Report on Port Kembla
Introduced Marine Pest Species Survey

D.A. Pollard and R.L. Pethebridge

NSW Fisheries Office of Conservation
Cronulla Fisheries Centre
P.O. Box 21, Cronulla, NSW 2230
Australia

Report to Port Kembla Port Corporation
December 2002

PORT KEMBLA
PORT CORPORATION

NSW FISHERIES

NSW Fisheries Final Report Series
No. 41
ISSN 1440-3544

Report on Port Kembla
Introduced Marine Pest Species Survey

D.A. Pollard and R.L. Pethebridge

NSW Fisheries Office of Conservation
Cronulla Fisheries Centre
PO Box 21, Cronulla, NSW 2230
Australia

Report to Port Kembla Port Corporation

December 2002

NSW Fisheries Final Report Series
No. 41
ISSN 1440-3544

PREFACE

A prerequisite for any attempt to control the spread by shipping of introduced marine pest species in Australian waters is a knowledge of the current distribution and abundance of exotic species in Australian ports. However, until very recently this information base had been lacking for most of these ports. An Australian port survey program was therefore commenced as a joint initiative of the Australian Association of Port and Marine Authorities (AAPMA), the CSIRO's Centre for Research on Introduced Marine Pests (CRIMP), and a variety of individual state and territory agencies. This program is supported by the Australian Ballast Water Management Advisory Council (ABWMAC), and seeks to redress the lack of knowledge about the occurrence of exotic species in Australian ports in order to provide a consistent basis on which the introduced species status of individual ports can be assessed.

Port surveys designed to identify all exotic species present will inevitably be subject to scientific, logistic and cost constraints that will limit both their taxonomic and spatial scope. Recognition of these constraints has led to the adoption of a targeted approach, which concentrates on a known group of introduced and potentially invasive species and provides a cost-effective approach to the collection of baseline data for all ports studied. These surveys are designed to determine the distributions and abundances of a range of target species in each port. These species are listed in Appendix 1, and comprise: those species listed on the ABWMAC schedule of target 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 and pose a threat to Australian ports; and those known exotic species present in Australian waters that currently are not assigned pest status.

These targeted surveys will also identify species of uncertain status (endemic or introduced) that are abundant in a port and/or are likely to become major pest species. Where appropriate, a component of the port survey may include a local public awareness program designed to collect any available information that might indicate the presence of introduced species in the port and adjacent areas, the approximate dates of any introductions, and their potential impacts on native marine communities.

This report details the results in relation to the search for targeted ABWMAC pest species during an introduced species survey of Port Kembla, New South Wales, carried out between 8 and 18 May 2000. This survey was undertaken as part of the broader AAPMA/CRIMP port survey initiative by staff of NSW Fisheries assisted by CRIMP staff. The Port Kembla Port Corporation funded the survey and the preparation of this report, with assistance from the Maritime Assets Division of the NSW Waterways Authority and significant in-kind contributions from NSW Fisheries.

TABLE OF CONTENTS

PREFACE ..... **I**

TABLE OF CONTENTS ..... **II**

LIST OF TABLES ..... **IV**

LIST OF FIGURES ..... **IV**

ACKNOWLEDGMENTS ..... **V**

EXECUTIVE SUMMARY ..... **VI**

1. DESCRIPTION OF THE PORT **1**
1.1. General features *1*
1.2. Port developments *2*
1.3. Shipping movements *4*

2. REVIEW OF EXISTING BIOLOGICAL INFORMATION **5**

3. SURVEY METHODS **7**
3.1. Sampling strategy *7*
3.2. Sampling methods *7*

4. SURVEY RESULTS AND DISCUSSION **11**
4.1. Port environment *11*
4.2. Marine floral and faunal taxa found during the port survey *11*
4.2.1. Dinoflagellates 11
4.2.2. Macroalgae *16*
4.2.3. Poriferans 19
4.2.4. Hydrozoans 20
4.2.5. Anthozoans 22
4.2.6. Polychaetes 23
4.2.7. Other worms 25
4.2.8 Crustaceans 27
4.2.8.1. Cirripedes 27
4.2.8.2. Malacostracans 29
4.2.9. Molluscs 34
4.2.10. Bryozoans 38
4.2.11. Echinoderms 42
4.2.12. Chordates 42
4.2.12.1. Ascidians 42
4.2.12.2. Fishes 44
4.3. Environmental data recorded during the port survey *47*

5. POTENTIAL IMPACTS OF INTRODUCED SPECIES FOUND IN THE PORT **48**
5.1. Species found in Port Kembla *48*
5.2. Comparisons with other NSW ports *49*

6. ORIGINS OF AND POSSIBLE VECTORS FOR THE INTRODUCTION OF EXOTIC SPECIES FOUND IN THE PORT **52**

7. EFFECT OF THE PORT ENVIRONMENT AND PORT PRACTICES ON COLONISATION AND SURVIVAL OF INTRODUCED SPECIES **53**

8. ASSESSMENT OF THE RISK OF NEW INTRODUCTIONS TO THE PORT **53**

9. ASSESSMENT OF THE RISK OF TRANSLOCATION OF INTRODUCED SPECIES FOUND IN THE PORT **54**

10. RECOMMENDATIONS **54**
10.1. Management and monitoring of existing introduced species in the port *54*
10.2. Prevention of new introductions to the port *55*

11. REFERENCES **56**

APPENDICES **60**

APPENDIX 1. SCHEDULE OF INTRODUCED SPECIES **60**

APPENDIX 2. SAMPLING PROCEDURES **63**

APPENDIX 3. BALLAST WATER ACTIVITY AT THE BERTHS IN PORT KEMBLA **67**

APPENDIX 4. CODE OF PRACTICE FOR IN-WATER HULL CLEANING AND MAINTENANCE **69**

LIST OF TABLES

Table 1.2:	Summary of foreshore and port-related developments at Port Kembla.	2
Table 1.3:	Shipping movements to and from Port Kembla between 1 May 1999 and 30 April 2000.	4
Table 3.1:	Summary of sampling methods used, habitats sampled and target taxa, Port Kembla survey, May 2000.	8
Table 3.2:	Summary of the distribution of sampling methods used within sampling sites, Port Kembla survey, May 2000.	10
Table 4.2.1.1:	Dinoflagellate cysts collected from Port Kembla.	13
Table 4.2.1.2:	Phytoplankton collected from Port Kembla.	14
Table 4.2.2:	Macroalgal and seagrass flora collected from Port Kembla.	17
Table 4.2.3:	Poriferan fauna collected from Port Kembla.	19
Table 4.2.4:	Hydrozoan fauna collected from Port Kembla.	21
Table 4.2.5:	Anthozoan fauna collected from Port Kembla.	22
Table 4.2.6:	Polychaete fauna collected from Port Kembla.	25
Table 4.2.7:	"Other worm" fauna collected from Port Kembla.	27
Table 4.2.8.1:	Cirripede fauna collected from Port Kembla.	28
Table 4.2.8.2:	Malacostracan fauna collected from Port Kembla.	32
Table 4.2.9:	Molluscan fauna collected from Port Kembla.	36
Table 4.2.10:	Bryozoan fauna collected from Port Kembla.	41
Table 4.2.11:	Echinoderm fauna collected from Port Kembla.	42
Table 4.2.12.1:	Ascidian fauna collected from Port Kembla.	44
Table 4.2.12.2:	Fish fauna collected from Port Kembla.	46
Table 4.3:	Environmental data recorded from Port Kembla.	47
Table 5.1:	List of ABWMAC target marine pest species and other introduced and cryptogenic species collected from Port Kembla in May 2000.	50
Table 5.2:	List of ABWMAC target marine pest species and other introduced and cryptogenic species collected during NSW port surveys from the ports of Eden, Port Kembla, Botany Bay and Newcastle (listed south to north).	51

LIST OF FIGURES

Figure 3.2: Sampling sites in and around Port Kembla mentioned in the text. 9

ACKNOWLEDGMENTS

The authors wish to thank the many specialist taxonomists who identified or confirmed the identifications of the numerous marine plant and animal samples collected. These included: Dinoflagellates: Dr S. Brett and Dr D. Hill (Microalgal Services, Melbourne); Macroalgae: Dr A. Millar (Royal Botanic Gardens, Sydney); Poriferans: Dr P. Bergquist (University of Auckland, New Zealand); Hydrozoans: Dr J. Watson (Hydrozoan Research Laboratory, Melbourne); Anthozoans: Dr P. Harrison (Southern Cross University, Lismore, NSW); Polychaetes: Dr P. O'Donnell (The Ecology Lab, Brookvale, NSW); Other Worms: Dr L. Newman (Southern Cross University, Lismore, NSW); Cirripedes: Dr D. Jones (Western Australian Museum, Perth); Malacostracans: Dr G. Poore (Museum of Victoria, Melbourne); Molluscs: Mr J. Pogonoski (Australian Museum, Sydney); Bryozoans: Dr R. Nair (Anmika Enterprises, Wentworthville, NSW); Echinoderms: Mr J. Pogonoski (Australian Museum, Sydney); Ascidians: Ms K. Moore (Hobart, Tasmania); and Fishes: Mr M. Lockett (University of Technology, Sydney).

Numerous NSW Fisheries and CRIMP (CSIRO) divers and other field staff are thanked for their assistance with the survey fieldwork, which was supervised by Dr D. Pollard of NSW Fisheries and Dr C. Hewitt of CSIRO Marine Laboratories. Divers from CRIMP included Chad Hewitt, Britta Schaffelke, Alice Morris, Nicole Murphy and Jeff Ross. Divers from NSW Fisheries included Jim Craig, Will Macbeth, Bruce Pease, Brett Rankin, Marcus Miller, David Barker and Marnie Tanner. Michael Mulligan (Geraldton Port Corporation, WA) and Matthew Lockett (University of Technology, Sydney) also assisted with the diving operations. Brett Rankin of NSW Fisheries and Marnie Campbell of CRIMP assisted with the organisation of the field operations. Anisul Afsar (Marine Science Centre, University of NSW) carried out the initial sorting of samples to the level of phylum or class. John Matthews of NSW Fisheries is thanked for his help in preparing the site locality map, and Brett Rankin, also of NSW Fisheries, for the cover photograph. Bob Creese and Bruce Pease of NSW Fisheries are thanked for their constructive criticisms of the draft manuscript.

