (1)	Hudson Creek (2)
% Sand (>75µm)	11	19	11	2	66	82	2	23	12	24	5
%Silt/ Mud (<75µm)	89	81	89	98	34	18	98	77	88	76	95
Total organic Carbon	18600	18500	16000	14400	7900	-	-	16000	7300	-	19400

5.2 Marine Fauna Collections

The results of the biological sampling in the Dry Season (August 1998) and Wet Season (March 1999) are presented separately in the tables in Appendix 6. The species are listed in taxonomic order (Phylum, Class and Family) and their occurrence at each sample site is indicated by an asterisk. It should be noted that due to a lack of taxonomic expertise in Australia and overseas, some groups at present remain unidentified to species (see Section 5.3 below). Voucher specimens of these groups have been deposited in the MAGNT and will be made available to for taxonomic identification as and when the expertise becomes available.

5.2.1 Dinoflagellates (Phylum Pyrrophyta)

Dinoflagellates were collected at 8 sites. No confirmed harmful or toxic dinoflagellate species were found. Cyst assemblages were dominated by Peridinoid species, particularly *Scrippsiella* spp. The presence of a number of indicator species (*Pyrophacus steinii*, *Protoperidinium latissimum*, and several tropical *Protoperidinium* species) is consistent with a coastal, mangrove tropical environment. While cysts of the widespread tropical toxic species *Pyrodinium bahamense* were not recorded during this survey, their previously recorded presence in areas of northern Australia (McMinn 1990) is of future concern for the Port of Darwin's activities and while there is no requirement for ongoing plankton monitoring, it is suggested that a repeat baseline cyst and plankton survey be undertaken within 5 years (Bolch 1999).

5.2.2 Foraminifera (Phylum Rhizopoda)

Unidentified foraminifera were collected at 9 sites. Previous work on foraminifera of Darwin Harbour (Michie 1987) does not indicate any exotic species.

5.2.3 Sponges (Phylum Porifera)

Sponges were collected at 25 sites. Although all of the samples remain unidentified, previous work on the sponges of Darwin Harbour (Hooper 1984, 1986a, 1986b, 1987, 1991, 1997) does not indicate any exotic species.

5.2.4 Coelenterates (Phylum Cnidaria)

Some 42 species, including at least 3 new species of hydroids were collected at 16 sites. Although the hydroid fauna of tropical Australia is still poorly known, none of the species from Darwin Harbour can be considered exotic or cryptogenic (Dr J. Watson pers. comm.). Some 47 species of anthozoans were collected from 18 sites. None of the species from Darwin Harbour can be considered exotic or cryptogenic (Dr P. Alderslade pers. comm.).

5.2.5 Nemerteans (Phylum Nemertea)

Unidentified Nemertean worms were collected from 6 sites. Nemertean worms are not included in the ABWMAC schedule of known marine pest and other exotic species, and are not considered to be a significant potential pest group.

5.2.6 Nematodes (Phylum Nematoda)

Unidentified Nematode worms were collected from 5 sites. Nematode worms are not included in the ABWMAC schedule of known marine pest and other exotic species, and are not considered to be a significant potential pest group.

5.2.7 Sipunculids (Phylum Sipuncula)

Unidentified sipunculid worms were collected from 4 sites. This group is not included in the ABWMAC schedule of known marine pest and other exotic species, and is not considered to be a significant potential pest group.

5.2.8 Polychaete worms (Phylum Annelida, Class Polychaeta)

Some 142 species of polychaete worms were collected at 27 sites and comprised the second most speciose group collected. Because of the large number of families of polychaete worms and the poor knowledge of their taxonomy, a targeted approach was taken in the identification to species of the samples collected, with those families with known exotic or pest representatives in Australia and elsewhere, such as tube worms, fan worms and spionid worms being subject to more detailed examination. One species, the tubeworm, *Hydroides elegans*, is an ABWMAC listed exotic species. However, there is some doubt as to the native range of this species which is widespread in Australia, and it is probably best regarded as a cosmopolitan rather than introduced species (Dr C. Glasby pers. comm.).

5.2.9 Molluscs (Phylum Mollusca)

Unlike other harbours in tropical northern and western Australia, the molluscan fauna of Darwin Harbour was relatively well known prior to the Port of Darwin Survey. Willan (In press) records a total of 944 marine molluscs from Darwin Harbour. The very intense Port of Darwin Dry Season survey yielded 38.1% of this total fauna and the less intense Wet Season survey yielded 10.6% of this total fauna. Major groups underrepresented by the Port of Darwin Survey were soft substrate gastropods, soft substrate bivalves, mangrove molluscs, opisthobranchs, cephalopods and holoplanktonic taxa.

The Mollusca comprised the largest set of samples collected on both the Dry and Wet Season phases of the Port of Darwin Survey. The very intense Dry Season survey contained 2,543 samples comprising 429 species. Of these, 226 were gastropods, 193 were bivalves, 5 were scaphopods (tusk shells), 4 were polyplacophorans (chitons) and 1 was a cephalopod (squid). The less intense Wet Season survey contained 554 samples comprising 103 species. Of these, 54 were gastropods, 48 were bivalves and 1 was a chiton.

The most ubiquitous species (in terms of presence at the greatest number of sites) encountered during the entire survey were (in taxonomic order) - *Peasiella tantilla* (Littorinidae), *Alvania* sp. 1 (Rissoidae), *Cerithium coralium* (Cerithiidae), *Zafra troglodytes*, *Mitrella venulata* (Columbellidae), *Euliginella angasi*, *Granulina anxia* (Cystiscidae), *Amathina tricarinata* (Amathinidae), *Arca avellana* (Arcidae), *Chlamys curtisiana* (Pectinidae), *Brachidontes maritimus*, *Musculus miranda* (Mytilidae), *Saccostrea* cf. *dactylena*, *Striostrea mytiloides* (Ostreidae),

Booneostrea cucullina (Ostreidae), *Isognomon isognomon*, *Isognomon legumen* (Isognomonidae), *Chama fibula* (Chamidae), *Irus irus* (Veneridae) and *Cryptomya* sp. 1 (Myidae).

The commonest species numerically (i.e., those occurring in at least one sample with a density exceeding 50 live individuals) were the bivalves *Brachidontes maritimus* (Mytilidae), *Striostrea mytiloides* (exceeding 500 individuals in some samples), *Saccostrea* cf. *dactylena*, *Booneostrea cucullina* (Ostreidae), *Isognomon legumen* (Isognomonidae), *Chama fibula* (Chamidae) and *Mytilopsis sallei* (maximum density 23,650m^{-2} in Cullen Bay Marina).

Mytilopsis sallei was the only introduced mollusc species encountered, but because of swift action by the NT Government following its discovery it appears to have been completely eradicated (see Section 5.5.1 below). *M. sallei* represented a new record for the species, the family (Dreissenidae) and the superfamily (Dreissenoidea) for Australia. Other new distributional records for the Northern Territory are: *Eubranchus rubropunctatus* (Eubranchidae), *Nuculana darwini* (Nuculanidae), *Cycladicama subquadrata* (Ungulinidae) and *Micromeris praeclava* (Carditidae).

5.2.10 Lamp shells (Phylum Brachiopoda)

One unexpected outcome of the Port of Darwin Survey was the discovery that the inarticulate brachiopod *Discinisca striata* (Disciniscidae) was relatively common subtidally at all the wharves in the Port of Darwin, particularly Fort Hill Wharf. Some 12 live specimens and 4 dead specimens were collected at a total of 10 sites during both phases of the survey. This small limpet-shaped brachiopod, which lives on dead oyster shells, represents a new record for the Northern Territory. Brachiopods are not included in the ABWMAC schedule of known marine pest and other exotic species, and are not considered to be a significant potential pest group.

5.2.11 Lace corals (Phylum Bryozoa)

Bryozoans occurred at 27 sites and were one of the most abundant encrusting organisms on wharf pilings and other hard substrates. The Port of Darwin survey samples are presently undergoing taxonomic study by Dr Peter Arnold (Museum of Tropical Queensland). Preliminary examination has shown no evidence of any ABWMAC listed marine pest or exotic marine species (Dr P. Arnold, pers. comm.).

5.2.12 Crustaceans (Phylum Crustacea)

The Phylum Crustacea is a large and very diverse group of organisms, many of which are poorly known taxonomically, especially in tropical waters.

The following groups could be identified by specialist taxonomists in Australia:

Barnacles: These are one of the most ubiquitous and abundant encrusting organisms on wharf pilings and other hard substrates occurred at 23 sites. A total of 27 species were recorded from the surveys. The fauna of Darwin Harbour is typical of tropical northern Australian waters and is dominated by members of balanomorphan families. The shore zonation follows the chthamalid-tetraclitid-balanid trend which is characteristic of tropical and warm temperate shores (Jones 1992a, 1992b, Jones and Hewitt, 1997). Lepadids occur pelagically and archaeobalanids occur in the subtidal. One of the species recorded,

Megabalanus tintinnabulum, is an ABWMAC listed exotic species. This species is is a well known cosmopolitan fouling species and was possibly introduced into West Australian waters in 1949 (Jones 1992a). It is not considered to pose a threat and is not a pest species.

Caridean Shrimps: a total of 35 species of caridean shrimps were recorded from 23 sites. None are ABWMAC listed exotic species.

Anomuran Crabs: A total of 15 species of anomuran crabs were recorded from 18 sites. None are ABWMAC listed exotic species.

Brachyuran Crabs: A total of 37 species of brachyuran crabs were recorded from 24 sites. None are ABWMAC listed exotic species.

5.2.14 Echinoderms (Phylum Echinodermata)

The echinoderms (starfishes and sea cucumbers) remain largely unidentified. Asteroids (starfishes) were recorded from one site; holothurians (sea cucumbers) from 8 sites; ophiuroids (Brittle stars) from 21 sites; and crinoids (Feather stars) from 2 sites. No ABWMAC listed marine pest or exotic species were found.

5.2.13 Ascidians (Phylum Chordata: Ascidiacea)

The ascidians (sea squirts) are a significant fouling group, but remain unidentified for lack of taxonomic expertise. The ABWMAC list of marine pest species does not include any ascidians and known exotic species are mainly temperate.

5.2.13 Fishes (Phylum Chordata: Osteichthys)

A total of 42 species were collected during the survey from 8 sites. None of the species collected nor any of the species recently recorded from Darwin Harbour by Larson and Williams (1997) are ABWMAC listed exotic species.

5.3 Comparison with other Tropical Ports

Species diversity for Darwin Harbour is high, and this is reflected in the generally high numbers of species in various taxon groups, compared with other tropical and temperate ports in Australia and Hawaii, that have been surveyed using similar methodologies (Table 5).

While some of the differences in species diversity reflect sampling intensity and the level of taxonomic identification, the differences between tropical and temperate ports are generally consistent with a general trend of increasing diversity in marine shelf benthic communities from high to low latitudes, ie from temperate to tropical waters (Longhurst and Pauly 1987). More detailed data is required to quantify the differences between tropical and temperate ports. However, based on their surveys of tropical Queensland ports, Hoedt *et. al* (unpublished) suggest that because of their higher diversity, tropical ports may require more sampling effort than temperate ports to adequately sample the

Table 5. Comparison of species diversity of selected taxa between Darwin (D), four tropical Queensland ports (Abbot Point - AP, Mourilyan Harbour - MH, Hay Point - HP) and three temperate ports (Hastings –H, Geelong – G, Portland – P). Data from Hoedt *et al* (unpublished).

Taxonomic group	**Tropical Ports**					**Temperate ports**		
	D	**AP**	**MH**	**HP**	**Haw**	**H**	**G**	**P**
Cnidaria	89	31	45	30	10	4	4	3
Mollusca	429	74	70	109	85	65	44	28
Crustacea	114	51	110	129	110	126	72	83
Polychaeta	142	119	158	100	54	55	68	49
Fish	42	20	15	21	59	26	32	16

marine communities. Our data support this conclusion and suggest that the CRIMP sampling protocols may need to be modified for future tropical port surveys.

Because of the high species diversity in the tropics, the sorting and identification of taxa is a major time and cost component of tropical port surveys, and needs to be carefully factored into the planning of future port surveys. Another important factor in planning of surveys is the taxonomic impediment. The skills base in taxonomy in Australia is grossly inadequate: there are now fewer taxonomists employed in Australia than in 1980 (Commonwealth of Australia 1999), and in the present survey there were several groups of organisms that were collected but which remain unidentified because of a lack of specialist expertise. Good taxonomic knowledge is crucial to describing and understanding marine species, biological systems and processes, and the lack of taxonomic expertise in Australia is a significant impediment to large scale port surveys.

5.4 Seasonal Patterns

A total of 879 taxa were collected from all sites over both sampling periods: some 827 taxa (94.1% of total) during the Dry Season and 324 taxa (36.9%) in the Wet, with an additional 53 taxa (6.0% of total) only occurring in the Wet Season samples (Table 6). In large part, the fewer taxa collected in the Wet Season reflects the different sampling effort compared with the Dry Season. In the Dry Season a total of 30 sites were sampled whereas in the Wet Season only 7 sites were sampled. Most of the bottom core samples and dinoflagellate core samples also were not repeated in the Wet Season.

Table 6. Comparison of number of taxa from Dry Season versus Wet Season survey sites.

	No. taxa Dry Season	No. taxa Wet Season	No. taxa Wet Season only	Total No. taxa
All sites (n=30)	826 (94.0%)	324 (36.9%)	53 (6.0%)	879
Primary sites (n=7)	564 (87.3%)	324 (50.2%)	81 (12.5%)	646

However, comparing the 7 primary sites sampled during both seasons, 564 taxa (87.3%) were collected during the Dry Season, and only 81 additional taxa (12.5%) were collected in the Wet Season samples (Table 6). These data suggest that there is little change in overall species composition between the Dry and Wet Seasons.

These results have implications for sampling effectiveness. They indicate that it may be more cost-effective to increase the number of samples from the same survey period rather than undertake sampling at different times of year.

5.5 Introduced Species in the Port

5.5.1 ABWMAC Target Species

No ABWMAC designated marine pest species (Appendix 1) were recorded from the Port of Darwin during the two survey periods.

However, on March 27 1999, during the Wet Season phase of the Port of Darwin survey, divers discovered dense (23,650 individuals m^{-2}) aggregations of a thin shelled "mussel" on floating pontoons, concrete piles, retaining walls, ship's hulls and mooring ropes inside Cullen Bay Marina (Plate 3). These were subsequently identified by Dr R. Willan as the Black-striped Mussel, *Congeria (Mytilopsis) sallei* (Récluz), an identification that was verified by Shirley Slack-Smith (Western Australian Museum) on the basis of preserved specimens. This represents the first record of a species from the family Dreissenidae and superfamily Dreissenoidea for Australia.

The original distribution of *Mytilopsis sallei* is Central America and it is believed to have been introduced into the Indo-Pacific via the Panama Canal (opened in 1915) attached to the hulls of ships (Morton 1981). *M. sallei* is now well-established in India, Singapore, Hong Kong and other Asian ports where it is a major fouling pest. The species is an opportunist with very fast growth, early maturity, high fecundity and wide tolerance to salinity, oxygen and pollution levels (Morton 1981).

A

B

C

D

Plate 3. Cullen Bay Marina **(A)** site of outbreak of infestation of marine pest *Mytilopsis sallei* **(C)**. which fouled 100% of all hard surfaces including ropes **(B)** and other objects **(D)**.

The extent of the Darwin outbreak was revealed during intensive searches by rapid response teams over the next week. One team discovered a population of small individuals (6 individuals m^{-2}) in the newly opened Tipperary Waters Marina and a lightly fouled vessel in Frances Bay Marina. Other teams discovered three moderately to heavily fouled vessels moored at different locations outside the marinas, but still within Darwin Harbour. Checking revealed that these five secondary infestations could all be confidently traced back to Cullen Bay Marina. Extensive searches failed to discover any individuals elsewhere in Darwin Harbour itself. As the previous Dry Season phase of the Port of Darwin Survey in August 1998 had also failed to reveal a single *M. sallei*, live or dead, anywhere within Darwin Harbour, it was concluded that the outbreak in Cullen Bay Marina must have taken place during the previous six months.

Because of its propensity to cause severe fouling on marine structures and displace native species (Morton 1981), the presence of *Mytilopsis sallei* in Darwin was considered to pose a very real threat to commercial shipping and recreational boating, as well to the pearl

farming and aquaculture industries throughout tropical and warm temperate Australia. In a commendable response to the threat, the Northern Territory Government declared a state of Natural Disaster on April 1 1999, closed and quarantined all three marinas, and instigated an eradication campaign. Under this campaign Cullen Bay Marina was treated with a total of 163,040 kg liquid sodium hypochlorite (i.e., a volume yielding a final concentration of 12% chlorine in solution) plus 4,325 kg powdered copper sulphate (i.e., a volume yielding a maximum final concentration of 0.5 $mg.litre^{-1}$ copper in solution) between April 3-22. Tipperary Waters Marina and Frances Bay Marina were treated similarly (1,980 kg sodium hypochlorite plus 1,050 kg copper sulphate, and 21,980 kg chlorine plus 2,075 kg copper sulphate respectively). The maximum final concentration of copper in solution reached 0.8 $mg.litre^{-1}$ in both Tipperary Waters Marina and Frances Bay Marina. Fouled vessels outside the marinas were recalled into the nearest marina prior to treatment, or lifted from the water, or, in the case of the bamboo raft *Nale Tasih* that had drifted/sailed from Kupang and become heavily fouled in Cullen Bay whilst on display there between January 8 and March 28, burnt above high water mark.

The chemical treatments of all three marinas were effective in killing *Mytilopsis sallei*. The last known living individual of *M. sallei* was detected in Cullen Bay Marina on April 18 1999. There was also considerable, but not complete, mortality of other marine life. As of May 31, levels of copper remain high but the toxicity to marine life has decreased due to formation of non-toxic, organic copper compounds.

Regular post-eradication surveys over the past 12 months have found no live *Mytilopsis sallei* inside any marina and no settlement has been detected in Darwin Harbour. Ongoing surveys are currently underway to monitor the re-establishment of the (largely adventive) fouling community dominated by the barnacle *Balanus amphitrite* and the serpulid tubeworm *Ficopomatus uschakovi* within the marinas, and check for settlement of *M. sallei* in the Harbour itself.

The possibility of residual populations of *Mytilopsis sallei* remains of great concern, and a program has been instigated by the Department of Primary Industry and Fisheries to monitor settlement and re-invasion by this species. In addition, the risk of introduction of other marine organisms continues.

Under the protocols put in place since the outbreak, masters of suspect incoming international vessels are requested to undergo an inspection of their vessel's hull plus treatment of seawater intake systems. Such inspections are a requirement for all such vessels intending to enter one of the marinas. No incoming (recreational or commercial) vessel is subject to mandatory inspection in the harbour. Neither are protocols in place to survey the ballast water tanks of vessels, but an Australia-wide Code of Practice for commercial shipping recommends against discharge of ballast in ports and it is illegal to discharge ballast water inside the Darwin marinas. This outbreak should reinforce the need for thorough quarantine inspections of hulls and ballast tanks of all vessels arriving at ports.

A more detailed summary of the Black-striped Mussel episode, and details of the pre-eradication surveys, the eradication program and post-eradication monitoring will be reported elsewhere (Willan *et al.* in press).

5.5.2 Other Introduced Species

No other introduced species have yet been identified amongst the 891 total number of species collected during the Port of Darwin survey, although several groups (notably sponges, bryozoans, isopods, amphipods and ascidians) still await identification by taxonomic experts. These species yet unidentified must be evaluated rigorously to identify native or introduced status and until sufficient evidence exists, they must be considered to be cryptogenic (native status unknown *sensu* Carlton 1996).

The Asian Green-lipped mussel, *Perna viridis*, has previously been recorded from Darwin Harbour. The MAGNT mollusc collection contains 40 specimens of the *Perna viridis* collected from the hull of a Vietnamese refugee vessel on 24 December 1991 (R. Willan pers. comm.). More recently, in September 1999 juveniles of this species was also found on the fouled hull of an Indonesian based charter vessel during detailed post-eradication surveys for Black-striped Mussels. The Asian Green-lipped Mussel is widespread in the tropical Indo-West Pacific and may pose a potential economic and environmental threat. Although there is no evidence that this species has established populations in the harbour or elsewhere in the Northern Territory, and it was not detected during the Port of Darwin Survey, the presence of both the Asian Green-lipped Mussel and the Black-striped Mussel on newly arrived vessels from overseas highlights the need for continued vigilance, and the establishment of protocols for checking all vessels arriving from 'high risk' international ports.

5.6 Public Awareness Program

There was good media coverage of the initial Dry Season survey by radio, television and the *NT News*. Public response, however, was poor, and no public enquiries were received in response to the request for information from the public about any sightings of unusual marine organisms. There was also strong media interest in the discovery of the first record of a brachiopod from Northern Territory waters. There was no separate public awareness program for the Wet Season sampling phase. However, following discovery of the Black-striped Mussel at Cullen Bay, there was strong local, national and international media coverage both of the finding of the marine pest and subsequent efforts to eradicate it. Public response was also excellent and a reporting hot line established by the Department of Primary Industry and Fisheries logged more than 500 reports of possible sightings of the pest.

6. ORIGIN AND POSSIBLE VECTORS FOR THE INTRODUCTION OF EXOTIC SPECIES

The only evidence of past and recent presence of exotic species in the Port of Darwin, is that of the Black-striped Mussel and Asian Green-lipped Mussel, neither of which appears to have established. In both cases, circumstantial and direct evidence indicates that they were introduced directly to the port by hull fouling.

There is no evidence of natural range expansion of species introduced to southern ports in Australia, and it is unlikely, given the major faunal differences between tropical and

temperate Australia, that the introduction of temperate exotic species through natural range extension poses a significant threat. However, the natural range extension of tropical introduced species from other Northern Territory ports (Gove, Groote Eylandt, Bing Bong) remains a mechanism for potential introduction of marine pests into Darwin Harbour. At present these ports remain unsurveyed for introduced marine pests.

The introduction of *Mytilopsis sallei* into Cullen Bay Marina and its subsequent discovery and settlement in at least one other Darwin marina highlights both the risk of initial introduction probably on a fouled hull, and its subsequent local translocation on the hulls of other vessels. It also highlights the importance of early detection in preventing the further spread of any marine pests through containment and eradication.

Two very recent further incursions of *M. sallei* both on the fouled hulls of Indonesian fishing boats apprehended by the Royal Australian Navy in the northern Australian Fishing Zone (AFZ) for illegal fishing and brought into Darwin Harbour on 23 August 2000 (subsequently departing for Indonesia on 7 September) and 8 September 2000 (departing for Indonesia on the same day) respectively, further highlight the importance of early detection in preventing the further introduction of marine. These incidents also highlight the need for proper vessel risk assessment and also identification of 'high risk' ports of origin. In both cases, the fishing vessels originated from Probolingo Province in East Java, near the Indonesian port of Surabaya, an area of potential very 'high risk' of marine pest incursion because of its high volume of international shipping.

Previous records of exotic species (*Perna viridis* and *Mytilopsis sallei*) from fouled hulls in Darwin Harbour indicate that species are most likely to be introduced directly from international shipping via commercial, recreational and fishing vessels or slower moving vessels. Extensive hull fouling can develop on these slow-moving vessels due to longer port residence times and the relative infrequency of dry-docking and brush-cart service (in water hull cleaning). Slower moving vessels are likely to increase the survival of species encrusting the hulls, leading to the entry and potential colonisation of the port of a diverse and adult community.

Because of the proximity of Darwin to Asian ports and its use as a first port of call for many visiting small craft the risk of possible introduction of marine pests from Asian tropical ports is considered highest. At present the risk of introductions in ballast water is low. However, with the expansion of port facilities at the new East Arm port able to handle larger vessels than at present, and the proposed construction of a large LNG plant in the harbour capable of serving vessels up to 100,000 t displacement, the risk of ballast water introduction is likely to increase significantly.

7. EFFECT OF THE PORT ENVIRONMENT AND PORT PRACTICES ON COLONISATION AND SURVIVAL OF INTRODUCED SPECIES

The resident fauna of the Port of Darwin is indicative of a mostly estuarine environment, enclosed and sheltered from the open coast with significant exposure to variations in salinity. Neither of the two previously detected introduced species in the port (*Perna viridis*,

Mytilopsis sallei) are restricted to estuarine environments and potentially may have been capable of extending their range beyond the Darwin locale.

Port enhancement activities such as maintenance dredging, berth development and revetment construction create disturbed and novel habitats, which may lead to increased invasion success. Many introduced species appear to require some form of disturbance in order to enter an existing native community (Fox and Fox 1986; Hobbs and Huenneke 1992). The wholly artificial environments created by marinas whose water levels are maintained by lock gates may provide ideal conditions for the establishment of some encrusting or fouling species such as *M. sallei*, which may not be able to establish in the macrotidal regime of the open harbour, and these areas should be considered 'high risk'.

Hull cleaning activities, either in water (brush cart cleaning) or in dry dock, can have significant influence on the inoculation and establishment of species. In Darwin the primary activities of the slipways and dry docks have been, and continue to be, hull cleaning and painting rather than construction and refit. Except for small boat slipways at Cullen Bay Marina and Spot-On Marine at Race Course Creek, the larger commercial slipways and dry dock facilities are subject to environmental regulation and all have washdown sumps to prevent inoculation into the port environs.

The current dredging practices in the port are unlikely to influence the distribution of species in the port with the exception of redistributing the cysts of dinoflagellate species. However, none of the dinoflagellate species identified as present in Darwin Harbour presents any problems of possible toxicity transfer.

8. ASSESSMENT OF THE RISK OF NEW INTRODUCTIONS TO THE PORT

The successful introductions of an exotic species to a port through hull fouling or ballast water discharge requires some level of environmental matching between the donor region and receiving ports; the degree of matching required and important characteristics will depend on the environmental tolerances of individual species. In the absence of this species-level information only general observations can be made on the risks of new introductions to the Port of Darwin.

Given the current level of international ship visits to the Port of Darwin, the risk of new introductions from overseas commercial vessels appears to be greatest at the berths adjacent to both the Fort Hill/Iron Loader, Roll-On-Roll-Off pontoon and Stokes Hill Wharf, and for the future the new East Arm Port. However, there are presently very few large bulk vessel visits to these areas and the discharge of large volumes of ballast water is rare.

Given the planned developments in and around Darwin Harbour over the next 5-10 years, however, this situation is likely to change considerably. With the completion of East Arm Port, the Alice Springs-Darwin rail link and proposed LNG plant there is likely to be a dramatic increase in the level of bulk ship visits to the Port of Darwin. Elsewhere in Australia bulk carriers in ballast have been documented to carry many fouling organisms compatible with the marine environment in Darwin. These vessels have previously been

documented as carrying toxic dinoflagellate cysts in the sediments (Hallegraef and Bolch 1992) and will carry, and discharge, significant numbers of larvae entrained in the ballast water. Many of the international vessels currently trading with Darwin originate from Indonesia and the Philippines, and in the future it is likely that LNG trade with China will also be significant. The route through SE Asia provides opportunity for transmission of Western Pacific fouling species to Darwin. Carlton and Geller (1993) examined the ballast water of a number of vessels from Asian ports arriving in Coos Bay, Oregon and found 367 different taxa from 47 ordinal or higher taxa. It is likely that similar numbers could apply equally to ballast arriving in Darwin. Although none of the species identified by Carlton and Geller (1993) were considered to be pests, they cite numerous recent examples of aquatic invasions probably mediated by ballast water. Similarly, Hilliard and Raaymakers (1997) in a study of ballast water risk assessment for Queensland ports have identified a triangular tropical/subtropical region south from Shanghai and southern Japan, and including Hong Kong and Taiwan, to Malaysia and Singapore as an area which has similar environmental characteristics and biological assemblages and contains species considered to pose a 'high risk' of introduction into tropical Australian waters.

The periodic presence of slow-moving long residence vessels such as dredges in the port may present an opportunity for significant fouling communities to establish themselves while in the port. Previous work in the north Pacific has demonstrated the ability for these vessels to transport complete assemblages over long distances (Carlton 1985). The long resident times allow for reproductive populations to establish themselves.

9. ASSESSMENT OF THE RISK OF TRANSLOCATION OF INTRODUCED SPECIES FOUND IN THE PORT

An assessment of risks of translocation of introduced species from the Port of Darwin to other ports by shipping involves similar considerations to those discussed in assessing the risks of new introductions. The likelihood of transport and successful establishment of species in those new environments will be determined by the presence of the organisms in the water column during uptake in Darwin, as well as their survival during the voyage and the environmental regime in the recipient port. This information is outlined in Hayes and Hewitt (1998) as the foundation of the risk assessment based Decision Support System being developed by the Australian Quarantine and Inspection Service. At present few vessels load ballast water in Darwin or travel in ballast from Darwin to other Australian ports. Therefore the risk of transport of potential marine pests in ballast water from Darwin to other Australian ports at present is considered to be low.

A number of vessels (fishing vessels, barges, pleasure craft, refugee vessels and other illegal watercraft) are likely to move organisms via hull fouling. These organisms are likely to include various encrusting bivalves, nudibranchs, bryozoans, hydroids, barnacles and sea squirts. The majority of domestic traffic occurs within the Northern Territory between ports of similar environments (see Appendix 3). Consequently, the risk of local translocation of any exotic marine species that may establish in Darwin Harbour to other ports within the Northern Territory, and vice versa, is considered high.

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APPENDICES

Schedule 1. Australia Ballast Water Management Advisory Council (ABWMAC) schedule of target introduced pest species (taxa).

Gymnodinium & *Alexandrium* sp (toxic dinoflagellates)
Undaria pinnatifida (Japanese seaweed)
Asterias amurensis (northern Pacific seastar)
Sabella spallanzanii (giant fan worm)
Carcinus maenas (European shore crab)
Vibrio cholera (cholera bacterium)
Fish pathogens

Schedule 2. Marine pest species that pose a significant threat to Australia.

Mnemiopsis leidyi (comb jelly)
Potamocorbula amurensis (Chinese clam)
Philine auriformis (sea slug)
Mytilus galloprovincialis (mussel)

Schedule 3. Known exotic species in Australian waters.

Species	Possible origin	Australian distribution
ANIMALIA		
Bougainville ramosa (hydroid)	N. Hemisphere	NSW
Hydroides elegans(serpulid)	Europe	WA, Vic, NSW, Tas
Boccardia proboscidea (spionid)	Japan/NE. Pacific	Vic
Polydora ciliata (spionid)	Europe	WA, NSW
Pseudopolydora paucibranchiata (spionid)	Japan/NE. Pacific/NZ	Vic
Sabella spallanzanii (fan worm)	Mediterranean	WA, NSW, SA, Tas, Vic,
Euchone (?) sp (fan worm)	?	Vic?
Maoricolpus roseus (screw shell)	NZ	Tas, NSW
Zeacumantis subcarinatus (screw shell)	NZ	NSW
Aeolidiella indica (sea slug)	widespread	NSW
Janolus hyalinus (sea slug)	Europe	Vic
Okenia plana (sea slug)	Japan	Vic, NSW
Polycera capensis (sea slug)	S. Africa	NSW
Polycera hedgpethi (sea slug)	California	WA, Vic, NSW
Godiva quadricolor (sea slug)	S. Africa	WA
Thecacera pennigera (sea slug)	?	NSW
Crassostrea gigas (Pacific oyster)	Japan	WA, NSW, SA, Tas, Vic
Neilo australis (clam)	NZ	Tas
Corbula gibba (clam)	Europe/Mediterranean	Vic
Ostrea lutaria (NZ mud oyster)	NZ	Vic
Paphirus largellierti (clam)	NZ	Tas
Perna canaliculus (NZ green mussel)	NZ	Tas
Musculista senhousia (Asian mussel)	Pacific/Asia	WA, Vic, Tas
Soletellina donacoides (tellinid)	NZ?	Tas?
Theora lubrica (semelid)	Pacific/Asia	WA, Vic
Amaurochiton glaucus (chiton)	NZ	Tas
Neomysis japonica (mysid shrimp)	Japan	NSW
Tanais dulongi (tanaid)	Europe	SA
Cirolana hardfordi (isopod)	USA	WA, Vic, NSW
Eurylana arcuata (isopod)	NZ/Chile	SA, NSW
Paracerceis sculpta (isopod)	USA/S. America	Qld
Paradella dianae (isopod)	USA/S. America	Qld
Sphaeroma serratum (isopod)	widespread	WA
Sphaeroma walkeri (isopod)	Indian Ocean	NSW, Qld

Schedule 3 continued

Synidotea laevidorsalis (isopod)	?	?
Balanus improvisus (barnacle)	Atlantic	SA?
Megabalanus rosea (barnacle)	Japan	WA
Megabalanus tintinnabulum (barnacle)	cosmopolitan	WA
Notomegabalanus algicola (barnacle)	S. Africa	NSW
Cancer novaezelandiae (crab)	NZ	Vic, Tas
Carcinus maenas (European shore crab)	Europe	WA, SA, Vic, NSW, Tas
Halicarcinus innominatus (crab)	NZ	Tas
Pyromaia tuberculata (crab)	E. Pacific	WA
Petrolisthes elongatus (half crab)	NZ	Tas
Palaemon macrodactylus (shrimp)	N. Pacific	NSW
Sergiella angra (shrimp)	?	?
Anguinella palmata (bryozoan)	Atlantic	NSW
Bugula flabellata (bryozoan)	Atlantic/Mediterranean	SA, NSW
Conopeum tubigerum (bryozoan)	Atlantic	Qld
Cryptosula pallasiana (bryozoan)	?	WA, SA, NSW, TAS
Membranipora membranacea (bryozoan)	cosmopolitan	SA, Vic?, Tas?
Schizoporella unicornis (bryozoan)	Japan	WA, SA, NSW, Qld
Watersipora arcuata (bryozoan)	Mexico	WA, SA, NSW, Qld
Asterias amurensis (seastar)	Japan	Vic, Tas
Astrostole scabra (seastar)	NZ	Tas
Patiriella regularis (seastar)	NZ	Tas
Ascidiella aspersa (ascidian)	Europe	WA, SA, Vic, Tas.
Ciona intestinalis (ascidian)	Europe	WA,SA,Vic,Tas,NSW,Qld
Molgula manhattensis (ascidian)	N. Atlantic	Vic, Qld
Styela clava (ascidian)	NW. Pacific/Europe	Vic
Styela plicata (ascidian)	widespread	WA, SA, NSW, Qld
Latelabrax japonicus (Japanese sea bass)	Japan	NSW
Triso dermopterus (grouper)	W.-Equat. Pacific	Qld
Sparidenrax hasta (Sobaity sea bream)	Arabian Gulf	WA
Tridentiger trigonocephalus (striped goby)	W.-Equat. Pacific	WA, Vic, NSW
Acanthogobius flavimanus (yellowfin goby)	W.-Equat. Pacific	Vic, NSW
Fosterygion varium (blenny)	NZ	Tas
Oreochromis mossambicus (tilapia)	SE Asia	WA, Qld
Salmo salar (Atlantic salmon)	N. America	Tas
Salmo trutta (brown trout)	UK	Tas
Oncorhynchus mykiss (rainbow trout)	NZ (California)	Tas
PLANTA		
Caulerpa filiformis (green alga)	S. Africa	NSW
Caulerpa taxifolia (green alga)	Atlantic/Indo Pacific	WA
Codium fragile tomentosoides (green alga)	Atlantic Europe	Vic
Gymnodinium catenatum (dinoflagellate)	Japan?	Vic, Tas, WA
Alexandrium minutum (dinoflagellate)	Mediterranean?	WA, SA, Vic, NSW, WA
Alexandrium catanella (dinoflagellate)	Japan?	WA, SA, Vic, NSW
Alexandrium tamarense (dinoflagellate)	Europe?Japan?	SA, Vic, Tas, WA
Arthrocladia villosa (red alga)	N. hemisphere	?
Sperococcus compressus	N. hemisphere	?
Antithamnionella spirographidis	N. hemisphere	?
Polysiphonia brodiaei (red alga)	N. hemisphere	?
Polysiphonia pungens (red alga)	N. hemisphere	?
Undaria pinnatifida ("wakame")	Japan	Tas, Vic
Discosporangium mesarthrocarpum	Mediterranean	SA
Spacella subtilissima (brown alga)	Mediterranean	SA
Zosterocarpus spp. (brown alga)	Mediterranean	SA

DETAILS OF PORT FACILITIES

DARWIN PORT AREA

Shipping is presently served by a container and general cargo terminal consisting of three major wharves, a 70 tonne rail mounted container crane and Roll-on/Roll-off facility, in the old Darwin port area:

NUMBER 1 BERTH (IRON ORE WHARF)

The berth has a face length of 142 m with mooring dolphins 69 m east and west able to accept vessels up to 250 m LOA an 11.5 m draft for discharge of bulk petroleum, bulk sulphuric acid and LP gas. Ores and dry bulk cargo can be loaded at a gross rate up to 600 t per hour by a travelling belt loader, having a transit distance of 140 m along the wharf and an outreach of 14 m beyond the fenders. High water air-draft of the loading boom is 11 m at wharf fender face. Least depth in the berth is 12m below chart datum.