Several people from the Port Kembla Port Corporation provided most helpful assistance with this survey: Captain Bill Hoogendoorn and Mr Rod Thompson provided valuable information in relation to shipping movements and port operations, and Jim Robinson, Paul Bowmaker and Paul Reeves are thanked for their valuable assistance during the field operations.

EXECUTIVE SUMMARY

A survey for introduced marine species at Port Kembla was carried out in the port area and around the adjacent ocean coastline between 8 and 18 May 2000. This survey focused on habitats that were likely to be colonised by introduced species and generally followed the sampling protocols developed for the National Australian Ports Surveys by the CSIRO's Centre for Research on Introduced Marine Pests (CRIMP).

Previous known introductions to Port Kembla included the toxic dinoflagellate *Alexandrium* sp. and two fish species, the yellowfin goby *Acanthogobius flavimanus* and the striped goby *Tridentiger trigonocephalus.* *Alexandrium* spp. and *Tridentiger trigonocephalus* were again collected during the present survey.

Two species of toxic dinoflagellates, *Alexandrium* sp. *(catenella* type) and *Alexandrium ostenfeldii/peruvianum,* were the only Australian Ballast Water Management Advisory Council (ABWMAC) listed target introduced marine pest species collected during the present survey. This genus of dinoflagellates, which generally occurs encysted in bottom sediments, has commonly been recorded from a number of coastal bays and estuaries (mainly ports) in south-eastern Australia. Blooms of such dinoflagellates in the water column produce neurotoxins, which may not only cause fish kills, but can also accumulate in shellfish and, being toxic to humans, may therefore affect oyster growing and other aquaculture industries (though no such industries are present in or around Port Kembla). *Alexandrium* cysts, however, were not found to be abundant in Port Kembla, and no toxic dinoflagellate blooms have previously been recorded there.

Apart from the above two dinoflagellates, a total of 47 other introduced (33) and cryptogenic (i.e. of unknown origin) (14) species were also recorded from the port during the present survey. These other introduced species are generally recognised as having been transferred to Australia in both historic and modern times, most probably via ships' ballast water discharge and/or hull fouling. None of them are listed as 'pest species' which are known to pose any significant economic or environmental threats in this area.

The additional 33 introduced species found in Port Kembla comprised:

- 1 species of hydrozoan *(Halecium delicatulum)*,
- 4 species of polychaetes *(Boccardia chilensis, Boccardia proboscidea, Hydroides dirampha* and *Hydroides ezoensis),*
- 8 species of crustaceans *(Megabalanus rosa, Cirolana harfordi, Paracerceis sculpta, Sphaeroma walkeri, Corophium acutum, Paradexamine pacifica, Liljeborgia c.f. dellavallei* and *Elasmopus rapax)*,
- 15 species of bryozoans *(Amathia* sp., *Bowerbankia* sp.*, Bugula dentata, Bugula flabellata, Bugula neritina, Bugula stolonifera, Cryptosula pallasiana, Schizoporella errata, Schizoporella* sp. A*, Schizoporella* sp. B*, Schizoporella* sp. C*, Schizoporella unicornis, Tricellaria occidentalis, Watersipora arcuata* and *Watersipora subtorquata)*,
- 3 species of ascidians *(Styela plicata, Botryllus schlosseri* and *Ciona intestinalis),* and
- 2 species of fishes *(Tridentiger trigonocephalus* and *Acentrogobius pflaumi).*

The 14 cryptogenic species found comprised:

- 1 species of alga *(Caulerpa filiformis),*
- 4 species of hydrozoans *(Bougainvillia macloviana, Sarsia eximia, Clytia* sp. and *Clytia hemisphaerica),*
- 1 species of anthozoan *(Culicia c.f. tenella)*
- 1 species of polyclad flatworm (Enatiid sp.1),

- 5 species of crustaceans *(Balanus amphitrite, Megabalanus tintinnabulum, Megabalnus zebra, Caprella equilibra* and *Stenothoe valida),*
- 1 species of mollusc *(Mytilus galloprovincialis),* and
- 1 species of bryozoan *(Calyptotheca* sp*.).*

Overall, and apart from the two toxic dinoflagellates *(Alexandrium* spp.) identified, Port Kembla would appear to be otherwise free of ABWMAC listed target introduced marine pest species. It is recommended that the occurrence of *Alexandrium* be periodically monitored in both the water column and sediments of the port.

The data collected during this survey provide the information necessary to fulfil the requirements of the Australian Quarantine Inspection Service's (AQIS) Decision Support System in relation to the need or otherwise for future ballast water controls on shipping using this port.

1. DESCRIPTION OF THE PORT

1.1. General features

Port Kembla is a large man-made harbour located on the south coast of New South Wales about 85 kilometres by road to the south of Sydney. It is situated on the coastal plain immediately eastward of the rugged Illawarra Escarpment, just south of the city of Wollongong, at around latitude 34°28' south and longitude 150°54' east (Macdonald *et al.* 1978).

The port was initially built to cater for ships servicing the local coal mines, which are situated nearby. The first jetty was built just north of Red Point, which was named by Lieutenant James Cook in 1770. The following entry, from the logbook of his ship the *Endeavour*, describes Red Point as follows: "There lies a point which, from the colour of lands about it, I called Red Point and a little way inland stands a round hill, the top of which looks like the crown of a hat" (Hoogendoorn 1999). Later, in 1796, the explorers George Bass and Mathew Flinders landed in the lagoon adjacent to Red Point. They named this lagoon Tom Thumb Lagoon after their boat. This later became the site for the Inner Harbour. In 1883 the Mount Kembla Coal and Oil Company built a railway from its Mount Kembla mine to the coast. There was no natural harbour, so a jetty was constructed just north of Red Point and the name Port Kembla thus evolved.

Port Kembla was officially proclaimed a port in 1898. Initially, two small breakwaters were constructed to form the Outer Harbour. This area has since been extended to cover about 130 ha (Marine Science & Ecology and Coastal Environmental Consultants Pty Ltd 1992).

In 1960, a second part to the Harbour, the Inner Harbour, was opened. This was a result of the dredging of Tom Thumb Lagoon and its associated swampland. The Inner Harbour is about 60 ha in area and services the BHP steelworks as well as containing coal and grain loading facilities and other wharves. Allans Creek and the Town Drain both drain into the Inner Harbour. Urban and agricultural runoff and industrial wastewaters flow into the harbour via these creeks. However, water quality improvement programs have been carried out since the 1970s (Marine Science & Ecology and Coastal Environmental Consultants Pty Ltd 1992).

Port Kembla now has facilities for large cargo ships, and is currently the second largest coal exporting port in New South Wales. The port also has potential for further expansion and greater diversity. The second largest trade is the import of iron ore and limestone, which is manufactured into iron and steel, and subsequently exported. A third export commodity is grain, of which over 2 million tonnes was exported in 1998. The port's Grain Terminal, in the Inner Harbour, supports this trade. The deepwater Multi-Purpose Berth and the Coal Loading Terminal, both in the Inner Harbour, are also important facilities for accommodating ships for trade purposes. In the Outer Harbour, the No. 6 Jetty has become an important berth for the trade of bulk goods (Anon. 1999). Overall, the port is primarily industrial, supporting several heavy industries. In 1898, 235,000 tonnes of coal were exported from Port Kembla; one hundred years later, 25.6 million tonnes of cargo, including 12.3 million tonnes of coal, were exported (Anon. 1999).

1.2. Port developments

Table 1.2 summarises the major port-related developments that have taken place in and around Port Kembla since its inception.

TABLE 1.2: SUMMARY OF FORESHORE AND PORT-RELATED DEVELOPMENTS AT PORT KEMBLA

Port Development	Date Built	Subsequent Modifications or Notes
Railway Line	1883	Built by the Mount Kembla Coal and Oil Company.
Outer Harbour		
No. 3 (Coal Loading) Jetty	1883	Jetty needed because there was no natural harbour available. Originally built and operated by Mount Kembla Coal and Oil Company. Jetty was 900 feet long.
No. 2 (Coal Loading) Jetty	1887	Originally built and operated by Southern Coal Company. Jetty was 1,400 feet long.
Eastern Breakwater	1901-1987	Constructed to protect the port from storms. Total length 3,750 feet, constructed with 844,631 tons of rock.
No. 4 Jetty	1908	Constructed to meet the needs of the Electrolytic Refining and Smelting Company Ltd. Modified in 1929 and 1999. Now used as a bulk liquids facility. Capable of accommodating vessels up to 60,000 tonnes deadweight.
No. 1 (Coal Loading) Jetty	1912-1915	Wooden jetty 1,343 feet long with a water depth alongside of between 14 and 35 feet. Superseded by the completion of a new Coal Berth in the Inner Harbour in 1964.
Northern Breakwater	1912-1925	Constructed to protect the port from storms; 3,263 feet long.
Small Boat Harbour	1920	Wall constructed close to inner side of the Eastern Breakwater. Needed to transfer people and equipment to and from Public Works launches. A 32 foot opening enabled safe anchorage for small boats and punts. Rebuilt in 1998.
Australian Iron and Steel (No. 2) Jetty	1928	Constructed for the import of iron ore products and the export of steel products. A rail line connects it to the blast furnace; 834 feet long, with a berthing length of 600 feet.
No. 5 (Inflammable Liquids) Berth	1937-1939	Constructed to allow vessels to discharge petroleum products. Upgraded in 1982-83 to accommodate ships up to 30,000 gross tonnes. Since 1988 has been used to import marine fuel.
No. 3 (Low Level) Jetty	1939	Operational until 1983 as a general cargo jetty. Since then, was used to accommodate tugs.
No. 6 Jetty	1958	Constructed as a cargo jetty to handle larger vessels using the port after World War II. Modified in 1991 and 1996. Upgrading to continue to accommodate ships up to 40,000 tonnes deadweight and 200 metres in length. Products include gypsum, cement, steel products, soda ash, coal tar, sodium sulphate, chemicals and plantation logs.
Jack Attwood Memorial Boating Facility	1998	Small boat harbour remodelled to allow for a large boat ramp and to provide moorings for recreational boats.

TABLE 1.2: SUMMARY OF FORESHORE AND PORT-RELATED DEVELOPMENTS AT PORT KEMBLA (continued)

Inner Harbour		
Inner Harbour	1956-1960	Constructed by dredging of Tom Thumb Lagoon to allow for increased shipping in the port.
Repair Berth	1962-1963	Was previously used to carry out repairs. Demolished when the second coal berth was constructed.
No. 1 Coal Berth	1963-1964	Constructed for export of coal and coke. Also occasionally exports slag and sand. Some coal is received from New Zealand to be mixed with local coal and shipped to Asia.
Roll-on Roll-off Berth	1969-1971	Constructed for stern ramp ships to unload or load cargo; 500 feet long and 80 feet wide. Facility became redundant in the mid 1980s, reopened in 1993 and closed again in 1994. Now used as a vessel waiting area only.
No. 2 Products Berth	1969-1971	Built in western part of Inner Harbour for export of steel products from the Hot and Cold Strip Mills.
Deepening of Inner Harbour	1971	Inner Harbour was deepened from 32 feet to 55 feet to allow for movement of large bulk carriers.
No. 2 Bulk Materials Discharge Berth	1974-1975	Built to accommodate the increase of iron ore imports in large bulk carriers.
No. 2 Coal Loader	1978-1982	Constructed to allow for increasing number of bulk carriers, which was possible due to the deepening of the harbour. Loading capacity of 5,000 tonnes per hour into ships of 110,000 to 120,000 tonnes deadweight.
Multi-Purpose Berth	1978-1983	Constructed to replace original repair berth. Also used for loading or discharging any type of cargo; 175 metres long, 26 metres wide. Dolphins at each end allow for larger vessels to berth there. Extended by 125m in 1995-96.
Grain Terminal	1986-1989	Constructed as a cheaper alternative to the Sydney grain terminal. Storage capacity of silos is 260,000 tonnes. Designed to service ships from 10,000 to 120,000 tonnes deadweight. Two ship loaders each carry 2,500 tonnes per hour.
Casting Basin	1987-1999	870,000 cubic metres of earth were excavated for the Sydney Harbour Tunnel Project.
Deepening of Inner Harbour's Eastern Basin	1992	To allow for movement of ships from the coal berth to the grain berth, and allow waiting vessels to berth if the tide was missed by deep draft ships.
Water Treatment Facility	1993	Constructed to reduce the amount of coal being washed into the harbour due to the expansion of coal facilities. The amount of coal being washed into the harbour has been reduced from 400 tonnes to 10 tonnes per year.
ESSO - BHP Oil Platforms	1995-1996	The construction of two oil platforms was carried out using the Casting Basin. These platforms were towed to Bass Strait.

From Anon. (1999) and Hoogendoorn (1999)

1.3. Shipping movements

Table 1.3 summarises shipping movements to and from Port Kembla over the 12 months prior to the period of the fieldwork carried out for this survey (i.e. from 1 May 1999 until 30 April 2000). A total of 629 ship movements occurred during this year. Ships visited the port a total of 41 times from 12 different overseas countries, with the most visits (12) being from Japan. Ships also visited the port from New Zealand 9 times and from Canada 6 times. A total of 181 visits occurred from 27 other Australian ports. The greatest number of ship movements from Australian ports was from Port Hedland (WA), with a total of 37 entries. Ships also visited Port Kembla from Port Latta (Tasmania) 32 times and from Whyalla (SA) 21 times.

A total of 169 ships left Port Kembla destined for 19 different overseas countries, with Japan being the most frequent country of destination (47 times). Other frequent overseas destinations were New Zealand (24 times) and South Korea (23 times). A total of 238 ships left Port Kembla destined for 28 other ports throughout Australia. Westernport (Victoria) was the most frequent destination (89 times). Other frequent Australian destinations were Newcastle (NSW) (32 times) and Hobart (Tasmania) (21 times).

Most of the ships entering and leaving the port were carrying raw materials and manufactured products for import and export. Port Kembla is currently the second largest coal exporting port in New South Wales. The second biggest trade is the import of iron ore and limestone for the manufacture of iron and steel, which is subsequently exported. In 1998, 25.6 million tonnes of cargo were handled, including 12.3 million tonnes of coal. A total of 8.4 million tonnes of raw materials were imported for steel production, with 2.6 million tonnes of steel products being exported. Exports of grain totalled 2.3 million tonnes and exports of coke and coal came to 12.6 million tonnes. Also handled at the port were 155,000 tonnes of bulk liquids and 340,000 tonnes of dry bulk cargoes (Anon. 1999).

The Port Kembla Port Corporation is responsible for the management of shipping operations. This includes the provision of port pilotage, ship scheduling and safe navigation services. The Port Kembla Port Corporation also manages port lands adjacent to the Inner and Outer Harbours, as well as port infrastructure such as wharves and jetties (Anon. 1999).

TABLE 1.3: SHIPPING MOVEMENTS TO AND FROM PORT KEMBLA BETWEEN 1 MAY 1999 AND 30 APRIL 2000

Last International Port of Call		Last Australian Port of Call		Next International Port of Call		Next Australian Port of Call	
Country	**No. Visits**	**Port**	**No. Visits**	**Country**	**No. Visits**	**Port**	**No. Visits**
Japan	12	Port Hedland	37	Japan	47	Westernport	89
New Zealand	9	Port Latta	32	New Zealand	24	Newcastle	32
Canada	6	Whyalla	21	South Korea	23	Hobart	21
China	5	Newcastle	10	China	17	Gladstone	14
India	2	Hobart	9	Singapore	13	Brisbane	13
Taiwan	1	Melbourne	9	North Korea	10	Sydney	12
South Korea	1	Ardrossan	8	Taiwan	10	Melbourne	11
Brazil	1	Brisbane	8	Indonesia	5	Portland	9
Papua New Guinea	1	Westernport	7	Phillipines	5	Geelong	8
Indonesia	1	Sydney	5	Malaysia	3	Burnie	4
Belgium	1	Risdon	5	Papua New Guinea	3	Whyalla	3
USA	1	Adelaide	5	Hong Kong	2	Townsville	3
		Devonport	3	Canada	1	Port Hedland	2
		Portland	3	Thailand	1	Wallaroo	2
		Geelong	3	India	1	Port Lincoln	2
		Gladstone	3	Argentina	1	Devonport	1
		Hay Point	2	Canada	1	Adelaide	1
		Burnie	2	Sudan	1	Lucinda Point	1
		Groote Eylandt	1	USA	1	Bell Bay	1
		Wyndham	1			Kurnell	1
		Thevenard	1			Thevenard	1
		Yarraville	1			Kwinana	1
		Mackay	1			Darwin	1
		Eden	1			Tasmania	1
		Fremantle	1			Fremantle	1
		Jervis Bay	1			Bunbury	1
		Port Stanvac	1			Port Alma	1
						Bell Bay	1
Total	**41**	**Total**	**181**	**Total**	**169**	**Total**	**238**
Overall Total Number of Ship Movements							**629**

Figures provided by R. Thompson, Port Kembla Port Corporation

2. REVIEW OF EXISTING BIOLOGICAL INFORMATION

Many of the marine pest introductions which have so far occurred in Australian ports have been attributed to ballast water, which is discharged from ships arriving from both overseas and other infected Australian ports. When such visiting ships take on cargo, ballast water is often discharged, which can contain numerous organisms originating from those ports visited previously (Carlton 1985). These organisms may settle and reproduce in the new port environment, some of them causing concern in relation to their associated dangers to human health, aquaculture and the aquatic environment in general (Anon. 1998). As well as living in ballast water (and ballast sediments), foreign organisms also often grow on ships' hulls, and if the hulls are cleaned while in port, these introduced marine organisms also have the potential to settle there and become pests.

Very few studies have previously been undertaken specifically on the flora and fauna of the Port Kembla region.

In 1977 a survey was carried out by Marine Science & Ecology (1978) of the marine biota in Port Kembla Harbour. The results of this survey determined that the lower reaches of Allans Creek and most harbour structures were depauperate in benthic organisms.

In 1982 Moran and Grant (1993) carried out a study to determine the effects of polluted water on the settlement of the larvae of four fouling organisms in Port Kembla. These organisms included four bryozoans, *Bugula avicularia, Bugula neritina, Watersipora arcuata* and *Tricellaria porteri*, and a sepulid worm, *Galeolaria caespitosa*. Results indicated that the settlement of larvae of *Bugula neritina* and *Tricellaria porteri* was reduced, while the settlement of *Watersipora arcuata* and *Galeolaria caespitosa* larvae was not affected by the pollution.

A general review of introduced organisms present in Australian marine waters was presented by Pollard and Hutchings (1990a,b). Pollard and Hutchings (1990a) stated that the yellowfin goby *(Acanthogobius flavimanus)* probably arrived in various Australian ports, including Port Kembla, in ballast water from Japanese ships. This report also noted that the striped goby *(Tridentiger trigonocephalus)* was abundant in Port Kembla, having been identified from fish samples collected under a coal loader berth. This latter fish species probably also arrived in Australian waters via the ballast water of ships from Japan.

Jones (1991) also reviewed marine organisms which had been transported to Australia in ships' ballast water. This report again mentioned both the yellowfin goby and the striped goby as occurring in Port Kembla.

An environmental study was carried out in 1991 for BHP Steel Slab and Plate Products Division (Marine Science & Ecology and Coastal Environmental Consultants Pty Ltd 1992). This study was undertaken in order to assess the physical processes and biological ecosystem present in the harbour. The biological component of the study was focused on the Inner Harbour, from which 87 fish species from 51 families, as well as large numbers of invertebrates belonging to only a few species, particularly polychaetes, were recorded. The introduced striped goby *Tridentiger trigonocephalus* was again recorded during that survey. Sampling was also carried out for microscopic organisms (plankton) in the water column. Overall, the conclusion from that study was that the biological communities in the harbours at Port Kembla were typically estuarine, with a reduced diversity of species.