NUMBER 2 BERTH (FORT HILL- WEST AND EAST)

Number 2 West Berth is 150 m long and can handle vessels up to 11.7 m draft and any beam. Least depth in berth at the eastern end is 12 m. The western end is serviced by the Port's high-capacity floating linkspan for working Roll on roll off cargoes. Number 2 East Berth is also 150 m long, making total quay length of 300 m. Both berths are served by the Port's IHI/Sumitomo rail-mounted gantry crane which has a heavy lift capacity of 70 t and an automatic telescopic spreader. The crane has a handling capability of 30 containers per hour.

NUMBER 3 BERTHS WEST & EAST (STOKES HILL WHARF - OUTER)

Number 3 Berth is a concrete decked steel piled wharf with a 300 m trestle approach. The berth is 292 m long and has a least depth of 9 m. The Stokes Hill Wharf, is now primarily a recreational facility with an outdoor eatery precinct. However, the wharf is used for cruise ships, naval vessels, fishing vessels, and to a lesser degree, commercial trading vessels. The East Berth also handles dry bulk products such as clinker and sulphur, which are landed by ship's grab. The use of this wharf by commercial vessels will reduce further as the new East Arm Port becomes operational.

NUMBER 4 BERTH WEST & EAST (STOKES HILL WHARF INNER)

Number 4 Berth is use mainly by smaller vessels such as prawn trawlers, small pleasure craft and tugs. The maximum vessel length is restricted to 70 m. Total length of berth is 280 m. It has a least depth of 4.5 m.

ROLL-ON/ROLL-OFF

The Roll-On-Roll-Off (Ro/Ro) facility used for vessels designed to load or discharge cargoes with ramps. This facility is also used by the navy, cruise ships and smaller pleasure craft. The Ro/Ro facility is installed at the western end of No.2 Berth. The Ro/Ro facility consists of a 'Linkspan' ship-to-shore semi-buoyant bridge, 77 m in length, connected to a 30 m x 42 m pontoon and is workable at all tidal levels. The pontoon may be extended or retracted to 33.6 m and ballasted to a 1 m freeboard, thus enabling Ro/Ro vessels of any size and type - side-loading, end-loading, quarter- loading (port and starboard) - to use the Port of Darwin.

FISHERMAN'S WHARF, FRANCES BAY

Fisherman's Wharf, designed primarily for the use of the fishing industry is 200 m long. Dredged to 4m below datum this berth has a face of concrete deck on steel piles stressed to 1.0t/m^2 with direct land backing.

DARWIN FISHING HARBOUR (FRANCES BAY) MOORING BASIN

Darwin Fishing Harbour Mooring Basin is a facility predominantly to support the fishing industry but which is also used by recreational vessels. The sheltered Basin offers 85 berths - either 20 m, 25 m or 30 m. Access is via a tidal lock, 35 m x 15 m, operable during a 3.2 to 7.5 m range of tide.

SADGROVES CREEK MOORING AREA

54 moorings which are leased mainly to pleasure craft, in the sheltered waters of Sadgroves Creek;

In addition, the port includes privately owned marinas at Cullen Bay, Tipperary Waters and Bayview Haven. The tidal level in each of these is maintained by lock gates.

A privately owned barge landing facility at Hudson's Creek is used mainly for shipment of live cattle.

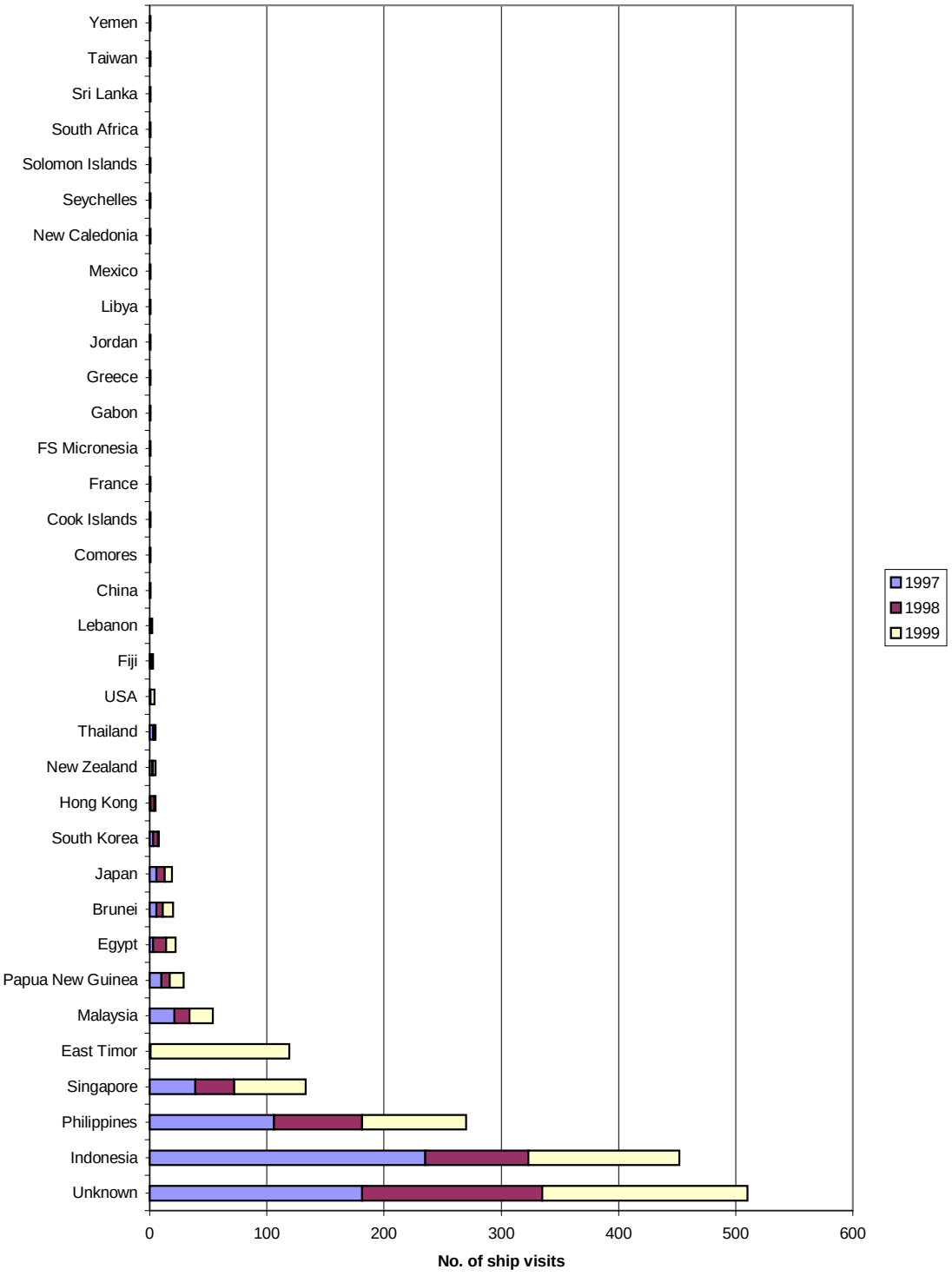
EAST ARM PORT

Darwin's new East Arm Port development complements the existing Darwin Port facilities by providing an additional 490 m of land-backed wharf. Of this, 300 m has a minimum depth alongside of 13 m and the remainder has a minimum depth of 14 m. The design of the wharf allows for further dredging tgo a depth of 15 m if required in the future.

The recently completed Stage 1 provides facilities for imported bulk cargoes, livestock carriers, rig tender and general vessels.

A future independent bulk liquids terminal will have a least depth of 14 m, and an additional 110 m of general purpose wharf will have a least depth of 13 m.

Ship visits by last international port of call 1997-99




Ship visits by next international port of call 1997-99
Viet Nam
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Tahiti
Peru
Netherlands
Marshall Islands
Liberia
Guinea
Fiji
Belgium
North Korea
Iran
India
Taiwan
South Korea
South Africa
Libya
New Zealand
Lebanon
China
Egypt
Brunei
Singapore
Japan
Papua New Guinea
Malaysia
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Indonesia
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500
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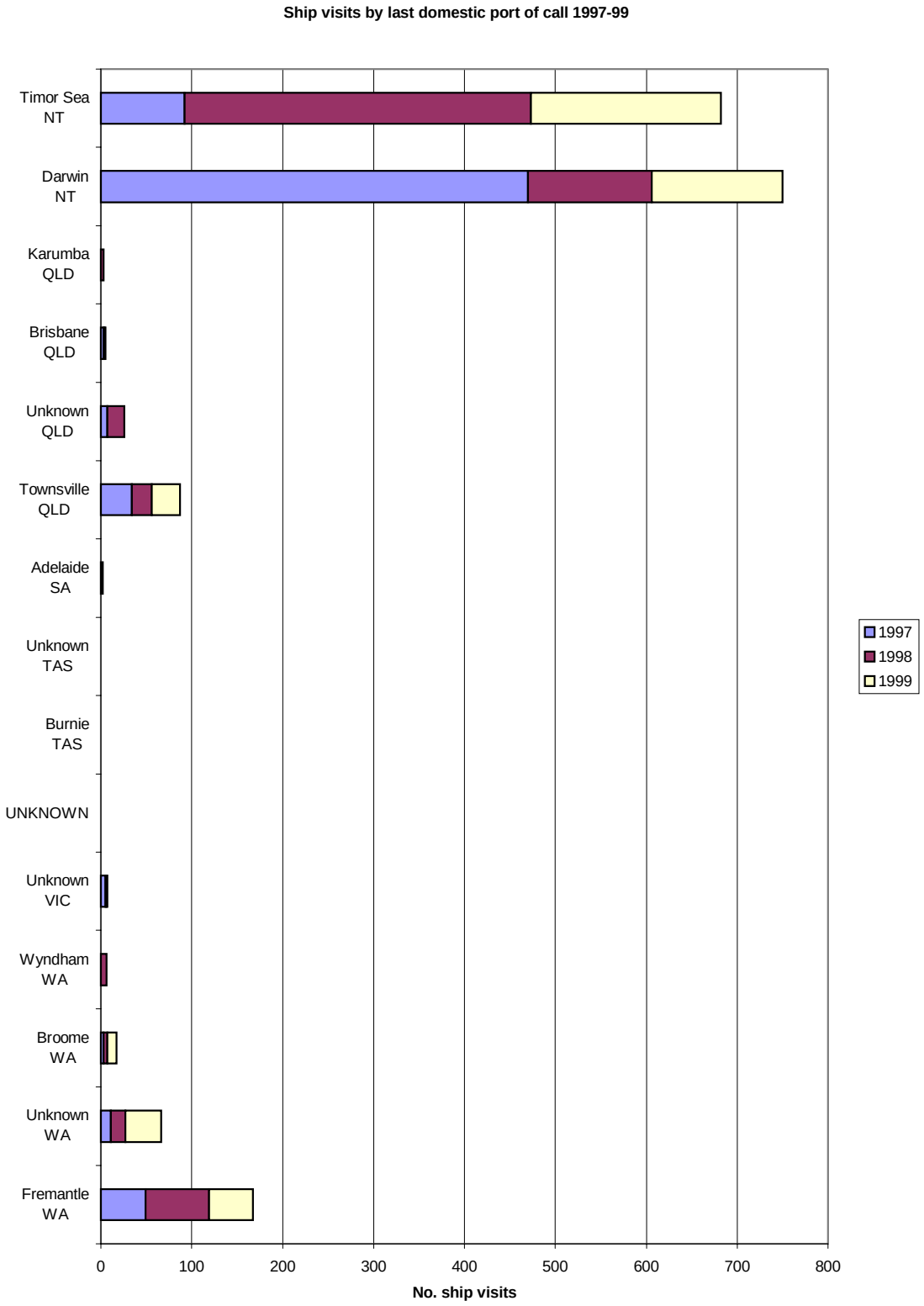
No. of ships
1997
1998
1999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Brisbane QLD
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Townsville QLD
Adelaide SA
Unknown TAS
Burnie TAS
UNKNOWN
Unknown VIC
Wyndham WA
Broome WA
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700
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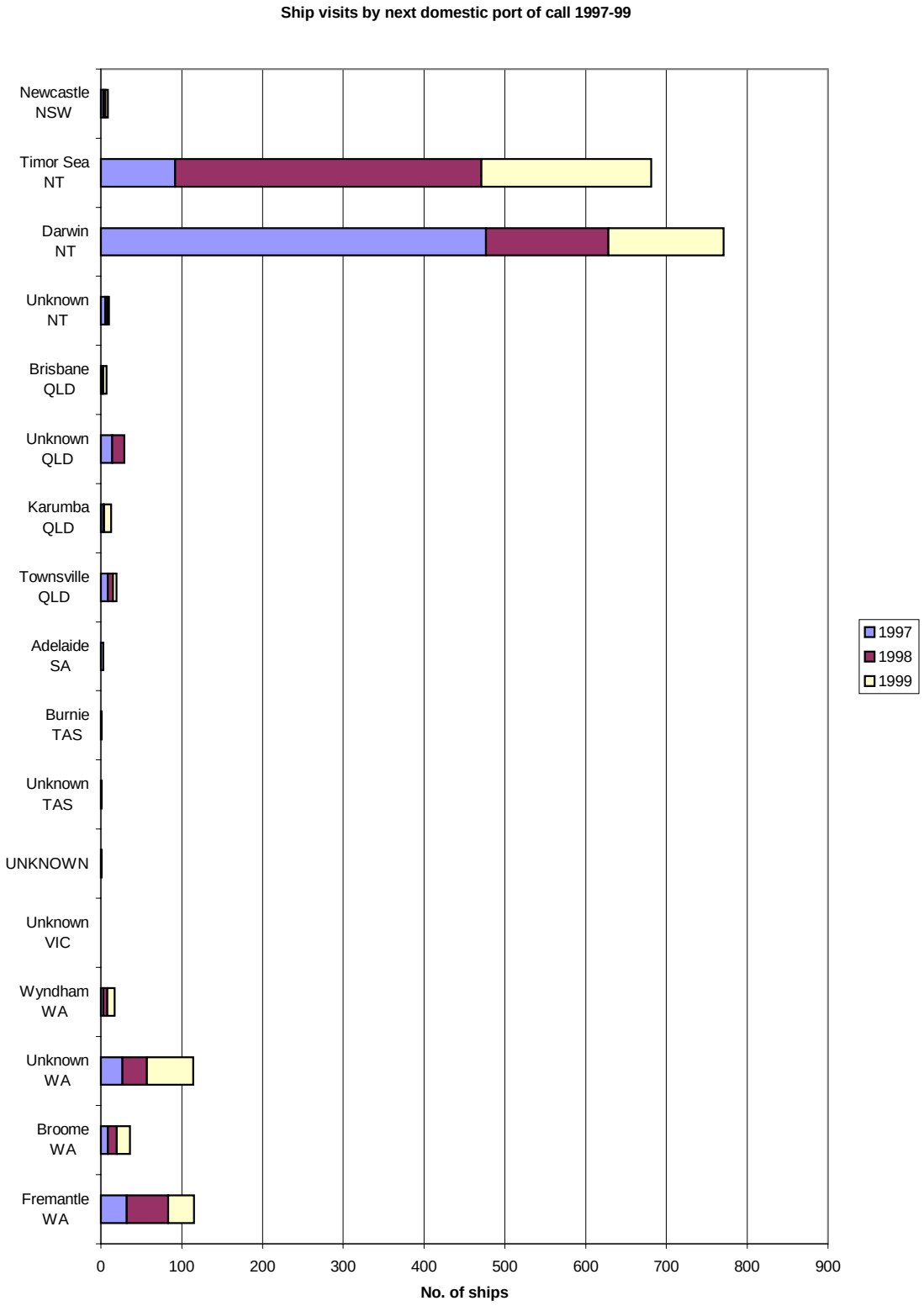
1997
1998
1999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Darwin NT
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Brisbane QLD
Unknown QLD
Karumba QLD
Townsville QLD
Adelaide SA
Burnie TAS
Unknown TAS
UNKNOWN
Unknown VIC
Wyndham WA
Unknown WA
Broome WA
Fremantle WA
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400
500
600
700
800
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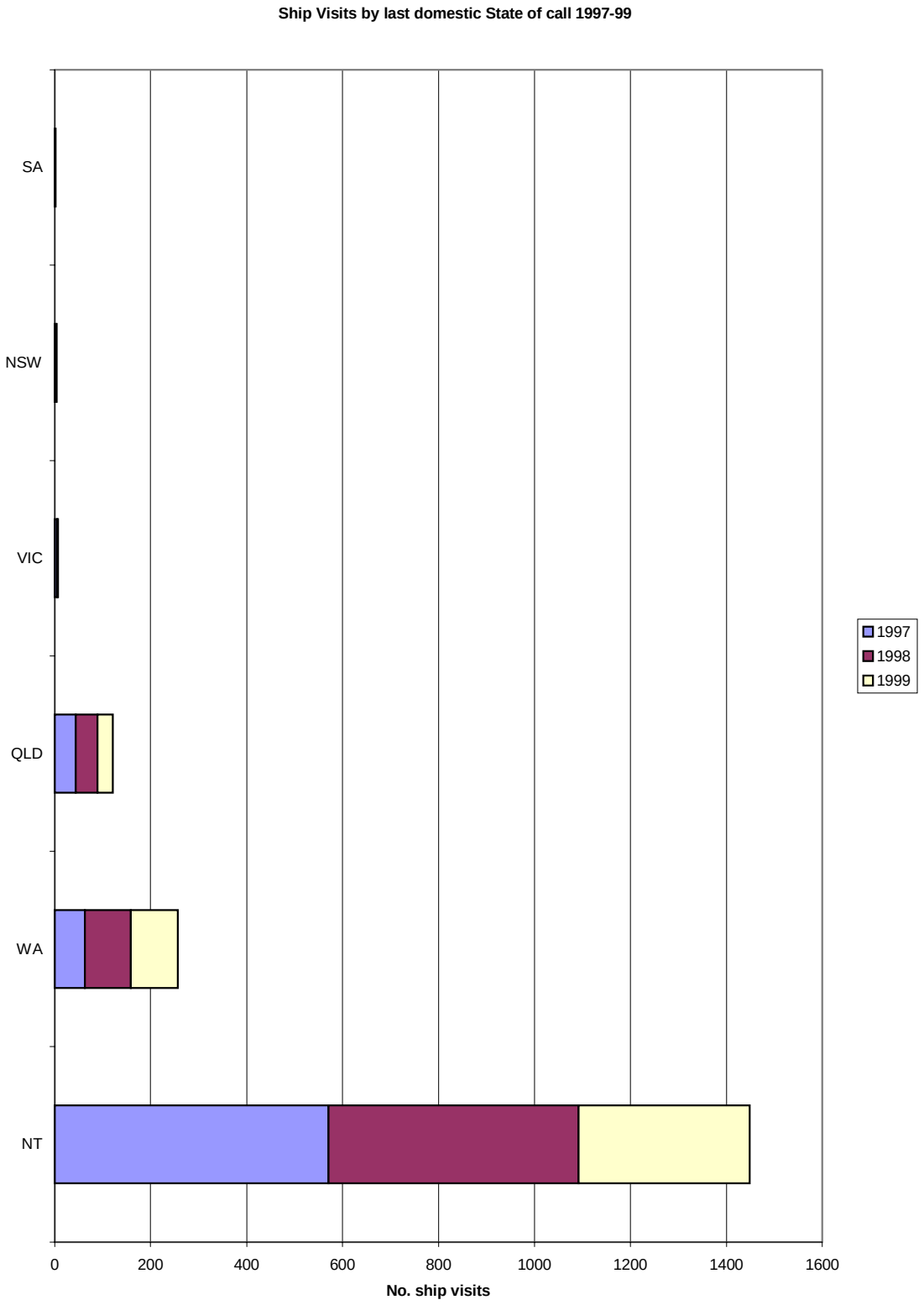
No. of ships
1997
1998
1999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SA
NSW
VIC
QLD
WA
NT
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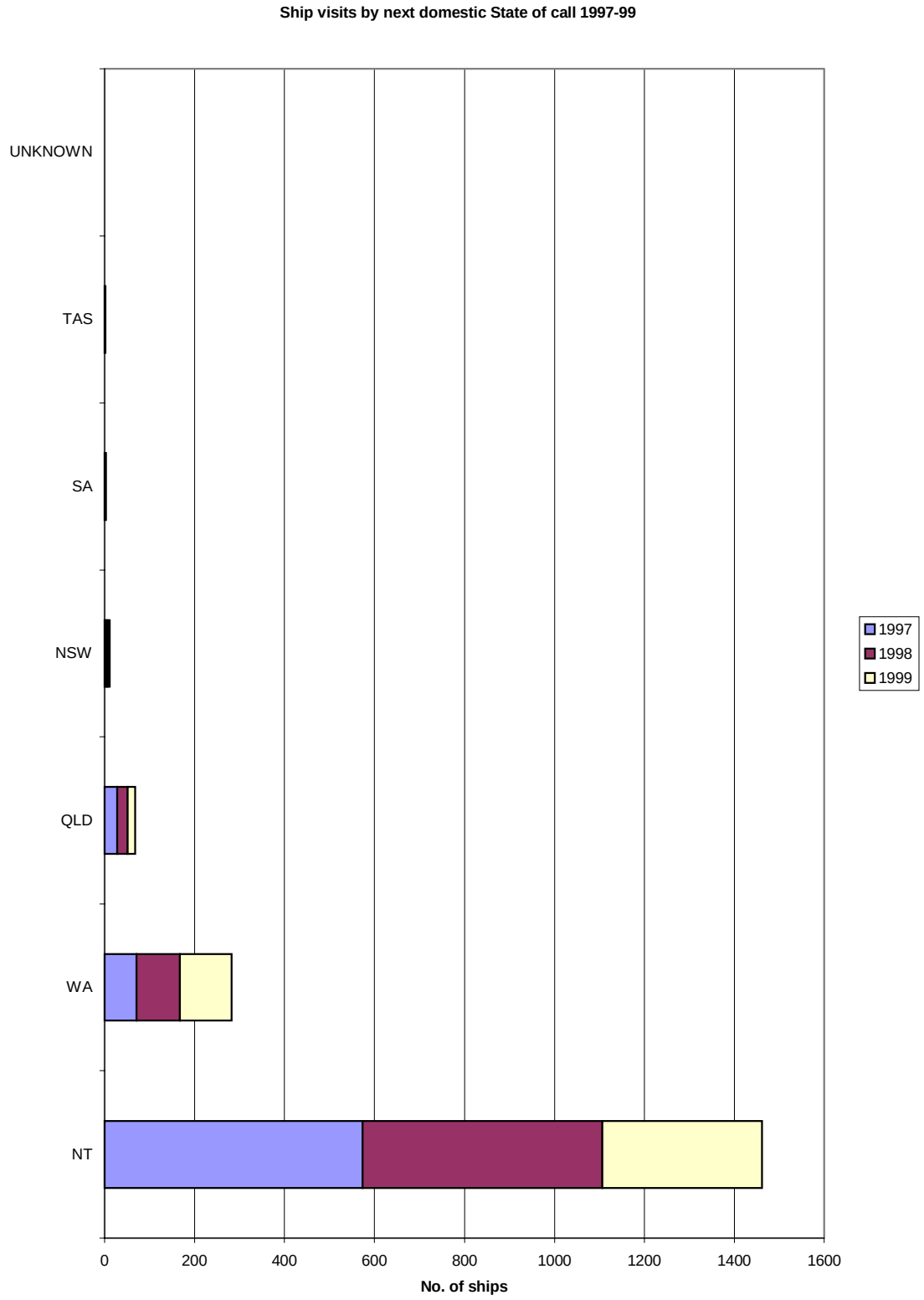
400
600
800
1000
1200
1400
1600
No. ship visits
1997
1998
1999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UNKNOWN
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SA
NSW
QLD
WA
NT
1997
1998
1999
0
200
400
600
800
1000
1200
1400
1600
No. of ships

1. ABWMAC TARGET SPECIES

1.1 Dinoflagellates

1.1.1 Sediment Sampling for Cyst-Forming Species (Small Cores)

Sediment cores were taken from locations within the estuary where the deposition and undisturbed accumulation of dinoflagellate cysts was likely to occur. Selection of sites was based on depth, local hydrography and sediment characteristics of the area. At each site triplicate sediment cores were taken by divers using 20 cm long tubes with a 2.5 cm internal diameter. Tubes were forced into the sediment then capped each end with a bung to provide an air-tight seal. Cores were stored upright in the dark at 4°C prior to size fractionation and examination for dinoflagellate cysts.

1.1.2 Sediment Preparation and Cyst Identification

The top 6 cm of sediment core was carefully extruded from the coring tube and stored at 4°C in a sealed container until further examination. Subsamples (approx. 1–2 cm^3) of each core sample were mixed with filtered seawater to obtain a watery slurry. Subsamples (5–10 ml) were sonicated for 2 min (Braun Labsonic homogenizer, intermediate probe, 100 watts) to dislodge detritus particles. The sample was screened through a 90 µm sieve and collected onto a 20 µm sieve and the remaining fraction was panned to remove denser sand grains and larger detritus particles. Subsamples (1 ml) were examined and counted on wet-mount slides, using a compound light microscope. Where possible, a total of at least 100 cysts were counted in each sample. Identification of species followed those of Bolch and Hallegraeff (1990). Cysts of suspected toxic species were not found in Darwin Harbour samples and it was not necessary to undertake cyst germination for further identification.

1.1.3 Plankton Sampling and Culture

Plankton sampling of diatoms were not undertaken

1.1.4 Toxicity Testing

As no suspected toxic species were found amongst the Darwin harbour samples, toxicity testing was not undertaken.

1.2 Crabs

1.2.1 Trapping

Crab species were sampled using light-weight plastic-coated wire-framed traps (60 cm long, 45 cm wide and 20 cm high) covered with 1.27 cm square mesh netting. Entry to the trap was through slits at the apex of inwardly-directed V-shaped panels at each end of the trap. The internal bait bag was baited with salmon, pilchards and pink ling heads. Traps were weighted with chain or divers weights and deployed with surface buoys. Whenever possible, traps were deployed in the late afternoon and recovered early the next morning.

1.2.2 Visual Searches

Visual searches for crabs and other target species were also made at selected wharves in the port area. Divers swam the length of the wharf, searching between the surface and the bottom, to provide a complete visual survey of the outer wharf.

1. NON TARGET SPECIES

2.1 Zooplankton

Zooplankton sampling was not undertaken for the Port of Darwin.

2.2 Hard Substrate Invertebrates

2.2.1 Wharf Pile Communities

Piles or projecting steel facings were selected from wharves having different types of shipping activity. Two or three piles or facings were selected in series from near one end of each wharf, starting about 5 m from the end to reduce "edge" effects, with about 10 m distance separating each piles or facing. Three piles or facings were sampled from all wharves.

The selected piles or facings were marked and their positions recorded and photographed. For each pile divers then took:

(i) video film of the outer surface of each pile/facing from approximately high-water level down to the deepest exposed part of the pile/facing using Hi-8 video camera recorder (Sony CCD-TR3000E) in an underwater housing (Sony MPK-TRB Handycam Marine Pack). The housing was fitted with twin 20 W (Sony HVL-M20) underwater lights and a distance-measuring rod with a scale and a digital depth meter. The rod ensured that the camera was a constant distance (approx. 50 cm) from the pile or sea floor. The scale and depth meter were positioned so they fell within the field of view of the camera and provided real-time depth information on the video recording.

(ii) 35 mm still photographs using a Nikonos V underwater camera with a 35 mm lens and a 1:6 overlens and single SB-102 flash to provide higher-resolution records of the fouling communities and selected species.

(iii) representative samples of the fouling communities present at various depths by scraping attached animals and algae as carefully as possible into plastic bags. These samples were preserved in 5% buffered formalin for subsequent sorting and identification in the laboratory.

2.2.2 Breakwaters

Using equipment detailed in section 2.2.1 above, divers took video and still photographs, and collected representative samples of the attached plant and invertebrate communities.

2.3. Soft Substrate Invertebrates

2.3.1 Epibenthos

Visual searches by divers to locate and collect non-target, soft-bottom, epibenthic species were carried out at selected sites. At each wharf sampled, divers video filmed a 50 m

transect between one of the piles and the outer series of infaunal cores, along a weighted transect line marked at 1 m intervals.

2.3.2 Benthic Infauna

Divers took infaunal samples using a tubular 0.025 m^2 (17.9 cm internal diameter) hand corer. The 40 cm corer had a pair of handles close to the upper end and was marked externally with grooves at 20 cm and 25 cm from the bottom to indicated the depth to which a core was taken. The upper end of the corer was closed except for a mesh-covered 8 mm diameter hole which could be sealed with a rubber bung to aid retention of the infaunal sample when the corer was withdrawn from the sediment.

When sampling around wharves, a core was taken within 1 m of the bottom of each outer pile and facing sampled, and a second core 50 m directly out from the wharf. For each wharf area sampled this provided three samples close to the wharf ("inner" cores) and three 50 m from the wharf ("outer" cores). When sampling around channel markers or single pylons three replicate cores were taken 1 m from the base of the pile. Each sample was transferred to a 1-mm mesh bag with drawstring mouth and then sieved underwater, either in situ or after the diver returned to the surface. The retained material was then washed into a plastic bag and preserved in 5% buffered formalin for subsequent sorting and identification in the laboratory.

2.4 Fish

2.4.1 Poison Stations

Rotenone was used to sample fish around the bottom of piles. The rotenone was mixed with seawater containing 5% detergent immediately before use and dispensed from squeeze bottles. Poisoned fish were collected by divers using hand-nets. Because of the strong tidal currents rotenone fish collection was not very successful. However, MAGNT has good data for a number of sites in Darwin Harbour based on rotenone samples (Larson and Williams 1997).

2.4.2 Nets

Seine netting was not undertaken during the Port of Darwin survey, as MAGNT has extensive beach seine records for Darwin Harbour (Larson and Williams 1997).

2. ENVIRONMENTAL DATA

3.2 Temperature and Salinity

Good temperature, salinity and other water quality data exists for Darwin Harbour (see Padovan 1997) and separate sampling was not undertaken as part of the Port of Darwin Survey.

3.3 Sediment Analysis

3.2.1 Sediment Collection

Sediment samples (minimum 100 g wet weight) were taken for analysis of grain size and organic content, to characterise the habitats of any introduced epibenthic and infaunal

species found. Samples were taken with each set of infaunal cores ("inner" and "outer") and at other selected sites. The sediment was collected by divers in sealable plastic bags, which were then frozen to stabilise the organic content levels and returned to the laboratory for analysis.

3.2.2 Particle Size Analysis

Sediment particle size analysis undertaken on the thawed samples consisted of seiving for sand sized fractions (>75µ) and hydrometer analysis for the silt/mud fractions following the methods of AS1289.3.6.1-1995 and AS1289.3.6.3-1994 respectively. This work was undertaken by the University of New South Wales Water Research Laboratory.

3.2.3 Organic Content

Approximately 25 g of dry, unsieved sediment was weighed in a crucible to 0.00001 g then ashed in a muffle furnace at 480° C for 4 hrs. The crucible was allowed to cool before being reweighed. The difference between the net dry and net ash-free weights was then calculated. This difference, or weight loss, was then expressed as a percentage of the initial dry weight and represents the organic content of the sediment sample.

Dry Season - August 1998

Site Code	Location	Sampling Method	Sampling Details
NTDCBM	Cullen Bay Marina	Qualitative	Qualitative assessment of pile communities
		Large cores	Cores taken from the base of 3 piles
		Pile scrapings	0.10m^2 quadrat scrapings from 0 and 3.0 m depth on 3 piles
		Crab Traps	2 traps set
NTDCBMO	Cullen Bay Marina Outer	Qualitative	Qualitative assessment of pile communities
		Rotenone	Poison station
NTDEP	East Point Sponge Garden	Qualitative	Qualitative assessment
		Still Photography	Qualitative photographs
NTDFHW	Fort Hill Wharf	Small cores	Dinoflagellate cores triplicate at 50 m
		Large cores	Cores taken from the base of 3 piles; triplicate at 50 m from pile 1
		Pile scrapings	0.10m^2 quadrat scrapings from 0, 3.0 and 7.0 m depth on 3 piles
		Sediment	
		Still Photography	Qualitative photographs
		Video Photography	Qualitative video
NTDFM	Frances Bay Marina	Small cores	Dinoflagellate cores
		Large cores	Cores taken from the base of 3 piles
		Qualitative	Qualitative assessment of pile communities
		Sediment	
		Crab Traps	
		Seine Nets	
NTDIOB	Iron Ore Wharf	Small cores	Dinoflagellate cores
		Large cores	Cores taken from the base of 3 piles
		Pile scrapings	0.10m^2 quadrat scrapings from 0, 3.0 and 7.0 m depth on 3 piles
		Sediment	
		Still Photography	Qualitative photographs
		Video Photography	Qualitative video

Site Code	Location	Sampling Method	Sampling Details
NTDSHW	Stokes Hill Wharf	Small cores	Dinoflagellate cores
		Large cores	Cores taken from 50 m out from the base of 3 piles
		Pile scrapings	0.10m^2 quadrat scrapings from 0, 3.0 and 7.0 m depth on 3 piles
		Sediment	Sediment sample taken 50 m out from the base of pile
		Still Photography	Qualitative photographs
		Video Photography	Qualitative video
NTDAR	Artificial Reef (Stokes Hill)	Qualitative	Qualitative assessment of pile communities
		Still Photography	Qualitative photographs
NTDCL	Catalina Landing	Qualitative	Qualitative assessment of pile communities
NTDEA1	East Arm 1	Small cores	Dinoflagellate cores
		Large cores	Cores taken from the base of 3 piles
		Transect cores	Cores taken 15, 30 and 50 m out from pile 1
		Pile scrapings	0.10m^2 quadrat scrapings from 0, 3.0 and 7.0 m depth on 3 piles
		Sediment	
		Still Photography	Qualitative photographs
		Video Photography	Qualitative video
NTDEA2	East Arm 2	Qualitative	Qualitative assessment of pile communities
		Pile scrapings	0.10m^2 quadrat scrapings from 0, 3.0 and 7.0 m depth on 3 piles
		Sediment	
		Plankton	
		Still Photography	Qualitative photographs
NTDEAB	East Arm Wharf Breakwater	Qualitative	Qualitative assessment of pile communities
		Still Photography	Qualitative photographs
NTDFJ	Ferry Jetty (Stokes Hill Wharf)	Qualitative	Qualitative assessment of pile communities
NTDFW	Fisherman's Wharf	Small cores	Dinoflagellate cores
		Large cores	Cores taken from the base of 3 piles
		Pile scrapings	0.10m^2 quadrat scrapings from 0 and 3.0 m depth on 3 piles
		Still Photography	Qualitative photographs
NTDFWR	Fisherman's Wharf Rock Wall	Qualitative	Qualitative assessment of pile communities