In 1993 a survey was carried out by the Ecology Lab Pty Ltd to determine if toxic dinoflagellates were present in Port Jackson, Botany Bay and Port Kembla. However, no toxic dinoflagellates

were detected in the samples collected from six sites in Port Kembla during this study (Ecology Lab Pty Ltd 1993).

In 1995 a study of Allans Creek was also carried out by Marine Science & Ecology and Coastal Environmental Consultants Pty Ltd (1996) for BHP Steel. The Allans Creek system was studied because it carries runoff from the surrounding catchment, as well as cooling and wastewater from the steelworks. From the results of that study a total of 13 species of fish were found, with no introduced species being recorded. Invertebrates recorded included four species of crabs and many species of polychaete worms. Results of a zooplankton survey showed a dominance of larval crabs of various species.

3. SURVEY METHODS

3.1. Sampling strategy

The CRIMP survey protocols which were used during the present study were designed to maximise the likelihood that exotic species present in the port would be detected (see Appendix 2). Sampling was concentrated on habitats and sites in Port Kembla and adjacent coastal areas that were most likely to have been colonised by species associated with recognised transport vectors (i.e. shipping, through both hull fouling and ballast water discharge).

The types of habitats selected for sampling (in priority order) were:

active berth structures,

existing jetty structures,

proposed port improvement areas,

known deballasting areas,

breakwaters,

channel markers or anchorage buoys, and

other representative habitats in and around the port.

Sampling methods were selected to ensure a comprehensive coverage of habitat types 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 was concentrated on maximising coverage within a site, with minimal sample replication. Replicate sampling was only undertaken in situations where small-scale heterogeneity was likely to influence detection of target species. The sampling methods used, habitats sampled and taxa targeted are summarised in Table 3.1. Detailed descriptions of the existing standard temperate port sampling procedures are outlined in the protocol of Hewitt and Martin (1996) and summarised in Appendix 2.

3.2. Sampling methods

Sampling was distributed over three main areas in and around Port Kembla (see Fig. 3.2), including:

Open Coast

Outer Harbour

Inner Harbour

Sampling methods employed in each of these areas and details of the sampling sites are summarised in Table 3.2, and their locations shown in Figure 3.2. Sampling was most intense in the immediate port area, and focused on habitats on and around wharf piles and in the adjacent soft bottom sediments. Visual searches and transects, quadrat scraping, video transects, still photography and coring were undertaken by snorkel or scuba divers. Shore surveys, beach

seining, trapping and plankton sampling were carried out from the shore, research vessels or wharves.

TABLE 3.1. SUMMARY OF SAMPLING METHODS USED, HABITATS SAMPLED AND TARGET TAXA, PORT KEMBLA SURVEY, MAY 2000

Sampling Methods	Habitat(s) Sampled	Target Taxa
Non-targeted surveys		
Qualitative surveys		
diver search	piles, reefs, soft bottoms	invertebrates, fish, algae
video/still photography	piles, reefs, soft bottoms	invertebrates, fish, algae
shore survey	beaches, rocky shores	invertebrates, fish, algae (wrack)
Quantitative surveys		
quadrat scraping	piles, channel markers	invertebrates, algae
transect diver search	reefs, breakwaters	invertebrates, algae
video/still photography	reefs, breakwaters, soft bottoms	invertebrates, algae
large benthic core	soft bottoms	invertebrate infauna
beach seine net	soft bottoms	mobile epifauna, fish
Targeted surveys		
diver search	piles, reefs, soft bottoms	*Sabella, Asterias, Carcinus*
crab/shrimp traps	piles, soft bottoms	*Carcinus,* fish
small dinocore	mud/silt soft bottoms	dinoflagellate cysts
phytoplankton net	water column	phytoplankton, dinoflagellates
fish poison	piles, rocky shores, breakwaters	fish

Sampling was undertaken between 8 and 18 May 2000. The survey fieldwork was carried out as a joint operation between NSW Fisheries' Office of Conservation Ecology Research Group and contracted CRIMP staff. Initial sorting and preservation were carried out immediately after sampling. Further sorting to the level of phylum or class was carried out at the Cronulla Fisheries Centre. After sorting, the samples were then sent to individual specialist taxonomists throughout Australia and New Zealand to be identified to species level where possible.

Identified taxa were classified into four groups, comprising ABWMAC introduced target species, other known introduced species, cryptogenic species (i.e. those of unknown origin), and species known to be native to south-eastern Australia.

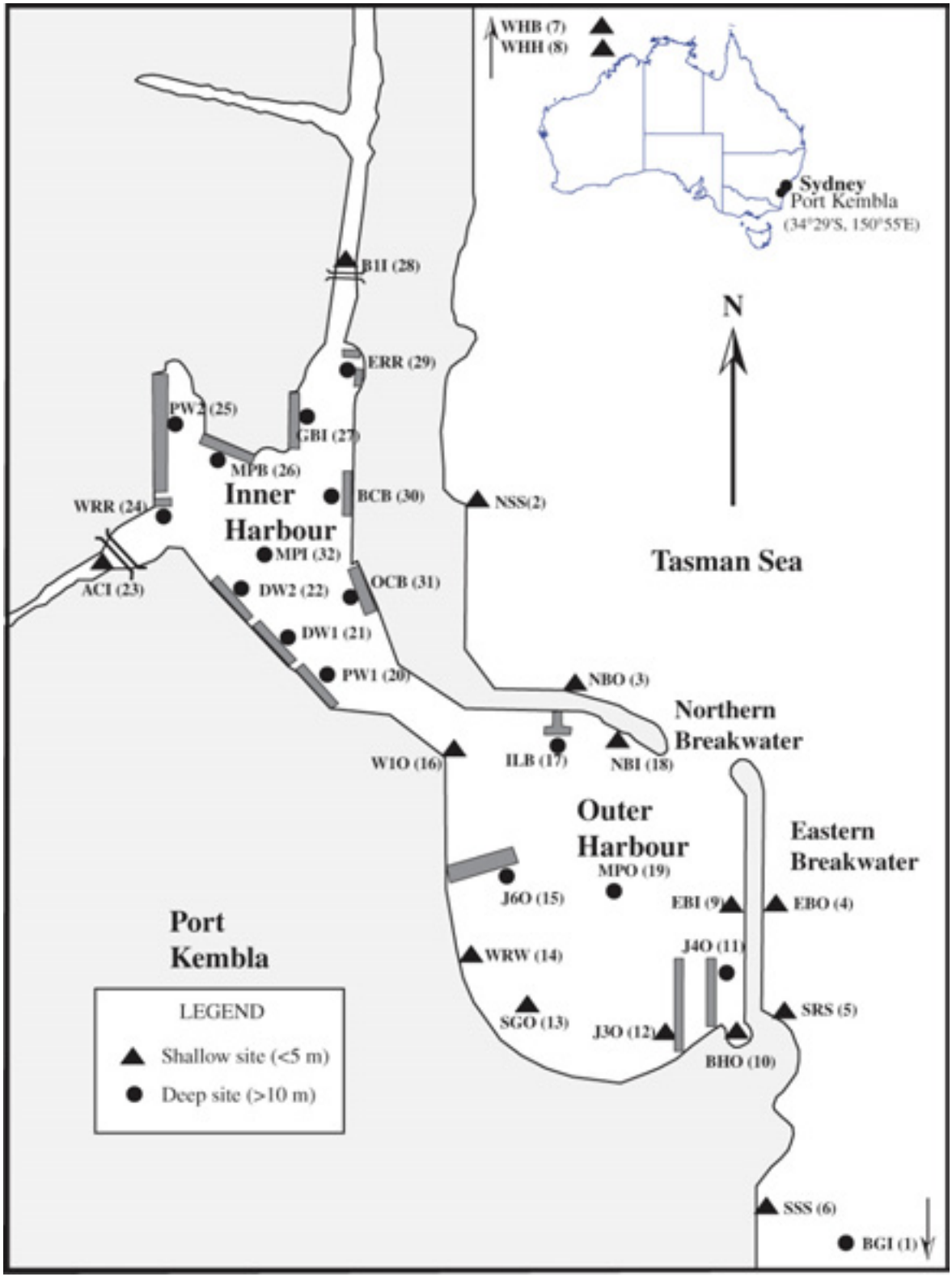

Figure 3.2: Sampling sites in and around Port Kembla

TABLE 3.2. SUMMARY OF THE DISTRIBUTION OF SAMPLING METHODS USED WITHIN SAMPLING SITES, PORT KEMBLA SURVEY, MAY 2000 (see also Fig. 3.2)