Site Code	Location	Sampling Method	Sampling Details
NTDFHI	Fort Hill Wharf Inner	Large cores	Cores taken from the base of 3 piles
		Pile scrapings	0.10m^2 quadrat scrapings from +2.0, 0 and 3.0 m depth on 3 piles
		Still Photography	Qualitative photographs
		Video Photography	Qualitative video
		Rotenone	Poison station
NTDFHN	Fort Hill Wharf Near	Qualitative	Qualitative assessment of pile communities
NTDHC	Hudson Creek	Small cores	Dinoflagellate cores
		Large cores	Core taken from the base of pile 1
		Qualitative	Qualitative assessment of pile communities
		Sediment	
NTDMJ	Mandorah Jetty	Qualitative	Qualitative assessment of Subtidal and intertidal communities
		Still Photography	Qualitative photographs
		Video Photography	Qualitative video
NTDNB	Naval Base	Small cores	Dinoflagellate cores
		Large cores	
		Qualitative	Qualitative assessment of pile communities
		Plankton	
		Still Photography	Qualitative photographs
NTDNBO	Naval Base Outside Breakwater	Qualitative	Qualitative assessment of pile communities
NTDOA	Offshore Anchorage	Qualitative	Qualitative assessment
		Still Photography	Qualitative photographs
		Video Photography	Qualitative video
NTDOFH	Old Fort Hill Wharf	Qualitative	Qualitative assessment
		Still Photography	Qualitative photographs
NTDPW	Perkins Wharf	Small Cores	Dinoflagellate cores
		Large Cores	Core taken from the base of pile 1
		Sediment	
NTDPWB	Barge off Perkins Wharf	Scrapings	0.10m^2 quadrat scrapings from Oyster zone, Red Algae zone and Barnacle zone (underside)
		Still Photography	Qualitative photographs

Site Code	Location	Sampling Method	Sampling Details
NTDQA	Quarantine Anchorage	Small cores	Dinoflagellate core taken from 3 m out from the base of pile 3
		Large cores	Core taken from 3 m out from the base of pile 1
		Qualitative	Qualitative assessment of pile communities
		Sediment	
		Still Photography	Qualitative photographs
		Video Photography	Qualitative video
NTDSHF	Stokes Hill Facing	Rotenone	Poison station
NTDSHI	Stokes Hill Wharf Inner	Small cores	Dinoflagellate cores
		Large cores	Cores taken from the base of 3 piles
		Pile scrapings	0.10m^2 quadrat scrapings from 0, 3.0 and +2.0 m depth on 3 piles
		Sediment	
		Still Photography	Qualitative photographs
		Video Photography	Qualitative video
NTDSHN	Stokes Hill Wharf Near	Qualitative	Qualitative assessment of pile communities
		Still Photography	Qualitative photographs
NTDYCM	Yacht Club Moorings	Qualitative	Qualitative assessment of mooring communities
		Still Photography	Qualitative photographs

Wet Season March 1999

Site Code	Location	Sampling Method	Sampling Details
NTDCBM	Cullen Bay Marina	Large Cores	Core taken from the base of pile 1
		Pile Scrapings	0.10m^2 quadrat scrapings from 0 and 3.0 m depth on 3 piles
		Still Photographs	Qualitative photographs
		Water samples	
NTDCBMO	Cullen Bay Marina Outer	Large Cores	Cores taken from the base of 3 piles
		Qualitative	Qualitative assessment of pile communities
		Pile Scrapings	0.10m^2 quadrat scrapings from 0 and 3.0 m depth on 2 piles
		Still Photographs	Qualitative photographs
		Video Photography	Qualitative video
NTDEP	East Point	Qualitative	Qualitative assessment (4 Quadrats)
		Water samples	
		Sediment	
		Still Photographs	Qualitative photographs
NTDFHW	Fort Hill Wharf	Large Cores	2 cores taken from the base of pile 1
		Qualitative	Qualitative assessment of pile communities
		Pile Scrapings	0.10m^2 quadrat scrapings from 0, 3.0 and 7.0 m depth on 3 piles
		Still Photographs	Qualitative photographs
		Video Photography	Qualitative video
		Water samples	
		Crab Traps	
		Seine Traps	
NTDFM	Frances Bay Marina	Large Cores	Core taken from the base of pile 1
		Pile Scrapings	0.10m^2 quadrat scrapings from 0 and 3.0 m depth on 3 piles
		Still Photographs	Qualitative photographs
		Video Photography	Qualitative video
		Water samples	
		TBT samples	

Site Code	Location	Sampling Method	Sampling Details
NTDIOB	Iron Ore Berth	Pile Scrapings	0.10m^2 quadrat scrapings from 0, 3.0 and 7.0 m depth on 3 piles
		Still Photographs	Qualitative photographs
		Video Photography	Qualitative video
		Water samples	
		Sediment	
		Crab Traps	
		Seine Traps	
NTDSHW	Stokes Hill Wharf	Pile Scrapings	0.10m^2 quadrat scrapings from 0 and 3.0 m depth on 3 piles
		Still Photographs	Qualitative photographs
		Video Photography	Qualitative video
		Water samples	
		TBT samples	

DRY SEASON – AUGUST 1998

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
PHYLUM PYRROPHYTA																															
Pyrophaceae	*Pyrophacus* sp.							*																							
Gonyaulaceae	*Spiniferites* spp.		*		*	*	*					*															*				
	Spinifierites bulloideus		*		*																										
	Spinifierites mambranaceus		*																												
	Spinifierites ramosus		*		*		*				*	*															*				
Goniodocacea	*Fragilidium cf. subglobosum*				*			*																			*				
Peridiniaceae	*Diplopelta* sp.							*																							
	Oblea sp.							*																							
	Protoperidinium cf. leonis							*				*																			
	Protoperidinium latissimum										*	*															*				
	Protoperidinium sp. A				*			*				*															*				
	Protoperidinium sp. B										*																				
	Protoperidinium sp. C						*	*																							
	Protoperidinium sp. D										*																				
	Protoperidinium spp.		*		*	*	*	*			*	*															*				
	Protoperidinium subienerme		*								*																				
Claciodinellaceae	*Pentapharsodinium tyrrhenicum*											*																			
	Scrippsiella crystallina		*		*	*	*	*			*	*															*				
	Scrippsiella imariense		*								*																				
	Scrippsiella spp.				*	*		*				*															*				
	Scrippsiella trochoidea		*		*	*		*			*	*															*				
Incertae sedis	Ovoid mucoid				*	*	*				*	*															*				
	Small spiny clear sp.				*	*	*	*			*	*															*				
	Spherical mucoid (2 spp.)				*	*	*	*			*	*															*				
PHYLUM RHIZOPODA																															
Class Granuloreticulosea																															
	Foramanifera						*	*			*			*					*		*		*			*	*				
PHYLUM PORIFERA																															
	Sponges	*	*	*	*		*	*	*	*	*	*	*	*		*	*	*		*		*	*	*	*		*		*	*	*
PHYLUM CNIDARIA																															
Class Hydrozoa																															
Bougainvilliidae	*Bougainvillia balei*				*																		*								
	?Bougainvillia balei											*																				
Clavidae	*?Merona* sp.																					*									
Pennariidae	*Pennaria disticha*								*																						

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
Eudendriidae	*Eudendrium kirkpatricki*						*							*																*	
	Eudendrium cf. kirkpatricki							*					*																		
	Eudendrium sp.				*												*					*									
	Eudendrium unidentifiable													*																	
Solanderiidae	*Solanderia secunda*												*																		
	Unidentifiable athecate										*											*									
Lafoeidae	*Filellum serratum*																					*									
	Filellum cf. serratum				*								*																		
	Hebella muscensis												*									*	*								
Haleciidae	*Halecium* sp.				*		*				*	*										*									
Aglaopheniidae	*Aglaophenia delicatula*				*																										
	Lytocarpia angulosa										*																				
	Macrorhynchia philippina				*		*				*	*	*	*								*								*	
	Macrorhynchia phoenicia							*	*		*	*	*									*	*							*	
	Unidentifiable Aglaopheniid																													*		
Halopteriidae	*Halopteris polymorpha*							*			*											*									
Plumulariidae	*Monotheca flexuosa*																						*									
	Nemertesia sp. 1												*																			
	Plumularia badia										*		*										*									
	Plumularia bedoti																						*									
	Plumularia setacea												*																			
Sertulariidae	*Diphasia digitalis*																					*					*					
	Diphasia heurteli																					*										
	Dynamena sp. 1				*																											
Class Hydrozoa																																
Sertulariidae	*Idiellana pristis*				*		*		*		*		*	*							*	*	*							*	*	
	Salacia hexodon																					*										
	Sertularella decipiens				*		*	*																								
	Sertularella diaphana var. delicata																					*										
	Sertularella quadridens																						*									
	Sertularella sp.																					*										
	Thuiaria sp.												*																			
	Thyroscyphus torresii				*		*															*	*									
Syntheciidae	*Synthecium orthogonium*				*								*									*									
Campanulariidae	*Clytia cf. warreni*										*	*																				
Class Anthozoa																																
Poritidae	*Porites eridani*																					*										
	Porites cf. annae			*																												
Pectiniidae	*Mycedium elephantotus*																				*											

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
Mussidae	*Cyanarina lacrimalis*																					*									
Faviidae	*Goniastrea retiformis*																					*									
	Goniastrea aspera																					*									
	Moseleya latistellata																					*									
Merculinidae	*Hydnophora exesa*																					*									
Rhizangiidae	*Culcia hoffmeisteri*				*		*						*	*							*	*									
Caryophylliidae	*Conocyathus n.sp. cf. C. zealandiae*							*																							
	Paracyathus sp.				*		*	*														*									
Dendrophylliidae	*Rhizopsammia nuda*							*																							
	Turbinaria mesenterina																					*									
	Balanophyllia sp.								*																						
	Dendrophyllia sp.						*																								
Clavulariidae	*Carijoa* sp.			*	*		*	*	*		*	*	*	*												*			*	*	
Alcyoniidae	*Lobophytum* sp. 1												*																		
Nephthyidae	*Dendronephthya heterocyathus*			*																											
	Dendronephthya michaelseni var. raevis																						*								
	Dendronephthya sp. 1	*																													
	Steronephthya sp. 1			*									*			*														*	
Subergorgiidae	*Subergorgia suberosa*												*																		
Anthothelidae	*Icilogorgia brunnea*								*		*		*																		
Melithaeidae	*Acabaria serrata*						*																								
	Acabaria sp. 1				*											*						*								*	
	Acabaria sp. 2						*																								
	Acabaria sp. 3				*																								*		
	Acabaria sp. 4				*																										
	Acabaria sp. 5				*																										
	Acabaria sp. 6				*																										
	Clathraria sp. 1				*																										
	Clathraria sp. 2				*																										
	Mopsella sp. 1				*																										
Plexauridae	*Echinogorgia* sp. 1																													*	
	Echinogorgia sp. 2												*																		
	Echinogorgia sp. 3												*																		
	Echinogorgia sp. 4												*																		
	Echinomuricea coccinea												*																		
	Echinomuricea cf. *indomalaccenesis*																														

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
	Echinomuricea sp. 1												*																		
Gorgoniidae	*Rumphella* sp. 1												*																		
Junceella	*Ctenocella pectinata*												*																	*	
	Dichotella gemmacea												*																	*	
	Junceella fragilis												*																		
	Junceella juncea								*																						
Parazoanthidae	*Parazoanthus* sp. 1								*				*							*											
Antipathidae	*Cirrpathes* sp. 1						*																								
PHYLUM NEMERTEA																															
	Nemertean		*				*				*									*				*							
PYHLUM NEMATODA																															
	Nematoda	*					*					*		*			*														
PHYLUM SIPUNCULA																															
	Sipunculid															*	*						*	*							
PHYLUM ANNELIDA																															
Class Polychaeta																															
Ampharetidae					*			*			*		*	*		*	*					*		*					*	*
Amphinomidae											*		*																		
	? Chloeia sp																										*				
Aphroditidae	*Laetmonice mollucana*												*	*																	
Capitellidae		*	*	*	*		*	*	*		*	*	*	*								*	*	*					*	*	*
Chaetopteridae														*																	
	Spiochaetopterus sp. 1													*																	
Chrysopetalidae					*						*	*		*															*		
	Bhawania ambonensis				*		*	*						*									*								
	Chrysopetalum sp. 1			*	*		*	*	*		*	*	*	*						*		*	*	*		*	*		*	*	
	Chrysopetalum sp. 2											*		*								*	*								
	Treptopale sp. 1																														*
Cirratulidae					*		*	*	*		*		*	*																	
Cossuridae																														*	
	Cossura sp. 1																													*	
Dorvilleidae			*	*			*	*			*		*	*												*			*		
	Dorvillea sp. 1						*	*			*		*	*												*			*		
	Ophryotrocha sp. 1		*																												
Eunicidae		*	*	*	*		*	*	*		*	*	*	*		*	*			*	*	*	*	*		*	*		*	*	
	Lysidice collaris	*	*	*	*		*	*			*	*	*	*		*	*			*		*		*		*	*		*	*	
	Nematonereis unicornis		*	*	*		*	*			*	*		*			*							*					*	*	
	Lysidice sp. 1																									*					
	Palola cf *siciliensis*			*	*		*	*		*	*			*										*					*		

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
	Eunice indica						*															*				*	*				
	Marphysa sanguinea		*																												
	Eunice tubifex		*	*	*		*	*			*		*	*			*							*					*		
	Eunice antennata		*	*	*		*	*	*		*	*	*	*			*			*		*	*	*		*	*			*	
	Eunice sp. 1																				*										
	Eunice sp. 2				*																										
Euphrosinidae	*Euphrosine* sp. 1										*		*																		
Flabelligeridae		*	*		*		*	*				*		*						*	*	*		*						*
	Pherusa parmata		*		*		*	*				*		*						*		*		*						*
Glyceridae									*					*																	
Goniadidae					*																										
Hesionidae				*	*		*	*	*			*	*	*		*	*			*		*		*		*	*		*	*	*
Lumbrineridae		*	*	*	*		*	*	*		*	*	*	*		*				*		*		*		*			*		
	Lumbrinereis cf. coccinea	*		*	*		*	*	*		*	*		*		*						*								*	
	Lumbrinereis sp.1						*																									
	Lumbrinereis sp. 2										*																					
	Lumbrinereis sp. 3													*																		
	Lumbrinereis cf. tetraura										*													*								
Oenonidae			*																										*			
	Drilonereis cf. australiensis							*																								
	Halla sp. 1		*																													
	Oenone fulgida				*			*			*			*										*		*						
Maldanidae											*		*				*							*						*	
Nephtyidae							*	*																								
	Micronephtys cf. *sphaerocirrata*						*																									
Nereididae		*	*	*	*		*	*	*	*	*	*	*	*		*	*			*		*	*	*		*	*		*	*	*
Onuphidae		*	*	*	*		*	*	*		*	*	*	*			*			*		*		*		*			*	*	
	Diopatra cf. amboinensis				*																											
Opheliidae			*		*		*		*					*		*							*					*			
	Armandia intermedia						*	*						*									*							*	
	Polypthalmus pictus		*		*									*		*															
Orbiniidae		*						*			*													*							
Paraonidae								*																								
	Sigambra parva		*																													
Phyllodocidae		*			*		*	*			*	*	*	*						*		*	*	*					*	*	
Pilargidae			*														*															
Polynoidae		*	*	*	*		*	*	*	*	*	*	*	*	*	*	*			*		*	*	*		*			*	*	*
	Harmothoe cf. praeclara				*		*		*																				*			
	Harmothoe dictyphora			*	*		*	*			*	*		*								*	*								
	Harmothoe sp. 1						*																									

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
	Harmothoe sp. 2				*																										
	Iphione muricata						*	*																							
	Lepidonotus carinulatus				*		*	*	*		*	*		*						*		*							*	*	
	Lepidonotus cf. carinulatis				*			*															*	*							
	Lepidonotus glaucus						*	*																							
	Lepidonotus yorkianius		*		*		*		*															*		*			*		
	Paralepidonotus indicus								*					*																	
Sabellariidae		*			*		*	*				*												*					*	
	Sabellaria sp.1				*		*					*												*			*		*	*	
Sabellidae			*		*						*			*										*						
	Branchiomma nigromaculata		*		*		*	*	*		*			*						*		*				*			*	*	*
	Chone australiensis				*						*																				
	Demonax cf. pallidus				*		*		*		*	*	*	*			*					*	*	*		*			*	*	*
	Demonax sp. 1				*		*	*	*					*																	
	Demonax sp. 2							*																		*					
	Demonax sp. 3				*		*	*	*	*				*		*													*	*	
	Hypsicomus sp. 1				*		*		*		*						*							*						*	
	Laonome triangularis		*				*																								
	Megalomma macrophthalma																												*		
	Perkinsiana sp. 1				*		*		*					*															*		
	Perkinsiana sp. 2				*																										
	Potamethus sp.1						*		*		*						*							*						*	
	Pseudobranchiomma orientalis	*	*		*		*	*			*	*		*							*	*		*		*			*	*	
	Pseudobranchiomma cf. emersoni	*	*		*		*	*			*	*		*								*		*		*				*	
	Pseudopotamilla laciniosa				*		*	*	*		*			*			*			*		*		*						*	
	Sabellarstarte indica													*																	*
Serpulidae			*		*						*			*															*		
	? Sprirobranchus sp.		*			*		*																		*					
	Apomatus sp.1				*																										
	Ficopomatus uschakovi		*		*			*			*																			*	
	Hydroides albiceps				*																	*							*		
	Hydroides cf. externispina				*							*		*																	
	Hydroides cf. ralumiana		*																												
	Hydroides diramphus										*																				
	Hydroides elegans								*		*			*												*				*	
	Hydroides malleolaspina			*	*		*	*	*		*	*		*												*					
	Hydroides nodosa						*																								
	Hydroides recta						*				*	*														*					
	Hydroides sp. 1															*															

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
	Hydroides sp. 2				*		*																								
	Hydroides sp. 3											*		*										*							
	Hydroides tambalagamensis				*		*	*				*		*																	
	Hydroides trivesiculosus				*		*	*			*	*		*						*		*		*					*	*	
	Hydroides tuberculata				*		*				*			*												*			*		
	Josephella marenzelleri																				*										
	Neovermilia sp.1																					*	*			*					
	Pomatoleios kraussi				*		*	*			*	*					*								*	*			*		
	Pomatostegus stellatus				*		*	*			*	*		*							*								*		
	Protula magnifica							*														*									
	Salmacina dysteri				*		*																				*			*	
	Serpula magna				*		*																								
	Serpula cf. *vermicularis*				*		*	*	*		*	*		*								*									
	Spirobranchus coronatus						*				*											*									
	Vermiliopsis infundibulum/ glandigera group						*	*													*	*		*							
Sigalionidae								*																							
Spionidae			*											*													*				
	? Spiophanes sp.		*																												
	Polydora cf *socialis*				*		*	*			*	*		*			*							*		*				*	*
	Polydora hoplura						*							*																	
	Polydora cf. pilocollaris				*																										
	Polydora woodwicki		*					*									*									*					
	Spio cf. pacifica				*		*							*			*							*						*	*
Spirorbidae		*			*		*	*	*			*	*	*			*					*		*			*			*	*
Sternaspidae	*Sternapsis scutata*							*													*										
Syllidae		*	*	*	*	*	*	*	*		*	*	*	*		*	*			*		*	*	*		*	*		*	*	*
	Haplosyllis spongicola																*														
Terebellidae		*		*	*		*	*	*		*	*	*	*	*	*	*			*		*	*	*		*	*		*	*	
Trichobranchidae																				*			*	*		*				*	
PHYLUM MOLLUSCA																															
Class Polyplacophora																															
Chitonidae	*Acanthopleura gemmata*				*					*										*				*					*		
	Chiton sp. 1																												*		
	Rhyssoplax sp. 1																					*									
Acanthochitonidae	*Acanthochitona* sp. 1																					*							*		
Class Gastropoda																															
Lottiidae	*Patelloida cryptalirata*		*		*			*			*			*						*					*				*		
Fissurellidae	*Clypidina* sp. 1				*			*						*															*		
	Diodora jukesii				*		*	*						*																	
	Diodora mus						*																								

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
	Diodora ticaonica				*									*								*									
	Emarginula sp.		*																												
	Emarginula sp. 1				*																										
	Emarginula sp. 2				*																										
	Emarginula variegata						*	*						*															*		
	Scutus unguis						*								*																
Turbinidae	*Austroliotia* sp. 1				*																										
	Crosseola sp. 1		*																												
	Liotina sp. 1						*				*		*														*				
	Liotina sp. 2				*																										
	Liotina sp. 3																				*										
	Liotina sp. 6							*																	*						
	Lithopoma sp. 1																												*		
	Pseudoliotia sp. 1						*							*																	
	Pseudoliotia sp. 2				*		*										*		*												
	Pseudoliotia sp. 3																										*				
	Tricolia fordiana	*																													
	Turbo cinereus																			*											
Trochidae	*Calliostoma similarae*																				*										
	Calliostoma sp. 1												*																		
	Calthalotia mundula										*		*												*						
	Clanculus johnstoni				*		*														*										
	Euchelus atratus						*																								
	Euchelus cf. foveolatus				*								*	*							*										
	Euchelus sp. 1													*																	
	Euchelus sp. 2													*																	
	Issanda coronata																								*						
	Microtis tuberculata												*																		
	Monodonta labio																				*										
	Spectamen sp. 1				*						*																				
	Tallorbis roseolus														*																
	Turcica maculata						*							*																	
Neritidae	*Nerita balteata*																														
	Nerita chamaeleon						*										*														
	Nerita polita																			*											
	Nerita undata													*						*											
	Smaragdia souverbiana		*																												
Cerithiidae	*Bittium zebrum*			*																											
	Cerithium coralium		*				*			*	*			*			*		*		*				*		*				
	Cerithium sp.		*																												

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
	Clypeomorus batillariaeformis													*											*						
	Clypeomorus bifasciata													*											*						
	Obtortio sp. 1		*																												
	Scaliola sp. 1		*																												
Dialidae	*Diala* sp.		*																												
	Diala sp. 1			*			*		*																		*				*
	Diala sp. 2																														*
Turritellidae	*Turritella terebra*		*				*							*											*		*				
Siliquariidae	*Tenagodus ponderosus*																				*										
	Tenagodus sp. 1												*																		
Planaxidae	*Fossarus* sp. 1				*																	*									
Potamididae	*Cerithidea cingulata*						*			*				*			*														
Littorinidae	*Littoraria articulata*				*		*	*					*	*						*					*				*		
	Peasiella tantilla		*		*		*	*		*	*			*			*			*		*			*				*		
Rissoidae	*Alvania* sp. 1	*	*		*		*	*			*	*		*						*	*	*		*			*		*	*	
	Lironoba sp. 1				*																											
	Merelina sp. 1		*		*		*										*		*										*		
	Merelina sp. 2		*		*						*						*				*						*				
	Merelina sp. 3				*		*	*			*			*							*				*						
	Merelina sp. 4				*																										*	
	Pisinna sp. 1		*																													
	Rissoina sp.1				*		*						*	*							*										*
Iravadiidae	*Iravadia australis*		*											*																	
	Iravadia sp. 1				*																											
Vitrinellidae	*Circulus cingulifera*				*		*	*			*										*				*						
	Lodderia sp. 1							*																								
	Teinostoma lucidum						*																									
	Vitrinella sp. 1				*		*							*																		
	Vitrinella sp. 2				*																											
Calyptraeidae	*Clypeola* sp. 1				*		*	*																								
Ovulidae	*Diminovula punctata*	*																														
Vermetidae	*Serpulorbis* sp. 1																													*		
Cypraeidae	*Cypraea cylindrica*																			*												
	Cypraea sp. 1													*																		
Triviidae	*Trivia oryza*												*																			
Naticidae	*Natica colliei*				*						*																					
	Natica fasciata				*		*	*			*			*	*						*				*		*				
	Natica gualteriana													*							*						*				
Ranellidae	*Biplex pulchellum*				*		*				*			*																	
Triphoridae	*Inella* sp. 1				*																											

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
	Mastonia cf. papillata				*									*																	
	Mastonia sp.				*												*						*								
	Mastonia sp. 1	*			*		*	*	*		*	*	*	*			*				*	*	*		*		*		*	*	
	? Mastonia sp.		*																												
	Subulophora sp. 1				*			*																							
	Subulophora sp. 2							*																							
Cerithiopsidae	*Cerithiopsis* sp. 1	*			*		*				*			*								*								
	Cerithiopsis sp. 2				*																*										
	Cerithiopsis sp. 3							*																							
	Cerithiopsis sp. 4							*																							
	Seila sp. 1				*																										
Epitoniidae	*Epitonium cf. jukesianum*							*													*										
	Epitonium sp.		*		*		*		*																						
	Epitonium sp. 1				*																										
	Epitonium sp. 2																				*										
	Epitonium tenellum							*																							
Eulimidae	*Balcis* sp. 1				*																										
	Curveulima sp. 1				*																										
	Eulima sp.				*		*										*														
	Eulima sp. 1				*									*												*	*				*
	Eulima sp. 2								*																						
	Hypermastus sp. 1										*																				
	Sticteulima cf. cameroni				*								*																		
Muricidae	*Chicoreus cornucervi*						*						*	*																	
	Latiaxena fimbriata				*		*																*							*	
	Latiaxena walkeri				*																										
	Morula amygdala																						*								
	Morula margariticola																			*											
	Murex macgillivrayi																										*				
	Murex sp.										*																				
	Thais trigonus									*																					
Coralliophilidae	*Babelomurex fearnleyi*				*																										
Buccinidae	*Cantharus fumosus*				*																										
	Cantharus tranquebaricus						*								*																
	Engina curtisiana												*								*										
	Nassaria acuminata						*																								
Columbellidae	*Cotonopsis* sp. 1																						*								
	Macrozafra sp. 1				*		*	*	*		*			*										*			*				
	Mitrella abyssicola		*		*		*	*	*			*		*							*	*		*		*	*			*	*
	Mitrella essingtonensis													*																	

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
	Mitrella sp.		*																												
	Mitrella sp. 1				*		*		*		*		*	*							*	*								*	
	Mitrella sp. 2																													*	
	Mitrella venulata				*		*	*			*			*	*						*	*	*				*		*	*	
	Zafra troglodytes		*		*		*	*			*	*	*	*						*	*	*		*	*	*	*		*	*	
Nassariidae	*Nassarius bicallosus*				*		*							*							*								*		
	Nassarius celebensis		*		*		*	*			*		*	*	*		*				*						*		*		
	Nassarius comptus													*													*					
	Nassarius concinnus				*								*	*																		
	Nassarius dorsatus							*						*	*										*							
	Nassarius fraudator																										*					
	Nassarius pauperus				*		*	*						*							*	*										
	Nassarius sinusigerus				*		*				*			*							*						*				
	Nassarius sp.		*																													
Volutidae	*Amoria turneri*																			*												
Olividae	*Oliva caldania*							*																								
Marginellidae	*Haloginella torresina*						*							*																		
	Volvarinella walkeri				*																*											
Cystiscidae	*Euliginella angasi*	*	*		*		*	*			*		*	*							*			*			*			*		
	Granulina anxia	*			*		*	*						*							*	*		*		*	*		*	*		
Mitridae	*Mitra rosacea*				*		*							*													*					
	Mitra variabilis												*																			
Costellariidae	*Thala* sp. 1																				*											
Turridae	*Antiguraleus* sp. 1						*							*							*											
	Daphnella sp. 1													*							*						*					
	Daphnella sp. 2																										*					
	Epitrema sp. 1				*		*														*											
	Eucithara arenivaga				*		*	*						*							*				*		*					
	Heterocithara sp. 1				*																											
	Inquisitor formidabilis																										*					
	Inquisitor sp.						*							*																		
	Inquisitor sp. 1																				*											
	Lienardia sp. 1				*		*							*							*											
	Lienardia sp. 2				*		*				*			*							*											
	Lienardia sp. 3				*		*				*			*							*											
	Lienardia sp. 4																				*											
	Ptychobela sp. 1													*							*											
	Splendrillia sp. 1																										*					
	Tomopleura sp. 1													*																		
	Turricula nelliae granobalteus				*			*						*											*		*					

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
	Veprecula sp. 1						*														*										
Terebridae	*Terebra cf. analis*				*																										
Architectonicidae	*Heliacus* sp. 1								*																						
Pyramidellidae	*Chemnitzia* sp.		*											*																	
	Chemnitzia sp. 1				*			*													*								*		
	Chemnitzia sp. 2				*																										
	Chrysallida tribulationis				*		*	*					*	*							*										
	Gumina sp. 1																		*										*		
	Odostomia sp.										*																				
	Odostomia sp. 1				*																										
	Odostomia sp. 2																*														
	Oscilla sp. 1				*																										
	Pyramidella sp. 1										*																				
	Tiberia cf. pulchella																				*										
	Turbonilla sp.																*														
	Turbonilla sp. 1																								*						
	Turbonilla sp. 2																				*										
Amathinidae	*Amathina tricarinata*			*	*		*	*			*			*								*				*			*		
Acteonidae	*Pupa* sp. 1		*					*						*							*										
Ringiculidae	*Ringicula* sp.																				*										
	Ringicula sp. 1				*		*	*			*																				
	Ringicula sp. 2						*	*			*			*							*						*				
Cylichnidae	*Cylichna cf. japonica*							*																							
	Cylichna sp. 1						*	*			*			*							*						*				
	Cylichna sp. 2				*																										
	Rhizorus sp. 1				*		*							*																	
Tornatinidae	*Tornatina* sp. 1		*			*					*						*														
Retusidae	*Pyrunculus* sp. 1							*																								
	Retusa sp. 1		*				*														*				*						
Haminoeidae	*Atys cf. cylindricus*		*																												
	Atys cf. ooformis										*																				
	Atys semistriatus				*		*				*								*		*					*	*				
	Atys sp. 1				*		*				*		*	*					*						*		*				
	Haminoea sp.		*																												
	Haminoea sp. 1				*																										
	Mnestia sp. 1		*				*				*											*					*				
Runcinidae	*Ilbia* sp. 1																					*									
Goniodoridae	*Okenia* sp. 1				*																										
Onchidoridae	*Onchidoris* sp. 1						*																								

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
Gymnodoridiidae	*Gymnodoris alba*	*																													
Chromodoridiidae	*Ceratosoma trilobatum*	*			*									*																	
	Chromodoris cf. verrieri	*											*																		
	Chromodoris fidelis												*																		
	Chromodoris striatella	*																													
	Hypselodoris obscura						*																								
	Mexichromis macropus	*																													
Tritoniidae	*Tritonia* sp. 1				*																										
Dotidae	*Doto cf. racemosa*	*																													
	Doto sp. 1										*																				
Lomanotidae	*Lomanotus vermiformis*								*													*									
Arminidae	*Dermatobranchus* sp. 1	*																													
	Dermatobranchus sp. 2				*								*																		
Flabellinidae	*Flabellina rubrolineata*										*																				
Eubranchidae	*Eubranchus rubropunctatus*	*																													
Tergipedidae	*Cuthona sibogae*						*															*									
Facelinidae	*Phyllodesmium serratum*				*																										
	Pteraeolidia ianthina												*																		
Onchidiidae	*Onchidium* sp. 1													*																*		
Amphibolidae	*Salinator fragilis*		*																												
Siphonariidae	*Siphonaria* sp. 1							*												*										*		
Ellobiidae	*Cassidula* sp. 1													*																		
	Melampus sp. 1				*																											
Class Bivalvia																																
Nuculidae	*Leionucula cf. dilecta diaphana*										*										*						*					
	Leionucula cumingi		*				*																				*		*			
	Leionucula superba		*				*						*								*						*					
	Nucula sp.		*																													
	Nucula sp.1		*																													
Nuculanidae	*Nuculana aff. electilis*		*		*		*	*			*			*							*				*		*		*		
	Nuculana cf. dasea		*																													
	Nuculana corbuloides				*		*	*			*			*	*						*				*		*				
	Nuculana darwini						*	*			*			*																		
	Nuculana dasea		*		*		*							*					*								*				
	Yoldia lata				*		*	*			*			*							*						*				
	Yoldia narthecia		*				*	*			*			*														*				
Nucinellidae	*Nucinella* sp. 1							*																								
Mytilidae	*Botula silicula*		*																													

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
	Brachidontes maritimus		*		*		*	*		*	*			*	*				*	*						*			*	*	*
	Lithophaga malaccana		*	*	*		*	*			*			*						*		*	*			*			*		
	Modiolus micropterus		*																					*							
	Modiolus sp.		*		*																										
	Modiolus sp. 1				*		*	*			*						*			*	*								*		
	Modiolus vagina						*																								
	Musculus cumingianus				*		*							*																	
	Musculus miranda	*	*	*	*		*	*	*		*	*	*	*						*		*	*	*		*				*	*
	Rhomboidella malaccana						*						*																		
	Trichomusculus sp. 1				*																										
Arcidae	*Anadara granosa*						*	*						*			*								*		*				
	Anadara inaequivalvis													*													*				
	Arca avellana				*		*	*					*	*						*	*	*									
	Arca navicularis				*		*				*			*							*	*	*			*					
	Arcopsis afra				*		*	*					*	*	*						*	*			*		*				
	Barbatia amygdalumtostum				*									*			*			*	*										
	Barbatia cf. foliata				*									*	*																
	Barbatia helblingi		*																												
	Barbatia sp. 1			*	*		*	*				*										*									
	Sheldonella repenta				*		*	*						*							*										
	Sheldonella venustopsis				*		*														*	*									
	Striarca olivacea													*																	
Glycymerididae	*Melaxinaea vitrea*										*			*									*				*				
Pteriidae	*Electroma physoides*	*			*				*		*	*	*	*								*		*						*	
	Pinctada maxima				*			*	*					*		*				*		*				*					
	Pinctada radiata			*																											
	Pteria cf. lata						*	*																							
	Pteria peasei	*			*				*				*	*								*									
	Pteria sibogae												*																		
Malleidae	*Malleus daemoniacus*				*																										
	Malleus sp.		*																												
	Vulsella vulsella				*		*	*						*																*	
Isognomonidae	*Crenatula modiolaris*				*																										
	Crenatula viridis												*																		
	Isognomon ephippium						*	*												*									*		
	Isognomon isognomon	*	*		*		*	*	*					*						*		*				*					
	Isognomon legumen			*	*		*	*	*		*	*		*	*					*		*				*			*	*	*
Limidae	*Limaria fragilis*													*																	
	Limaria sp. 1													*																*	
	Limatula tadena												*																		