Site No	Site Name	Site Code (NSWPK…)	Date Sampled	Sampling Methods
	Open Coast			
1	Big Island (offshore to south)	BGI	13/5	QD
2	Coal Loader Groyne (Northern Sandy Shore)	NSS	17/5	RT, SN, BS
3	Northern Breakwater (outer side)	NBO	16/5	QD
4	Eastern Breakwater (outer side)	EBO	16/5	QD
5	Toe of Eastern Breakwater (Southern Rocky Shore)	SRS	16/5	QD
6	Fisherman's Beach (Southern Sandy Shore)	SSS	16/5	SN, BS
7	Wollongong Harbour (Boat Basin)	WHB	17/5	QD
8	Wollongong Harbour (Boat Harbour)	WHH	17/5	QD
	Outer Harbour			
9	Eastern Breakwater (inner side)	EBI	12/5	QD
10	Boat Harbour (Boat Ramp)	BHO	17/5	SN, RT, QD, CO
11	N^{o} 4 (Bulk Liquids Berth) Jetty	J4O	16/5	DC, QD, CO
12	N^{o} 3 Jetty	J3O	16/5, 17/5	PS, BC, DC, CT, ST
13	Spoil Ground	SGO	12/5	BC, DC, SS
14	Western Revetment Wall	WRW	14/5	SN, QD, BS
15	N^{o} 6 Jetty	J6O	14/5	PS, BC, DC, QD
16	BHP Saltwater Intake	WIO	10/5	QD
17	Inflammable Liquids Berth	ILB	13/5	PS, BC, DC, RT
18	Northern Breakwater (inner side)	NBI	13/5	SN, QD
19	Mid Port (Outer Harbour)	MPO	12/5	BC, DC, SS, PT, DN, QD
	Inner Harbour			
20	N^{o} 1 Products Wharf	PW1	10/5	PS, BC, DC, SS
21	N^{o} 1 Discharge Wharf	DW1	8/5	PS, BC, DC, RT, QD, SS
22	N^{o} 2 Discharge Wharf	DW2	8/5, 14/5	PS, BC, DC, SS
23	Allans Creek	ACI	12/5	CT
24	BHP Roll-on Roll-off Berth (western)	WRR	12/5	PS, BC, DC, SS
25	N^{o} 2 Products Wharf	PW2	14/5	PS, BC, DC, SS
26	Multi-Purpose Berth	MPB	9/5, 17/5	PS, BC, DC, CT, ST, QD, SS
27	Grain Berth	GBI	8/5, 13/5	PS, DC, RT, QD
28	Tom Thumb Road Bridge	B1I	12/5	CT, ST
29	ANL Roll-on Roll-off Berth (eastern)	ERR	8/5, 10/5	PS, BC, DC, RT, QD, SS
30	N^{o} 1 (Bulk) Coal Berth	BCB	8/5, 17/5	PS, BC, DC, CT, ST, SS
31	N^{o} 2 (Old) Coal Berth	OCB	9/5, 13/5	PS, BC, DC, RT, SS, CO
32	Mid Port (Inner Harbour)	MPI	10/5	BC, DC, SS, PT, DN, QD

Key: PS: pylon/piling scraping; BC: large benthic core; DC: dino core; RT: rotenone; SN: seine net; CT: crab trap; ST: shrimp trap: PT: plankton tow; SS: sediment sample; CO: clove oil; DN: dino net; BS: beach survey; QD: qualitative diver search

4. SURVEY RESULTS AND DISCUSSION

4.1. Port environment

Port Kembla is made up of an Inner and an Outer Harbour. The Outer Harbour is 137.5 hectares, with depths ranging to 17.5 metres. Four berths have been built in the Outer Harbour. The Inner Harbour is 56.5 hectares, with depths ranging to 16 metres. Ten berths have been built in this area. Breakwaters protect the Outer Harbour, while the Inner Harbour, which has been dredged out of the flat hinterland, is well protected during all weather conditions (Anon. 1999).

4.2. Marine floral and faunal taxa found during the port survey

The samples of fauna and flora collected, mainly from pile scrapings and benthic sediment cores, comprised 14 major animal and plant groups. These were the dinoflagellates, macroalgae, poriferans, hydrozoans, anthozoans, polychaetes, several phyla of "other worms", cirripedes, malacostracans, molluscs, bryozoans, echinoderms, ascidians and fishes. Scientific (genus and species) names in ***bold italics*** at first substantive mention in the text indicate those introduced or cryptogenic (i.e. of unknown origin) species found or known to occur in Port Kembla.

4.2.1. Dinoflagellates

The dinoflagellates are a group of microalgae belonging to the Kingdom Protista, which comprises a wide variety of single celled microorganisms.

Many species of dinoflagellates occur in Australian waters, and these show extreme variation in size and shape. Around 60 of these species can survive for several years as sedentary cysts, which are very different from their motile free swimming forms (Edgar 2000). This may be an adaptation for surviving under unfavourable environmental conditions, and definite identification of some cysts to species cannot be readily undertaken without germinating the cyst into its motile form.

It is these "cyst-forming" dinoflagellate species which are often known for their negative environmental effects. Under suitable conditions they may multiply rapidly to produce "blooms". These blooms can cause the infamous "red tides". Oxygen depletion and/or toxins produced during these blooms may lead to the destruction of marine life over large areas (Edgar 2000). These toxins may concentrate in filter-feeding invertebrates, such as mussels and oysters. Sometimes they may have little direct effect on the host invertebrates, but if the latter are consumed by humans or other vertebrate predators, these toxins can be potentially fatal (Edgar 2000, Paxinos 2000). The cysts of these toxic dinoflagellates usually accumulate and lie dormant in soft bottom sediments until disturbed.

Dr Steve Brett and Dr David Hill of Microalgal Services, Melbourne, undertook analysis of the small benthic dinocore and phytoplankton net samples collected during the present survey.

Analyses of the cores revealed the presence of low levels of *Alexandrium* cysts, similar in appearance to *Alexandrium "catenella* type" cysts, which was the only ABWMAC listed pest species recorded from Port Kembla during the survey.

Results from the small benthic core ("dinocore") sampling for dinoflagellates in Port Kembla are presented in Table 4.2.1.1. Of the 24 sites sampled for marine flora and fauna in the Outer and Inner Harbours during this survey, small benthic dinocore samples were collected from 17 sites

(see Table 3.2). At 7 of these sites, dinocore samples were also collected 50 metres away as well as at the immediate site. These latter sites included the Spoil Ground (SGO), Inflammable Liquids Berth (ILB), Mid Port (Outer Harbour) (MPO), Number 1 Products Wharf (PW1), Grain Berth (GBI), ANL Roll-on Roll-off Berth (eastern) (ERR) and No 2 (Old) Coal Berth (OCB). No small benthic dinocore samples were collected from the Open Coast sites.

The cysts of at least 16 different dinoflagellate species were identified in these sediment cores. ***Alexandrium "catenella* type"** cysts were reported from sites SGO (3.9% of total cysts present), Jetty 6 (J6O) (4.7%), MPO (0.9%), Discharge Wharf 2 (DW2) (5.6%), BHP Roll-on Roll-off Berth Western (WRR) (1.9%), GBI (2.7% at the immediate site and 1.3% 50 metres out), ERR (0.9%), Number 1 (Bulk) Coal Berth (BCB) (1.9%), OCB (1.8%) and Mid Port in the Inner Harbour (MPI) (0.8%). While cyst numbers were relatively low, the presence of *Alexandrium* cysts in the sediments of Port Kembla raises the possibility of future potentially toxic blooms. Collection of additional samples may enable the germination and thus unequivocal identification of the *Alexandrium* species present, and also provide further understanding of cyst distribution and abundance within Port Kembla (S. Brett, pers. comm.). *Alexandrium "catenella* type" cysts were also present in the samples collected during the introduced marine pests survey carried out in Botany Bay (Pollard and Pethebridge 2000).

Phytoplankton net sampling for dinoflagellates in the water column was also undertaken during this survey (Table 4.2.1.2). Samples were collected by vertical tows of a hand deployed 20 µm mesh plankton net (3 replicate tows at each site) according to the protocol outlined in Appendix 2. A single one litre surface water sample was also taken at each site for direct phytoplankton counts. Samples were taken at the Inner Harbour Mid Port (MPI) and Outer Harbour Mid Port (MPO) sites. Low numbers of *Alexandrium* sp. *(catenella* type) cells were found in one of the phytoplankton samples from the Inner Harbour. Another species belonging to this genus, ***Alexandrium ostenfeldii/peruvianum,*** was also found in phytoplankton samples from both the Inner and Outer Harbours. The toxicity of this latter species is not well known, although in New Zealand it has been found to have variable toxicity (S. Brett, pers. comm.).

Alexandrium catenella occurs worldwide in temperate waters. Although it is not known if it was present in Australian waters prior to European settlement, there is no evidence from any Aboriginal history or customary story to suggest that toxicity had occurred previously in Australian shellfish. Reports of shellfish toxicity due to this species in the more recent past have, however, been recorded from Bateman's Bay in 1935, Port Hacking in the 1940s, and from Port Phillip Bay in 1986 (Furlani 1996).

Alexandrium catenella is only one of several known species of toxic dinoflagellates which have been found in Australian waters. Other known species include *Alexandrium minutum, Alexandrium tamarense* and *Gymnodinium catenatum* (Furlani 1996). All of these species are designated ABWMAC pests, and are highly toxic. They can all pose a threat to human health through the consumption of contaminated shellfish after toxic blooms. Paralytic shellfish poisoning (PSP) due to toxic dinoflagellates has only occurred in Australia since the 1980s (Ecology Lab 1993). The first outbreaks were caused by *Gymnodinium catenatum* in Hobart, by *Alexandrium catenella* in Melbourne and by *Alexandrium minutum* in Adelaide.

Alexandrium catenella was previously known from coastal estuaries and embayments from the Hawkesbury River, NSW, south to Port Phillip Bay, Victoria (Hallegraeff *et al.* 1991). However, Newcastle has more recently been confirmed to be the most northerly extent of its known Australian distribution (CSIRO Marine Research 1998).

In southern Australia, blooms of *A. catenella* most usually occur for about two to four weeks in the warmer months between December and April. These blooms produce potent neurotoxins which

accumulate in shellfish and may result in PSP in humans (Furlani 1996). If dredging occurs, and cysts are disturbed and their dispersal is thus enhanced, there is a possibility of toxic blooms occurring. To date, however, there is no evidence of any such toxic blooms having occurred in Port Kembla.

TABLE 4.2.1.1: DINOFLAGELLATES COLLECTED FROM PORT KEMBLA (dinocore samples)

Family, etc.	Species	Outer Harbour Sites													
		EBI	BHO	J4O	J3O	SGO	SGO	WRW	J6O	WIO	ILB	ILB	NBI	MPO	MPO
						0 m	50 m				0 m	50 m		0 m	50 m
Gonyaulacids	*Alexandrium* sp. *(catenella* type)						3.9		4.7					0.9	
	Gonyaulax sp.				0.9				0.9		2.0	2.0			
	Protoceratium reticulatum				3.7	1.0	7.8		1.9		5.9	2.0		5.1	1.8
Protoperidiniids	*Protoperidinium c.f. calidicans*				0.9										0.9
	Protoperidinium conicum								2.8						1.8
	Protoperidinium leonis			2.9	3.7	3.1						1.0			2.7
	Protoperidinium minutum			1.0	0.9									0.9	
	Protoperidinium nudum					6.1								0.9	
	Protoperidinium oblongum													0.9	
	Protoperidinium pentagonum			3.8	0.9	2.0			0.9			3.0			
	Protoperidinium subinerme						1.0								
	Protoperidinium round brown			26.7	18.3	48.0	19.6		17.8		13.7	12.0		42.7	12.6
	Diplopsalid sp.										1.0				0.9
Others	Gymnodinioid spp.			8.6	11.9	14.3	23.5		11.2		4.9	8.0		15.4	7.2
	Scrippsiella sp.			56.2	58.7	25.5	38.2		59.8		72.5	72.0		23.9	72.0
	Unidentified spp.						4.9							9.4	

Key: Numbers in columns = % of total cysts present

TABLE 4.2.1.1: DINOFLAGELLATES COLLECTED FROM PORT KEMBLA (dinocore samples) (continued)

Family, etc.	Species	Inner Harbour Sites															
		PW1	PW1	DW1	DW2	ACI	WRR	PW2	MPB	GBI	GBI	B1I	ERR	ERR	BCB	OCB	OCB	MPI
		0 m	50 m							0 m	50 m		0 m	50 m		0 m	50 m	
Gonyaulacids	*Alexandrium* sp. *(catenella* type)				5.6		1.9			2.7	1.3		0.9		1.9	1.8		0.8
	Gonyaulax sp.									0.9								
	Protoceratium reticulatum	4.8		4.3	5.6			11.4	2.9	11.5	13.5		8.3	15.5	6.6	5.3	4.6	5.0
Protoperidiniids	*Protoperidinium c.f. calidicans*																	
	Protoperidinium conicum								1.0					0.9	0.9		0.8	
	Protoperidinium leonis			0.9	2.8		1.9	1.8	1.9		1.3		0.9		1.9	0.9	1.5	
	Protoperidinium minutum	1.0		1.7				2.6		2.7	3.2					2.7		4.2
	Protoperidinium nudum			1.7											1.9	0.9		
	Protoperidinium oblongum																	
	Protoperidinium pentagonum	1.9		2.6				1.8	1.0	2.7			0.9	0.9	0.9	0.9	0.8	
	Protoperidinium subinerme	1.0						0.9		0.9								
	Protoperidinium round brown	25.7	22.2	28.4	8.4		14.0	14.9	17.1	15.0	21.9		10.2	16.3	13.2	28.3	22.3	34.5
Others	Diplopsalid sp.							0.9	1.0				1.9		1.9			
	Gymnodinioid spp.	12.4		11.2	6.5		16.8	14.0	4.8	10.6	11.0		4.6	2.7	8.5	19.5	8.5	18.5
	Scrippsiella spp.	52.4	77.8	47.4	69.2		65.4	50.9	69.5	53.1	47.7		72.2	63.6	62.3	35.4	61.5	27.7
	Unidentified spp.			0.9				0.9								4.4		8.4

Key: Numbers in columns = % of total cysts present

TABLE 4.2.1.2: PHYTOPLANKTON COLLECTED FROM PORT KEMBLA (net and water samples)

Family, etc.	Species	Inner Harbour Mid Port				Outer Harbour Mid Port			
		Count	Rep. 1	Rep. 2	Rep. 3	Count	Rep. 1	Rep. 2	Rep. 3
Diatoms	*Achnanthes* sp.								x
	Amphora sp.	1.6E+0.3				5.0E+02			
	Ardissonea crystallina			x			x	x	
	Bacillaria paxillifera		x					x	
	Bacteriastrum sp.		x						
	Campylodiscus sp.	2.0E+0.2		x					
	Cerataulina pelagica		x		x				
	Chaetoceros spp.		xx	x		3.5E+03	xx	x	xxx
	Cocconeis sp.	4.0E+02				5.0E+02			
	Coscinodiscus spp.							x	
	Cylindrotheca closterium	1.2E+03	x			6.0E+03		x	x
	Cymbella sp.	8.0E+02							
	Dactyliosolen antarcticus			x					
	Dactyliosolen fragilissimus					2.0E+02			
	Detonula sp.		x		x				x
	Entomoneis sp.	8.0E+02	x						x
	Guinardia deliculata								x
	Guinardia flaccida			x			x		x
	Guinardia striata		x		x				
	Helicotheca tamesis		x	x			x	x	x
	Hemiaulus sp.	4.0E+02							
	Leptocylindrus danicus	2.0E+02	x	x	x	1.0E+02	x	x	x
	Licmorphora sp.							x	x
	Minidiscus trioculatus	3.6E+03				9.5E+03			
	Melosira sp.	1.0E+02							
	Naviculoid spp.	7.6E+03		x		2.5E+03			
	Nitzchia spp.			x				x	x
	Nitzchia longissima		x	x				x	
	Nitzchia sigmoidea		x	x					
	Paralia sulcata				x				
	Pleurosigma sp.	4.0E+02	x	x	x		x	x	
	Proboscia alata								x
	Pseudo-nitzchia spp.	8.0E+02							
	Pseudo-nitzchia pseudodelicatissima					5.0E+02			
	Pseudo-nitzchia pungens/multiseries				x				x
	Rhizosolenia spp.			x	x				x
	Skeletonema costatum	3.2E+03							x
	Surirella sp.	1.0E+02	x	x			x	x	
	Thalassionema sp.	2.0E+03		x		5.0E+02		xx	
	Thalassiosira sp.	5.2E+03		x	x	5.5E+03	x		x
Dinoflagellates	*Alexandrium* sp. *(catenella* type)				x				
	Alexandrium ostenfeldii/peruvianum		x	x			x		
	Cachonina niei		x						
	Ceratium sp.							x	
	Ceratium arietinium								x
	Ceratium furca		xx	xx	x		xx	xx	xx
	Ceratium fusus							x	x
	Ceratium gibberum							x	

Key: x = rarely observed species, xx = common species, xxx = dominant species in replicate net samples; counts = cells per litre in water samples

TABLE 4.2.1.2: PHYTOPLANKTON COLLECTED FROM PORT KEMBLA (net and water samples)(continued)

Family, etc.	Species	Inner Harbour Mid Port				Outer Harbour Mid Port			
		Count	Rep. 1	Rep. 2	Rep. 3	Count	Rep. 1	Rep. 2	Rep. 3
Dinoflagellates	*Ceratium horridum/tenue*			x					x
	Ceratium lineatum						x		
	Ceratium macroceros								x
	Ceratium teres						x		x
	Ceratium tripos		x					x	x
	Dinophysis acuminata		x	x	x			x	xx
	Dinophysis caudata							x	
	Dinophysis tripos						x		
	Diplopelta bomba		x						
	Gonyaulax spinifera		x	x			x		
	Gymnodinium spp.	1.2E+03				1.1E+04			
	Gymnodinium sanguineum								x
	Heterocapsa rotundata	4.0E+02				7.0E+03			
	Oblea rotunda							x	
	Ornithocerus magnificus							x	x
	Paleophalachroma unicincta						x	x	
	Peridinium quincecorne		xx						
	Phalachroma rotundatum		xx	xx	x			x	
	Preperidinium meuneri		x						
	Prorocentrum compressum					1.0E+02		x	
	Prorocentrum gracile							x	
	Prorocentrum micans		x		x		x		
	Prorocentrum triestinum							x	
	Protoperidinium spp.		x				xx	x	
	Protoperidinium bipes							x	
	Protoperidinium brevipes							x	
	Protoperidinium claudicans		x	x					
	Protoperidinium depressum		x					x	
	Protoperidinium leonis		x	x			x	x	
	Protoperidinium pallidum/pellucidum		x	x	x			x	x
	Scrippsiella spp.		x	x		5.0E+02		x	x
Prymnesiophytes	*Chrysochromulina* spp.	1.6E+03				8.0E+03			
	Emiliania huxleyi	8.0E+02				2.5E+03			
Chrysophytes	*Calycomonas* spp.	4.0E+02							
	Ochromonad spp.	4.0E+02				1.0E+03			
Cryptomonads	*Leucocryptos marina*	4.0E+02							
	Plagioselmis prolonga	4.0E+02				1.0E+03			
	Rhodomonas salina	8.0E+02				3.0E+03			
Prasinophytes,	*Micromonas pusilla*	1.2E+03				1.0E+03			
Chlorophytes and	*Nephroselmis* sp.	4.0E+02				5.0E+02			
Euglenoids	*Pyramimonas* spp.	2.8E+03				8.5E+03			
	Staurastrum sp.	4.0E+02				5.0E+02			
	Tetraselmis sp.	8.0E+02							
Cyanophytes	*Oscillatoria* sp. (filaments)	4.0E+02		x					
Others	*Eutreptiella* sp.								x
	Apedinella spinifera	4.0E+02				1.0E+03			
	Unidentified bodonids/heterotrophs	2.4E+03				3.2E+03			

Key: x = rarely observed species, xx = common species, xxx = dominant species in replicate net samples; counts = cells per litre in water samples

4.2.2. Macroalgae

The term macroalgae refers to the main group of primarily attached macroscopic marine plants, or seaweeds, which inhabit the coastal shallows and deeper sunlit regions of the continental shelf.

Seaweeds, together with seagrasses, are the major primary producers in inshore coastal regions, and kelp beds can far exceed the richest agricultural lands in terms of plant material produced annually (Christianson *et al*. 1981). Macroscopic algae, together with seagrasses and microscopic algae (mainly phytoplankton), form the basis of marine and estuarine food chains.

Macroalgae are classified into three main groups: the Chlorophyta, or green algae; the Phaeophyta, or brown algae; and the Rhodophyta, or red algae. Around 113 species of green algae (Millar and Kraft 1994a), 140 species of brown algae (Millar and Kraft 1994b) and 400 species of red algae (Millar and Kraft 1993) are known to occur in eastern Australian waters.