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
Gryphaeidae	*Parahyotissa numisma*													*									*	*					*		
Ostreidae	*Booneostra cucullina*		*		*		*	*	*	*	*	*	*	*	*		*		*		*	*		*	*	*	*		*	*	
	Dendostrea folium				*			*			*	*		*												*			*		
	Ostrea sp. 1																			*											
	Planostrea pestigris		*				*	*			*			*			*												*	*	
	Saccostrea cf. dactylena			*	*		*	*			*	*	*	*			*			*	*	*		*	*	*			*	*	*
	Saccostrea cucullata							*																								
	Striostrea mytiloides		*	*	*		*	*		*	*	*		*			*		*	*	*				*	*			*	*	*
Plicatulidae	*Plicatula australis*				*		*						*	*							*			*							
Pectinidae	*Annachlamys flabellata*													*																		
	Chlamys curtisiana				*		*	*			*		*	*							*	*				*				*	
	Chlamys sp. 1													*	*						*										
	Complicachlamys dringi						*														*										
	Excellichlamys spectabilis							*						*																	
	Mimachlamys funebris						*																								
Spondylidae	*Spondylus wrightianus*																										*				
Anomiidae	*Patro australis*				*		*	*			*	*		*							*					*	*				
Trigoniidae	*Neotrigonia uniophora*						*				*			*	*																
Chamidae	*Chama fibula*			*	*		*	*	*		*	*	*	*						*	*	*		*		*	*		*	*	
	Chama lazarus				*								*									*		*							
Lucinidae	*Cardiolucina eucosmia*				*		*	*			*			*							*				*		*				
	Cardiolucina rugosa						*																				*					
	Cardiolucina sp. 1						*																									
	Divaricella irpex		*																													
	Lucina sp. 1						*				*																*					
Ungulinidae	*Cycladicama subquadrata*		*					*																			*				
	Diplodonta sp. 1												*														*				
	Diplodonta sp. 2																										*				
Galeommatidae	*Borniola* sp. 1	*	*		*		*	*			*		*	*										*					*	*	
	Borniola sp. 2										*																					
	Kellia cf. physema							*																		*	*					
	Montacuta sp. 1				*		*	*			*			*															*			
	Mysella sp. 1													*													*					
	Scintilla cf. borneensis																				*											
	Tellimya ephippiolum				*						*																					
Neoleptonidae	*Micropolia* sp. 1		*																													
	Neolepton sp. 1												*																			
Carditidae	*Cardita crassicosta*						*																									
	Cardita muricata				*		*						*	*							*											
	Cuna sp. 1																				*											

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
	Glans sp. 1																												*		
	Micromeris praeclava		*				*	*																							
	Micromeris sp. 1				*		*	*			*								*		*				*		*				
	Pleuromeris sp. 1				*		*	*			*			*							*						*				
	Venericardia cardioides				*		*	*					*	*																	
Crassatellidae	*Salaputium rhomboides*				*		*				*			*							*										
Cardiidae	*Acrosterigma impolitum*																				*										
	Fragum hemicardium																										*				
	Fulvia australe				*		*	*			*		*				*				*						*		*		
	Maoricardium pseudolatum										*										*										
	Maoricardium setosum				*									*																	
	Vasticardium vertebratum													*							*										
Mactridae	*Mactra abbreviata*		*																												
	Mactra ovalina	*																													
	Mactra sp.		*								*																*				
	Notospisula sp. 1		*					*						*																	
Mesodesmatidae	*Paphies altenai*													*																	
Solenidae	*Solen* sp. 1												*																		
Pharidae	*Cultellus attenuatus*										*																				
	Sinonovacula constricta																										*				
Psammobiidae	*Gari lessoni*		*				*	*						*							*						*				
	Gari simplex				*		*	*			*		*	*					*		*						*				
Tellinidae	*Cadella* sp. 1		*																												
	Clathrotellina sp. 1							*																								
	Aenigmotellina sp. 1																				*										
	Exotica assimilis		*											*																	
	Exotica donaciformis		*				*	*			*			*							*						*		*		
	Exotica sp. 1				*		*	*			*			*							*						*				
	Macalia bruguieri												*	*																	
	Pinguitellina langiuda				*		*	*			*			*							*						*				
	Pinguitellina sp. 1				*			*																							
	Psammotreta amboynensis							*																							
	Tellina aff. tenuilirata				*		*	*			*			*							*						*				
	Tellina armata										*																*				
	Tellina inflata																										*				
	Tellina piratica		*																												
	Tellina sp.		*																												
	Tellina sp. 1						*																								
	Tellina sp. 2													*																	
	Tellina sulcata																				*										

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
Semelidae	*Semele* sp. 1						*																								
	Semele amabilis						*																				*				
	Semele casta													*																	
	Semele jukesii						*																								
	Semele sp.										*																*				
	Semele sp. 1												*								*										
	Theora fragilis		*																										*		
Trapezidae	*Trapezium sublaevigatum*		*				*						*																*		
Corbiculidae	*Polymesoda erosa*		*		*									*																	
	Polymesoda sp. 1						*				*			*																	
Veneridae	*Antigona chemitzii*		*				*	*						*													*				
	Antigona sp.										*																				
	Circe australe				*						*									*	*										
	Clementia crassiplica							*																							
	Dosinia amphidesmoides	*																													
	Dosinia exasperata																										*				
	Dosinia histrio				*		*				*			*							*				*		*				
	Dosinia juvenilis																										*				
	Dosinia lochi							*						*													*				
	Dosinia sculpta												*																		
	Dosinia sp.		*														*														
	Gouldia sp. 1				*		*	*			*		*	*					*		*				*		*			*	
	Irus irus		*		*		*	*			*	*	*	*			*				*			*						*	
	Marcia sp. 1				*																										
	Paphia gallus												*								*										
	Paphia undulata							*			*																				
	Periglypta sp. 1							*																							
	Pitar sp. 1							*																							
	Placamen calophyllum		*				*	*			*			*							*						*				
	Tapes platyptycha				*		*						*	*							*						*				
	Tapes sp. 1				*																										
	Tawera laticostata	*			*								*																		
	Timoclea infans						*							*													*				
Myidae	*Cryptomya blackburnae*						*																								
	Cryptomya sp.		*																												
	Cryptomya sp. 1		*	*	*		*	*	*	*	*	*		*						*						*			*		
	Tugonia sp. 1																										*				
Corbulidae	*Anisocorbula macgillivrayi*						*	*						*			*										*				
	Anisocorbula sp. 1				*		*	*			*			*	*						*				*		*				
	Corbula sp. 1												*																		

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
	Corbula sp. 2												*																		
	Notocorbula fortisulcata		*				*	*			*			*							*				*		*				
	Notocorbula hydropica							*						*											*		*				
	Notocorbula monilis										*																*				
	Serracorbula crassa				*		*	*			*			*							*				*		*				
	Serracorbula solidula	*			*		*	*			*			*			*				*		*		*		*				
	Serracorbula sp. 1													*																	
Gastrochaenidae	*Gastrochaena cuneiformis*																						*						*		
Pholadidae	*Barnea cf. manilensis*								*		*																				
	Jouannetia globosa																						*								
	Martesia sp. 1							*																							
	Martesia striata							*	*					*															*		
Myochamidae	*Myadora cf. pulleinei*		*																												
	Myadora parvimenta						*				*																*				
	Myadora sp. 1													*													*				
	Myadora sp. 2						*	*																			*				
	Myadora tessera							*																							
Cleidothaeridae	*Cleidothaerus pliciferus*				*		*	*					*	*																	
Cuspidariidae	*Cuspidaria elegans*							*			*																				
	Cuspidaria sp. 1						*				*																				
Class Scaphopoda																															
Dentaliidae	*Dentalium cheverti*							*			*										*										
	Dentalium hexagonum							*																							
	Dentalium sp.		*																												
Laevidentaliidae	*Laevidentalium cf. lubricatum*							*																							
	Laevidentalium sp. 1							*																							
Class Cephalopoda																															
Sepiidae	*Sepia* sp. 1																														*
PHLYUM BRYOZOA																															
	Bryozoans	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*		*	*	*	*	*	*	*	*		*	*	*
PHYLUM BRACHIOPODA																															
Class Inarticulata																															
Discinidae	*Discinisca striata*				*	*					*		*				*												*		
PHYLUM ECHINODERMATA																															
Class Holothuroidea																															
	Holothurians						*					*	*	*								*							*		
Class Asteroidea																															
	Asteroids								*																						
Class Ophiuroidea																															
	Ophiuroids	*	*	*	*	*	*	*	*		*	*	*	*		*				*		*	*	*			*		*	*	*

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
PHYLUM CRUSTACEA																															
Class Maxillopoda																															
Subclass Cirripedia																															
Lepadidae	*Lepas anatifera*																										*				
Archaeobalanidae	*Acasta* sp		*		*		*	*			*			*		*	*					*							*	*	
	Armatobalanus quadrivittatus		*		*		*		*		*	*	*	*			*				*		*							*		
	Armatobalanus terebratus				*		*	*						*																*		
	Chirona ?tenuis						*	*			*			*						*												
	Chirona amaryllis				*		*	*	*		*	*		*		*				*		*	*			*	*			*		
	Chirona tenuis				*			*												*										*		
	Conopea ?calceolus						*							*																		
	Conopea calceolus				*																											
Balanidae	*Balanus* sp. *?*													*													*					
	Balanus ?amphitrite		*		*		*	*	*		*	*		*			*			*						*	*		*		
	Balanus ?cirratus/reticulatus								*																							
	Balanus ?poecilotheca																					*										
	Balanus ?reticulatus								*																							
	Balanus amphitrite		*		*	*	*		*											*					*	*					
	Balanus cirratus				*		*	*	*		*	*		*			*			*						*	*		*		
	Megabalanus tintinnabulum													*																		
Chthamalidae	*Chthamalus malayensis*				*															*												
	Euraphia caudata																			*												
	Euraphia intertextus																			*												
	Euraphia sp.				*															*												
	Euraphia withersi				*																											
Iblidae	*Ibla cumingi*				*		*	*						*						*										*		
Pyrgomatidae	*Pyrgomatid* sp.													*								*										
Tetraclitidae	*Tetraclita squamosa*				*			*			*			*						*												
	Tetraclitella ?multicostata				*															*										*		
	Tetraclitella ?cf. multicostata				*																										*		
Class Ostracoda																																
	Ostracoda	*			*		*	*	*		*	*		*		*	*					*	*	*			*		*		
Class Malacostraca																																
	Leptostraca			*			*	*	*		*		*	*								*		*			*		*		
	Cumacea						*																									
	Tandaidacea				*		*	*	*		*	*	*	*		*	*			*	*	*	*	*			*		*		*
	Mysidacea			*	*		*					*		*							*			*			*		*	*	
	Amphipoda	*	*	*	*		*	*	*	*	*	*	*	*		*	*			*		*	*	*		*	*		*		*
	Isopoda			*	*		*	*	*		*	*	*	*		*	*			*	*	*	*	*		*	*		*		*

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
Order Decapoda																															
Infraorder Caridea																															
Alpheidae	Alpheidae ?						*																								
	Alpheidae		*		*		*	*	*		*	*		*	*						*	*	*			*	*		*	*	
	Athanas sp.				*			*					*	*																	
	Synalpheus sp.				*		*	*			*			*										*					*		
Palaemonidae	Palaemonidae						*																							*	
Palaemonidae/	*Onycocaridella prima*													*																	
Pontoniinae	*Palaemon serrifer*																			*											
	Palaemonella ?lata				*																										
	Palaemonella rotumana						*	*						*																	
	Palaemonella rotumana ?																													*	
	Palaemonella spinulata																										*				
	Palaemonella sp.											*																			
	Periclimenaeus sp.																												*		
	Periclimenes sp. ?						*	*												*											
	Periclimenes nilandensis																						*								
	Periclimenes obscurus				*		*				*												*								
	Periclimenes obscurus ?				*				*																					*	
	Periclimenes sp. 1			*																											
	Periclimenes sp. 2			*																											
	Periclimenes sp.				*		*	*	*		*		*	*								*							*	*	
Hippolytidae	Hippolytidae							*																						*	
	Latreutes sp.								*																						*
	Latreutes sp. ?										*																				
	Thor paschalis													*																	
	Thor spinipes													*																	
	Thor sp.			*			*	*					*	*								*								*	
Ogyrididae	*Ogyrides* sp.							*																							
Infraorder Thalassinidea																															
Thalassinidae	Thalassinidae				*		*	*	*		*																		*		
Upogebiidae	**Upogebiidae**						*	*					*														*			*	
Infraorder Anomura																															
Porcellanidae	*Aliaporcellana pygmaea*				*		*	*					*									*							*	
	Ancylocheles gravelei				*		*																								
	Enosteoides ? sp. nov.				*										*															*	
	Enosteoides ornatus				*																										
	Lissoporcellana (?) spinuligera						*	*																							
	Petrolisthes haswelli																			*											
	Petrolisthes militaris																						*								

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
	Pisidia cf. gordoni	*		*	*		*	*	*			*	*	*	*					*		*								*	*
	Pisidia dispar				*		*								*																
	Polyonyx biunguiculatus				*		*	*				*	*		*			*											*		
	Polyonyx maccullochi														*																
	Polyonyx sp.1						*	*							*																
Galatheidae	*Galathea (?) aegyptiaca*			*	*		*	*				*		*	*							*							*	*	
Infraorder Brachyura																															
Dromiidae	*Cryptodromia* sp.1						*								*																
Majidae	*Achaeus lacertosus*						*	*																							*
	Hyastenus sp. 2 *(cf. H. bispinosis)*				*		*	*	*			*	*	*	*															*	
	Hyastenus sp. 3											*																		*	
	Paratymolous sexspinosus																													*	
	Schizophrys rufescens				*		*															*									
Hymenosomatidae	*Elamena ?* sp. nov.				*				*				*										*								
	Neorhynchoplax minima						*	*							*															*	
Portunidae	*Charybdis callianassa*																														*
	Thalamita crenata					*																									
Xanthidae	*? Novactaea* sp. nov.				*		*																								
	Actaea tuberculosa														*																
	Gaillardiellus rueppelli				*			*																							
	Leptodius exaratus																			*											
Pilumnidae	*Glabropilumnus seminudus*				*		*	*				*																			
	Heteropanope glabra				*							*								*						*					
	Pilumnus minutus				*		*	*	*			*	*		*															*	
	Pilumnus sp. 1 *(nr P. longicornis)*														*																
	Pilumnus sp. 2 *(nr P. bleekeri)*								*																						
	Pilumnus sp. 3 *(? P. monilifer)*				*																										
	Pilumnus sp. nov.				*		*	*	*		*	*	*	*	*		*			*		*		*					*	*	
	Serenepilumnus (?) leopoldi						*																						*		
Goneplacidae	*Ceratoplax* sp.1				*																										
	Eucrate haswelli				*																										
Grapsidae	*Metopograpsus (?) messor*											*																			
	Metopograpsus frontalis							*		*		*		*						*				*							*
	Plagusia depressa tuberculata																										*				
Ocypodidae	*Baruna* sp. nov.				*			*																					*		
Oziidae	*Myomenippe fornasinii*																							*							

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
PHYLUM CHORDATA																															
Class Ascidiacea																															
	Ascidians	*	*	*	*		*	*	*		*	*	*	*		*	*			*		*	*	*		*	*		*	*	*
Class Osteichthyes																															
Muraenidae	*Gymnothorax* sp. 1																											*			
Muraenosocidae	*Muraenesox bagio*			*																											
Ophichthidae	*Muraenicthys macropterus*			*																											
Clupeidae	*Herklotsichthys konigsbergeri*																											*			
	Sardinella albella																											*			
	Sardinella sp.1			*																											
Antennariidae	*Antennarius hispidus*																											*			
	Antennarius pictus																											*			
Atherinidae	*Atherinomorus ?endrachtensis*																											*			
	Craterocephalus mugiloides			*																											
Ambassiidae	*Ambassis nalua*																											*			
	Ambassis vachelli			*																								*			
Serranidae	*Cephalopholis boenack*																					*						*			
	Epinephelus coioides			*																								*			
Pseudochromidae	*Pseudochromis qenie*																											*			
Teraponidae	*Amniataba caudavittata*		*																												
	Terapon theraps													*																	
Apogonidae	*Apogon rueppellii*		*																									*			
Leiognathidae	*Leiognathus decorus*			*																											
	Leiognathus equulus																											*			
	Leiognathus sp.1													*																	
	Leiognathus splendens																											*			
Lutjanidae	*Lutjanus russelli*			*																								*			
Nemipteridae	*Scaevius millii*			*																											
Gerreidae	*Gerres cf. oyena*			*																											
Toxotidae	*Toxotes chatareus*																											*			
Chaetodontidae	*Chelmon marginalis*			*																											
	Chelmon muelleri													*																	
Pomacentridae	*Pomacentrus milleri*																					*									
Sphyraenidae	*Sphyraena qenie*																											*			
Blenniidae	*Omobranchus ferox*			*																											
	Omobranchus punctatus			*																											
Gobiidae	*Acentrogobius viridipunctatus*			*																											
	Amoya gracilis			*										*																	
	Drombus globiceps					*																									

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW	AR	CL	EA1	EA2	EAB	FHI	FHN	FJ	FW	FWR	HC	MJ	NB	NBO	OA	OFH	PW	PWB	QA	SHF	SHI	SHN	YCM
	Palutrus sp. 3											*		*																	
	Priolepis nuchifasciatus							*																							
Butinae	*Butis butis*			*																											
Oxudercinae	*Apocryptodon* n. sp.																												*		
Soleidae	*Phyllichthys sclerolepis*													*																	
Tetradontidae	*Chelonodon patoca*																											*			

WET SEASON – MARCH 1999

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW
PHYLUM PORIFERA								
	Sponge	*	*	*		*	*	*
PHYLUM CNIDARIA								
Class Hydrozoa								
Bougainvilliidae	*Bougainvillia balei*				*			
Pennariidae	*Pennaria disticha*				*			
Eudendriidae	*Eudendrium cf. pennycuikae*							*
	Eudendrium kirkpatricki				*			*
	Eudendrium sp						*	*
Lafoeidae	*Hebella muscensis*				*			*
Haleciidae	*Halecium* sp				*		*	*
Aglaopheniidae	*Aglaophenia delicatula*						*	*
	Gymnangium longicorne			*				
	Macrorhynchia philippina			*	*		*	*
	Macrorhynchia phoenicia				*			*
Halopteriidae	*Halopteris polymorpha*							*
	Halopteris sp.				*			
Sertulariidae	*Idiellana pristis*				*		*	
	Salacia trigonostoma				*			
	Sertularella decipiens				*			
	Sertularella diaphana				*			
Syntheciidae	*Synthecium orthogonium*				*			
Campanulariidae	*Clytia cf. warreni*				*			
	Clytia linearis				*			
Class Anthozoa								
Clavulariidae	*Carijoa* sp.				*		*	*
Melithaeidae	*Acabaria* sp. 2				*			
	Acabaria sp. 3						*	
	Acabaria sp. 4				*			
	Acabaria sp. 5				*			
	Acabaria sp. 6				*			
	Clathraria sp. 1				*			
	Clathraria sp. 2				*			
	Mopsella sp. 1				*			
Plexauridae	*Echinogorgia* sp. 1				*			
PHYLUM NEMERTEA								