The macroalgae samples collected from Port Kembla were sent to Dr Alan Millar at the National Herbarium, Royal Botanic Gardens, Sydney, for identification. A total of 68 species were identified from 26 families, with no confirmed introduced species being found (see Table 4.2.2). These comprised 46 species of red algae, 16 species of brown algae and 6 species of green algae. Also included in the samples was one species of seagrass, *Halophila ovalis,* from the angiosperm family Hydrocharitaceae. Many of these species are common to New South Wales and southern Australia in general, and many are "cosmopolitan", being common worldwide.

Most of the algae collected came from qualitative samples, with some coming from pile scrapings, and one each from a beach wrack survey and a benthic core. The Boat Harbour site in Wollongong Harbour (WHH) contained the largest number of algal species, comprising 41 out of the 68 species found. The algal species collected at this site were all found in qualitative samples. Algal species were also quite common at other Open Coast sites, such as the Big Island (BGI) (13 spp.), Eastern Breakwater (EBO) (9 spp.), Southern Sandy Shore (SSS) (4 spp.) and Wollongong Harbour Boat Basin (WHB) (8 spp.) sites. In the Outer Harbour, algal species were found at the Eastern Breakwater (EBI) (4 spp.), Jetty 4 (J4O) (10 spp.), Jetty 3 (J3O) (7 spp.), Spoil Grounds (SGO) (1 sp.), Jetty 6 (J6O) (2 spp.), Inflammable Liquids Berth (ILB) (7 spp.) and Northern Breakwater (NBI) (4 spp.) sites. In the Inner Harbour, algal species were found at the No. 1 Products Wharf (PW1) (1 sp.), No. 2 Products Wharf (PW2) (3 spp.), Multi-Purpose Berth (MPB) (1sp.), Tom Thumb Road Bridge (B1I) (9 spp.) and ANL Roll-on Roll-off Berth (eastern) (ERR) (1 sp.) sites.

Caulerpa filiformis was the only algal species from the Port Kembla samples identified as possibly being cryptogenic in origin. This chlorophyte species is easily recognised by its bright green colour and its "simple, flattened, strap-like shape" (Edgar 2000). It was first recorded in Australia in 1923, and since then has proliferated to become a dominant plant on intertidal rock platforms in the Sydney area (Edgar 2000). Local scientists initially thought it was introduced from South Africa. However, recent genetic studies (Pillmann *et al*. 1997) have shown that the local *C. filiformis* differs from the South African form though the species is probably native to both countries (i.e. it is probably not an introduced species in Australia). The recent perceived proliferation of this species in the Sydney area may be due to its ability to utlilise increased nutrient loadings better than many related algae (A. Millar, pers. comm.). In Australian waters it occurs along the central NSW coast from south of Wollongong (including Port Kembla), around the Sydney area, and northwards to Port Stephens (Edgar 2000; D. Pollard and R. Pethebridge, pers. obs.).

Around Port Kembla, *Caulerpa filiformis* was found at two sites on the Open Coast, in qualitative samples collected at the Fisherman's Beach (Southern Sandy Shore) (SSS) and Wollongong Harbour Boat Harbour (WHH) sites. It was not found in either the Outer or Inner Harbours. This species was also collected during the Botany Bay introduced marine pests survey during 1998 (Pollard and Pethebridge 2000).

TABLE 4.2.2: MACROALGAL AND SEAGRASS FLORA COLLECTED FROM PORT KEMBLA

Family, etc.	Species	Open Coast Sites								Outer Harbour Sites						
		BGI	NSS	NBO	EBO	SRS	SSS	WHB	WHH	EBI	BHO	J4O	J3O	SGO	WRW	J6O
Rhodophyta																
Bangiaceae	*Porphyra columbina*						2B									
Bonnemaisoniaceae	*Delisea pulchra*								1Q							
Ceramiaceae	*Anotrichium planatum*								1Q							
	Antithamnion amphigeneum				1Q							2P	3P			
	Callithamnion korfense							1Q	1Q							
	Callithamniella pacifica								1Q			1P				
	Centroceras clavulatum								1Q							
	Ceramium flaccidum								1Q							
	Ceramium macilentum	1Q			1Q											
	Ceramium rubrum															
	Griffithsia sp.								1Q							
	Pleonosporium boergesenii				1Q											
	Rhipidothamnion secundum				1Q				1Q				3P			
Champiaceae	*Champia parvula*								1Q			1P				
Corallinaceae	*Amphiroa anceps*	2Q							1Q							
	Corallina officinalis	1Q							1Q							
	Crustose coralline	1Q							2Q	1Q						
	Haliptilon roseum	1Q														
Dasyaceae	*Dasya iyengarii*								1Q							
	Heterosiphonia australis											2P	1P			
Delesseriaceae	*Acrosorium venulosum*													1C		
	Apoglossum unguiculescens															
	Martensia fragilis	1Q														
	Nitophyllum delicatum								1Q							
	Phycodrys australasica															
	Platysiphonia marginalis								1Q							
Gelidiaceae	*Gelidium crinale*	1Q														
	Gelidium sp.											1P				
Halymeniaceae	*Halymenia kraftii*								1Q							
Plocamiaceae	*Plocamium* sp.								1Q							
Porphyrydiaceae	*Stylonema alsidii*								1Q							
Rhodomeliaceae	*Laurencia obtusa*															
	Polysiphonia constricta				1Q			1Q	3Q			1P				
	Polysiphonia sp.															
	Polysiphonia sp. x	1Q			1Q				1Q			1P	1P			
	Polysiphonia sp. 1								1Q							
	Polysiphonia sp. 2								1Q							
	Polysiphonia sp. 3								1Q							
	Polysiphonia sp. 4	1Q														
	Polysiphonia sphaerocarpa								1Q							
	Polysiphonia scopulorum				1Q				1Q			1P				
	Stypopodium flabelliforme	2Q			1Q			4Q	5Q							
Rhodymeniaceae	*Rhodymenia australis*												1P			
	Rhodymenia leptophylla							2Q								
Solieriaceae	*Soliera robusta*								1Q							
	Soliera sp.								1Q							
Phaeophyta																
Alariaceae	*Ecklonia radiata*	1Q								1Q						
Cladostephaceae	*Cladostephus spongiosus*								1Q							
Dictyotaceae	*Dictyopteris acrostichoides*															
	Dictyota alternifida								3Q				1P			
	Dictyota dichotoma								2Q	1Q		2P				
	Dilophus marginatus															1P
	Lobophora variegata							1Q								
	Padina fraseri								1Q							
	Spatoglossum sp.												1P			
	Zonaria diesingiana	1Q							2Q						1Q	
Sargassaceae	*Sargassum* sp.	1Q					1B	1Q	5Q	1Q						
Scytosiphonaceae	*Colpomenia sinuosa*								4Q							
Seirococcaceae	*Phyllospora comosa*						1B				1Q					
Sphacelariales	*Sphacelaria* sp.				1Q				1Q							
Stypocaulaceae	*Halopteris paniculata*								1Q							
	Halopteris sp.								2Q							
Chlorophyta																
Caulerpaceae	*Caulerpa filiformis* **						1Q		3Q							
Cladophoraceae	*Cladophora feredayi*							2Q								
Codiaceae	*Codium harveyi*															
Derbesiaceae	*Derbesia* sp.											1P				
	Derbesia tenuissima								2Q							
	Pedobesia clavaeformis							1Q								
Seagrasses																
Hydrocharitaceae	*Halophila ovalis*								1Q							1P

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample; 1B: 1 beach survey sample; ** cryptogenic species

TABLE 4.2.2: MACROALGAL AND SEAGRASS FLORA COLLECTED FROM PORT KEMBLA (continued)

Family, etc.	Species	Outer Harbour				Inner Harbour Sites												
		WIO	ILB	NBI	MPQ	PW1	DW1	DW2	ACI	WRR	PW2	MPB	GBI	B1I	ERR	BCB	OCB	MPI
Rhodophyta																		
Bangiaceae	*Porphyra columbina*																	
Bonnemaisoniaceae	*Delisea pulchra*																	
Ceramiaceae	*Anotrichium planatum*																	
	Antithamnion amphigeneum		1P	1Q		1P					1P	1P						
	Callithamnion korfense		1P															
	Callithamniella pacifica																	
	Centroceras clavulatum																	
	Ceramium flaccidum																	
	Ceramium macilentum														1Q			
	Ceramium rubrum													1Q				
	Griffithsia sp.																	
	Pleonosporium boergesenii																	
	Rhipidothamnion secundum		3P															
Champiaceae	*Champia parvula*																	
Corallinaceae	*Amphiroa anceps*													1Q				
	Corallina officinalis																	
	Crustose coralline																	
	Haliptilon roseum													3Q				
Dasyaceae	*Dasya iyengarii*																	
	Heterosiphonia australis																	
Delesseriaceae	*Acrosorium venulosum*																	
	Apoglossum unguiculescens													1Q				
	Martensia fragilis																	
	Nitophyllum delicatum																	
	Phycodrys australasica		1P															
	Platysiphonia marginalis																	
Gelidiaceae	*Gelidium crinale*																	
	Gelidium sp.																	
Halymeniaceae	*Halymenia kraftii*																	
Plocamiaceae	*Plocamium* sp.																	
Porphyrydiaceae	*Stylonema alsidii*																	
Rhodomeliaceae	*Laurencia obtusa*										1P							
	Polysiphonia constricta																	
	Polysiphonia sp.			1P														
	Polysiphonia sp. x																	
	Polysiphonia sp. 1																	
	Polysiphonia sp. 2																	
	Polysiphonia sp. 3																	
	Polysiphonia sp. 4																	
	Polysiphonia sphaerocarpa																	
	Polysiphonia scopulorum		1P								1P							
	Stypopodium flabelliforme																	
Rhodymeniaceae	*Rhodymenia australis*																	
	Rhodymenia leptophylla																	
Solieriaceae	*Soliera robusta*																	
	Soliera sp.																	
Phaeophyta																		
Alariaceae	*Ecklonia radiata*													3Q				
	Cladostephus spongiosus																	
Dictyotaceae	*Dictyopteris acrostichoides*			1P														
	Dictyota alternifida									1P								
	Dictyota dichotoma		1P	1P														
	Dilophus marginatus																	
	Lobophora variegata													1Q				
	Padina fraseri																	
	Spatoglossum sp.																	
	Zonaria diesingiana																	
Sargassaceae	*Sargassum* sp.													3Q				
Scytosiphonaceae	*Colpomenia sinuosa*																	
Seirococcaceae	*Phyllospora comosa*																	
Sphacelariales	*Sphacelaria* sp.		1P															
Stypocaulaceae	*Halopteris paniculata*													2Q				
	Halopteris sp.										1P							
Chlorophyta																		
Caulerpaceae	*Caulerpa filiformis* **																	
Cladophoraceae	*Cladophora feredayi*																	
Codiaceae	*Codium harveyi*													1Q				
	Derbesia sp.																	
	Derbesia tenuissima																	
	Pedobesia clavaeformis																	
Seagrasses																		
Hydrocharitaceae	*Halophila ovalis*																	

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample; 1B: 1 beach survey sample; ** cryptogenic species

4.2.3. Poriferans

The Phylum Porifera, or sponges, includes about 6000 marine and 100 freshwater species. Nearly 1000 of these species occur in southern Australia (Edgar 2000).