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW
	Nemertean						*	*
PHYLUM NEMATODA								
	Nematodes						*	
PHYLUM ANNELIDA								
CLASS POLYCHAETA								
Ampharetidae		*			*		*	*
Amphinomidae					*		*	
	Eurythoe complanata				*			
Aphroditidae					*			
	Laetmonice mollucana				*			
Capitellidae			*	*	*		*	*
Chrysopetalidae		*	*	*	*		*	*
	Bhawania ambonensis		*	*	*		*	*
	Chrysopetalum sp.1	*	*	*	*		*	*
Cirratulidae			*	*	*		*	*
Dorvilleidae			*		*	*	*	*
	Dorvillea sp. 1		*		*		*	
	Ophryotrocha sp. 1					*		
Eunicidae		*	*	*	*		*	*
	Eunice (Palola) siciliensis		*	*	*		*	*
	Eunice cf. aequabilis			*				
	Eunice antennata		*	*	*		*	*
	Eunice tubifex		*	*	*		*	*
	Lysidice collaris	*	*	*	*		*	*
	Nematonereis unicornis		*		*		*	*
Euphrosinidae					*		*	*
	Euphrosine sp. 1				*		*	*
Flabelligeridae		*	*		*		*	
	Pherusa parmata	*	*		*		*	
Hesionidae			*	*	*		*	*
Lumbrineridae			*	*	*	*	*	*
	Lumbrinereis cf. coccinea			*	*		*	*
	Lumbrinereis cf. tetraura						*	
Oenonidae			*		*		*	*
	Oenone fulgida						*	
Maldanidae			*		*			
Nereididae		*	*	*	*	*	*	*
Onuphidae			*	*	*		*	
Opheliidae							*	*
Phyllodocidae			*	*	*		*	*

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW
Polynoidae			*	*	*		*	*
	Harmothoe dictyphora		*		*		*	*
	Harmothoe sp. 2				*			
	Lepidonotus carinulatis		*	*	*		*	*
	Lepidonotus cristatus							*
	Lepidonotus glaucus				*		*	*
	Lepidonotus yorkianus			*			*	
Sabellariidae		*	*		*		*	*
	Sabellaria sp.	*	*	*	*		*	*
Sabellidae		*	*	*	*		*	*
	Brachiomma nigromaculata	*	*	*			*	*
	Demonax cf.pallidus	*		*	*		*	*
	Demonax sp. 3		*		*		*	*
	Megalomma monopthalma		*	*				
	Perkinsiana sp. 1				*		*	
	Perkinsiana sp. 2				*			
	Potamethus sp.1		*		*		*	*
	Pseudobranchiomma emersoni		*		*		*	*
	Pseudobranchiomma orientalis		*		*		*	*
	Pseudobranchiomma sp. 1			*	*			
	Pseudopotamilla laciniosa				*		*	*
	Sabella sp. 1	*			*			
	Sabellastarte indica			*				
	Sabellid genus ?						*	
Serpulidae		*	*	*	*	*	*	*
	Ficopomatus ushakovi		*	*			*	*
	Hydroides albiceps				*		*	
	Hydroides cf. externispina				*		*	
	Hydroides elegans					*	*	
	Hydroides malleolaspina		*		*		*	
	Hydroides recta				*		*	
	Hydroides sp. 2			*			*	
	Hydroides tambalagamensis				*			*
	Hydroides trivesiculosus		*	*	*		*	*
	Hydroides tuberculata				*		*	
	Pomatoleios kraussi				*		*	
	Pomatostegus stellatus		*		*		*	*
	Serpula cf. vermicularis			*	*		*	*
	Spirobranchus coronatus		*					
	Vermiliopsis infundibulum/glandigera sp group		*		*			

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW
Spionidae			*		*		*	*
	Polydora cf *socialis*		*		*		*	*
	Pseudopolydora cf. glandulosa		*					
	Pseudopolydora cf. kempi		*		*			
	Polydora hoplura						*	
	Polydora woodwicki		*		*			
	Polydora pilocollaris				*		*	
	Polydora cf. pilocolaris				*			
Spirorbidae			*		*		*	
Syllidae		*	*	*	*	*	*	*
Terebellidae		*	*	*	*		*	*
PHYLUM MOLLUSCA								
Class Polyplacophora								
Chitonidae	*Acanthopleura gemmata*						*	
Class Gastropoda								
Lottiidae	*Patelloida cryptalirata*		*	*				
Fissurellidae	*Clypidina* sp. 1			*				*
	Diodora jukesii		*	*				
	Diodora ticaonica				*		*	
Trochidae	*Euchelus atratus*				*			
	Euchelus cf. foveolatus				*			
Cerithiidae	*Bittium zebrum*			*				
	Clypeomorus sp.	*						
Dialidae	*Diala semistriata*		*					
	Diala sp. 3			*				
Planaxidae	*Fossarus* sp. 1				*			
Littorinidae	*Littoraria articulata*				*			
	Peasiella tantilla		*	*	*		*	*
Rissoidae	*Alvania* sp. 1		*		*			*
	Merelina sp. 1		*	*				
	Merelina sp. 2	*						
	Merelina sp. 3	*	*					
Vitrinellidae	*Circulus cingulifera*		*					
Velutinidae	*Lamellaria* sp. 1							*
Triphoridae	*Mastonia* sp. 1		*	*	*		*	*
	Notosinister sp. 1		*		*		*	
Cerithiopsidae	*Cerithiopsis* sp. 1	*	*					
	Cerithiopsis sp. 3							*
Epitoniidae	*Epitonium cf. jukesianum*		*		*		*	

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW
	Epitonium sp.		*					
Eulimidae	*Sticteulima cf. cameroni*				*			
Columbellidae	*Cotonopsis* sp. 1				*			*
	Macrozafra sp. 1		*		*		*	*
	Mitrella abyssicola		*				*	
	Mitrella sp. 1		*		*		*	
	Mitrella venulata	*	*		*		*	*
	Zafra sp. 1		*	*	*		*	*
	Zafra sp. 2		*		*		*	
	Zafra troglodytes		*	*	*		*	*
Nassariidae	*Nassarius bicallosus*			*				
	Nassarius celebensis		*	*				
	Nassarius concinnus						*	
	Nassarius crematus				*		*	
	Nassarius dorsatus		*		*			
	Nassarius pauperus		*					
	Nassarius sinusigerus			*				
Cystiscidae	*Euliginella angasi*				*		*	*
Pyramidellidae	*Chrysallida tribulationis*		*		*			*
	Odostomia aff. stearnsiella				*			
	Odostomia sp. 1							*
	Odostomia sp. 2				*		*	*
	Tiberia sp. 1						*	*
	Turbonilla sp. 1	*			*			*
Amathinidae	*Amathina tricarinata*		*				*	*
Ringiculidae	*Ringicula* sp. 1		*					
Haminoeidae	*Atys semistriatus*		*	*				
Dendrodoridae	*Dendrodoris sp.*		*					
Tritoniidae	*Tritonia* sp.1				*		*	
Dotidae	*Doto* sp. 1						*	
Class Bivalvia								
Mytilidae	*Botula silicula*		*		*		*	
	Brachidontes maritimus		*		*		*	
	Lithophaga malaccana		*	*	*		*	*
	Lithophaga teres	*						
	Modiolus sp. 1		*	*			*	
	Musculus cumingianus	*	*					*
	Musculus miranda	*	*	*	*		*	*
	Rhomboidella malaccana	*	*					

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW
Arcidae	*Arca avellana*	*	*	*	*		*	*
	Arca navicularis		*	*	*			*
	Arcopsis afra				*			*
	Barbatia amygdalumtostum	*			*			
	Barbatia cf. foliata			*	*			
	Barbatia sp. 1				*			
	Sheldonella venustopsis		*	*	*			
Pteriidae	*Electroma physoides*				*			
	Pinctada maxima		*	*	*		*	
	Pteria cf. lata				*			
Malleidae	*Vulsella vulsella*				*		*	*
Isognomonidae	*Isognomon ephippium*						*	
	Isognomon isognomon	*	*				*	
	Isognomon legumen	*	*	*	*		*	*
Limidae	*Limaria fragilis*				*			
	Limaria sp.		*					
	Limaria sp. 1				*			
Gryphaeidae	*Parahyotissa numisma*			*	*			
Ostreidae	*Booneostrea cucullina*		*		*		*	
	Dendostrea folium		*					
	Saccostrea cf. dactylena	*	*	*	*		*	*
	Striostrea mytiloides		*	*	*		*	*
Plicatulidae	*Plicatula australis*		*					
Pectinidae	*Annachlamys flabellata*							*
	Chlamys curtisiana				*		*	
Chamidae	*Chama fibula*	*	*	*	*		*	*
	Chama lazarus				*			
	Chama pacifica		*					
Galeommatidae	*Borniola* sp. 1	*	*		*		*	*
	Borniola sp. 2						*	
	Kellia cf. physema				*			
	Lasaea sp. 1				*			
	Montacuta sp. 1			*				
Carditidae	*Cardita muricata*							*
Cardiidae	*Vasticardium vertebratum*	*						
Veneridae	*Irus irus*		*		*		*	*
	Pitar bullata		*					
Myidae	*Cryptomya* sp. 1	*	*	*	*		*	*
Dreissenidae	*Mytilopsis sallei*		*				*	

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW
Pholadidae	*Martesia striata*						*	
PHYLUM BRYOZOA								
	Bryozoans	*	*		*	*	*	*
PHYLUM BRACHIOPODA								
Class Inarticulata								
Discinidae	*Discinisca striata*	*	*		*		*	
PHYLUM ECHINODERMATA								
Class Holothuroidea								
	Holothurians	*		*			*	
Class Ophiuroidea								
	Ophiuroids	*	*	*	*		*	*
Class Crinoidea								
	Crinoids				*			*
PHYLUM Crustacea								
Class Maxillopoda								
Archaeobalanidae	*Acasta* sp.	*				*	*	*
	Armatobalanus quadrivittatus			*	*	*	*	*
	Armatobalanus terebratus						*	*
	Chirona amaryllis			*	*	*	*	
	Chirona tenuis					*		
Balanidae	*Balanus amphitrite*	*			*	*		
	Balanus ?amphitrite	*	*		*	*		
	Balanus ?cirratus/reticulatus							
	Balanus cirratus	*				*		
Iblidae	*Ibla cumingi*					*		
Tetraclitidae	*Tetraclita squamosa*				*	*		
	Tetraclitella ?cf multicostata					*		
Class Ostracoda								
	Ostracoda	*	*			*	*	*
Class Malacostraca								
	Leptostraca	*				*	*	*
	Tanaidacea	*	*			*	*	*
	Mysdiacea		*			*	*	*
	Amphipoda	*	*	*	*	*	*	*
	Isopoda	*	*		*	*	*	*
Order Deapoda								
Infraorder Caridea								
Alpheidae	Alpheidae	*	*			*	*	*
	Alpheus sp.		*			*	*	
	Athanas sp.					*		

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW
	Synalpheus sp.	*				*	*	*
	? Synalpheus sp.					*		
Hippolytidae	Hippolytidae					*	*	
	Latreutes sp.					*		
	Leandrites celebensis					*	*	
	Lysmata sp.						*	
	Thor sp.					*		*
Palaemonidea	Palaemonidea					*		
Penaeidae	Penaeidae						*	
Pontoniinae	*? Palaemonella* sp.					*		*
	Palaemonella sp.					*		*
	Palaemonella rotumana	*				*	*	*
	Palaemonella rotumana ?					*		
	Periclimenes sp.	*	*			*	*	*
	? Periclimenes sp.					*	*	
	Periclimenes obscurus					*		*
	Periclimenes obscurus ?					*		
Sergestidae	Sergestidae	*				*		
Infraorder Thalassinidea								
Thalassinidae	Thalassinidae						*	
Upogebiidae	Upogebiidae	*					*	
Infraorder Anomura								
Porcellanidae	*Aliaporcellana pygmaea*	*				*	*	*
	Enosteoides ornatus					*	*	*
	Lissoporcellana (?) spinuligera							*
	Petrolisthes kranjiensis					*		
	Pisidia cf. gordoni	*		*		*	*	*
	Pisidia dispar						*	
	Polyonyx biunguiculatus	*				*	*	*
Galatheidae	Galatheidae					*	*	*
	Galathea (?) aegyptiaca					*	*	*
Infraorder Brachyura								
Dromiidae	*Cryptodromia sp.*					*	*	*
Majidae	*Hyastenus* sp. 1 *(cf. H. ambonensis)*						*	
	Hyastenus sp. 2 *(cf. H. bispinosis)*					*	*	
	Hyastenus sp. 3					*	*	
	Schizophrys rufescens					*	*	
Hymenosomatidae	*Elamena ?* sp. nov.	*	*			*	*	

HIGHER TAXA	STATIONS ----> SPECIES	EP	CBM	CBMO	IOB	FM	FHW	SHW
	Neorhynchoplax minima					*	*	*
Portunidae	*Thalamita* sp.	*						
Xanthidae	*? Novactaea* sp. nov.						*	
	Chlorodiella nigra			*				
	Gaillardiellus rueppelli						*	
	Paratergatis longimanus					*		
Pilumnidae	*Glabropilumnus seminudus*					*	*	
	Heteropanope glabra					*		
	Pilumnus minutus	*				*	*	*
	Pilumnus sp. nov.	*	*	*		*	*	*
	Serenepilumnus (?) leopoldi						*	
	Viaderiana (?) striatus					*	*	
Grapsidae	*Metopograpsus frontalis*					*		
	Metopograpsus sp. juveniles	*	*			*		
	Pachygrapsus minutus		*					
	Plagusia depressa tuberculata		*					
Ocypodidae	*Baruna* sp. nov.		*			*		
Pinnotheridae	*Pinnotheres* sp.						*	
PHYLUM CHORDATA								
Class Ascidiacea								
	Ascidians	*	*	*		*	*	*
Class Osteichthyes								
Serranidae	*Epinephelus coioides*						*	
Blenniidae	*Omobranchus ferox*		*					

LOCAL ASSISTANCE NEEDED FOR MARINE PESTS SURVEY

A joint operation between the Department of Transport and Works Marine Branch (T&W), the CSIRO's Centre for Research on Introduced Marine Pests (CRIMP) and the Museum and Art Gallery of the Northern Territory to undertake a baseline study of the Port of Darwin for introduced marine pests, gets underway this week (Friday 14 August to Friday 21 August).

The survey, which is being funded by T&W will also use the resources of the local community which is being asked to report sightings of any strange or unusual marine animals and plants.

The Port of Darwin survey is part of a national strategy involving major Australian ports aimed at providing baseline data for assessing the scale of the introduced marine species problem and controlling the spread of pests between ports. The strategy was developed by the Association of Australian Ports and Marine Authorities (AAPMA) and CRIMP, and supported by the Australian Ballast Water Management Advisory Council. Darwin is the first N.T. port to be surveyed under this program.

Over 100 exotic species have been identified in Australian waters including toxic dinoflagellates, the giant fanworm, northern Pacific seastar, European shore crab and the Japanese seaweed Undaria. Ballast water and ship's hulls are believed to be major vectors for the introduction of marine pests to Australia.

As far as possible the survey will target exotic pest species, and will involve the collection of a wide range of marine invertebrates, fish and plants, using a variety of sampling techniques including sediment coring, video, trapping and netting, and hand catching.

To gain a head start with the survey the leader of the CRIMP survey team Dr Chad Hewitt has appealed to any members of the public who have seen unusual marine organisms (animals or plants) in the Harbour to contact the Museum and Art Gallery of the N.T. (ph: 89 998201) and give location details so these sightings can be investigated while the team is in Darwin.

"We want to hear from fishermen, divers, beachcombers, surfers, schoolchildren - anybody who thinks they might know of the whereabouts of exotic species. We don't need samples, just where they saw it and how recently - even the most sketchy details could help us a great deal", Dr Hewitt said.

For further information contact: Dr Barry Russell - MAGNT Darwin (08) 899 98209, Mr Richard Martin - CRIMP Hobart (03) 6232 5371, Dr Chad Hewitt - CRIMP Hobart 041 8370342, Darwin (14 - 21 August) 014 862 739.

SHIPPING INFORMATION PROFORMA

A. VISITING VESSELS

1 Origin of vessel entering the port
- 1.1 international
  - 1.1.1 last international port
  - 1.1.2 last port of call (if any) within Australia
- 1.2 domestic
  - 1.2.1 last port of call
  - 1.2.2 other ports visited

2 Frequency of visits
- 2.1 regular service
  - 2.1.1 frequency
  - 2.1.2 duration of service
- 2.2 occasional visits
  - 2.2.1 frequency
  - 2.2.2 over what period

3 Ballasting
- 3.1 vessel in ballast during voyage to port
- 3.2 port where ballast loaded
- 3.3 ballast water exchanged at sea
- 3.4 reballasting in or near port
  - 3.4.1 ballast water discharged; estimated volume discharged
    - at berth
    - within port (not at berth)
    - outside port
  - 3.4.2 ballast water loaded; estimated volume loaded
    - at berth
    - within port
    - outside port
    - no reballasting in or near port

4 Hull condition
- 4.1 level and type of fouling
- 4.2 date when last slipped and cleaned
- 4.3 port where last slipped and cleaned

5 Location (berth) in port

6 Turn round time
- 6.1 average turn round time
- 6.2 maximum time in port

B. VESSELS IN PORT FOR EXTENDED PERIODS (DREDGES, BARGES ETC.)

1 Type/name of vessel

2 Previous location
- 2.1 name of port
- 2.2 duration of stay in that port

3 Duration of stay in port

4 Location (berth or area of operation) in port

5 Destination (if departed)

6 Hull condition
- 6.1 on arrival
  - 6.1.1 level and type of fouling
  - 6.1.2 date when last slipped and cleaned
  - 6.1.3 not cleaned
- 6.2 at departure
  - 6.2.1 level and type of fouling
  - 6.2.2 date when last slipped and cleaned
  - 6.2.3 not cleaned