Sponges occur anywhere there is a suitable substratum, such as on artificial substrates, rocks, shells, submerged timber, coral, sand or mud. They survive best where there is a strong current or wave action, because they are filter feeders. They often tend to be more dominant in caves and deeper water, and less dominant in shallow waters where the faster growing seaweeds tend to dominate (Edgar 2000). Carnivorous animals generally avoid sponges as prey because of their sharp spicules and toxic chemicals.

Professor Pat Bergquist, from the University of Auckland, New Zealand, identified the sponges collected from Port Kembla. These included a total of 29 species from 16 families, which are listed in Table 4.2.3. None of the species found are considered to be introduced or cryptogenic.

TABLE 4.2.3: PORIFERAN FAUNA COLLECTED FROM PORT KEMBLA

Family, etc.	Species	Open Coast Sites								Outer Harbour Sites							
		BGI	NSS	NBO	EBO	SRS	SSS	WHB	WHH	EBI	BHO	J4O	J3O	SGO	WRW	J6O	WIO
Demospongiae																	
Order Chondrosida																	
Chondosiidae	*Chondrosia* sp.	1Q															
Order: Dendroceratida																	
Darwinellidae	*Chelonaplysilla violacea* Lendenfeld																
Order: Dictyoceratida																	
Irciniidae	*Ircinia* sp.																
	Ircinia rubra	1Q															
	Ircinia jacksoniana							1Q									
Dysideidae	*Dysidea* sp.											2P	2P			4P	
	Dysidea sp. 1																
Thorectidae	*Fasciospongia turgida*						1B										
Order: Hadromerida																	
Suberitidae	*Suberites* sp.																
Tethyidae	*Tethya* sp.																
	Tethya pellis																
Order: Halichondrida																	
Halichondriidae	*Halichondria* sp.												1P				
	Halichondria panicea																
Hymeniacidonidae	*Hymeniacidon perleye*																
Order: Haplosclerida																	
Callyspongiidae	*Callyspongia* sp.																
	Challinissa communis						1B										
	Dactylia palmata Carter																
Coelosphaeridae	*Coelospharea verrucosa*												1P				
Haliclonidae	*Haliclona* sp.											1P					
	Haliclona sp. 1												1P				
	Haliclona sp. 2												1P				
	Haliclona sp. 3																
Uncertain	*Echinoclathria* sp.	1Q															
Order: Poecilosclerida																	
Raspailiidae	*Raspailia* sp.																
Tedaniidae	*Tedania* sp.																
Calcarea																	
Order: Leucosoleniida																	
Sycettidae	*Sycon* sp.											1P	1P			1P	
	Sycon sp. 1							1P				1P	1P			1P	
	Sycon sp. 2											1P				1P	
	Sycon gelatinosum												1P				

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample, 1B: 1 beach survey sample

TABLE 4.2.3: PORIFERAN FAUNA COLLECTED FROM PORT KEMBLA (continued)

Family, etc.	Species	Outer Harbour			Inner Harbour Sites												
		ILB	NBI	MPO	PW1	DW1	DW2	ACI	WRR	PW2	MPB	GBI	B1I	ERR	BCB	OCB	MPI
Demospongiae																	
Order Chondrosida																	
Chondosiidae	*Chondrosia* sp.																
Order: Dendroceratida																	
Darwinellidae	*Chelonaplysilla violacea* Lendenfeld										1P						
Order: Dictyoceratida																	
Irciniidae	*Ircinia* sp.									1P							
	Ircinia rubra									1P			1Q				
	Ircinia jacksoniana																
Dysideidae	*Dysidea* sp.	3P					1P			2P	2P	1P			2P		
	Dysidea sp. 1	1P									1P						
Thorectidae	*Fasciospongia turgida*																
Order: Hadromerida																	
Suberitidae	*Suberites* sp.														1P		
Tethyidae	*Tethya* sp.						1P			1P	1P	1P			2P		
	Tethya pellis														1P		
Order: Halichondrida																	
Halichondriidae	*Halichondria* sp.				2P				1P	2P		1P					
	Halichondria panicea												1Q				
Hymeniacidonidae	*Hymeniacidon perleye*						1P										
Order: Haplosclerida																	
Callyspongiidae	*Callyspongia* sp.												1Q				
	Challinissa communis flabellum																
	Dactylia palmata Carter													1Q			
Coelosphaeridae	*Coelospharea verrucosa*																
Haliclonidae	*Haliclona* sp.	2P							1P 1C		1P	1P				1P	
	Haliclona sp. 1	4P			1P		1P		3P 1C	3P	2P	4P		1Q	4P	2P	
	Haliclona sp. 2	1P	1Q									1Q					
	Haliclona sp. 3										1P						
Uncertain	*Echinoclathria* sp.																
Order: Poecilosclerida																	
Raspailiidae	*Raspailia* sp.																1Q
Tedaniidae	*Tedania* sp.								1P						1P	1P	
Calcarea																	
Order: Leucosoleniida																	
Sycettidae	*Sycon sp.*				1Q				1P						2P		
	Sycon sp. 1																
	Sycon sp. 2																
	Sycon gelatinosum						1P		1P	1P							

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample, 1B: 1 beach survey sample

4.2.4. Hydrozoans

The Class Hydrozoa belongs to the Phylum Coelenterata, the cnidarians, which includes the hydras, jellyfishes, sea anemones and corals (Barnes 1987). Marine hydrozoans, or hydroids, are generally small colonial branching forms, which are often plant-like in appearance, and are therefore not commonly recognised or well known, often being casually dismissed as "seaweeds". However, around 2700 species exist (Barnes 1987), and they are most commonly found attached to wharf pilings, rocks and shells.

Dr Jeanette Watson of the Hydrozoan Research Laboratory, Melbourne, identified the hydrozoans from the present study. A total of fifteen species from eleven families were identified (see Table 4.2.4). Six of these species were from the order Anthoathecatae and nine from the order Leptothecatae.

Most of the hydroids found in Port Kembla were collected from wharf pile scrapings, often attached to worm tubes. According to Dr Watson, Port Kembla Harbour is not a good habitat for hydrozoans, because it is "too enclosed and lacks circulation". Therefore, there is a relatively low number of species, most of which are present in low abundances.

Halecium vasiforme is an introduced hydrozoan previously known from Japan, and is possibly a new record for Australia. Only two small infertile colonies of the species were collected, from the No 1 (Bulk) Coal Berth (BCB) and the No 2 (Old) Coal Berth (OCB) sites in the Inner Harbour.

A second species, ***Clytia* sp. 1**, could possibly be introduced. However, because species of the genus *Clytia* are difficult to identify, no positive identification to the species level was possible. Therefore, for the purposes of this survey, the form collected is considered as cryptogenic. It could be an undescribed species, or possibly *Clytia delicata*, which is known from the Philippines and Japan. There was a high abundance of this species in samples collected from various sites in Port Kembla. It was found in wharf pile scraping samples collected from the No 3 Jetty (J3O) and No 6 Jetty (J6O) sites in the Outer Harbour, and from the No 1 Products Wharf (PW1), No 2 Discharge Wharf (DW2), BHP Roll-on Roll-off Berth (western) (WRR), No 2 Products Wharf (PW2), BCB and OCB sites in the Inner Harbour.

Three other cryptogenic species were also collected from Port Kembla. These were *Clytia hemisphaerica, Bougainvillia macloviana* and *Sarsia eximia*.

Clytia hemisphaerica is a cosmopolitan species which is abundant in Australian coastal waters. Specimens of this species were found in moderate abundances in pile scraping samples collected from the J6O and PW2 sites. It was also found in qualitative samples collected from the Western Revetment Wall (WRW) and PW1 sites.

Bougainvillia macloviana is known from New Zealand, South Africa and other areas in the Southern Ocean region. This species was common in samples collected during this survey. It was collected from wharf pile scraping samples taken from the J3O, J6O, DW2 and OCB sites. It was also collected from qualitative samples taken at the Multi-Purpose Berth (MPB) site.

Sarsia eximia is a cosmopolitan species which is common in coastal waters of southern Australia. Only one fertile colony was found, in a qualitative sample collected at the PW1 site.

TABLE 4.2.4: HYDROZOAN FAUNA COLLECTED FROM PORT KEMBLA

Family, etc.	Species	Open Coast Sites								Outer Harbour Sites							
		BGI	NSS	NBO	EBO	SRS	SSS	WHB	WHH	EBI	BHO	J4O	J3O	SGO	WRW	J6O	WIO
Anthoathecatae																	
Aequoreidae	*Aequorea phillipensis*																
Bougainvilliidae	*Bougainvillia macloviana* **												1P			5P	
Coryniidae	*Sarsia eximia* **																
Cladonematidae	*Staurocladia haswelli*																
Clavidae	*Tubiclava* sp.												1P				
Family unknown	Anthoathecate sp.																
Leptothecatae																	
Campanulariidae	*Clytia* sp. 1 **												1P			3P	
	Clytia hemisphaerica **														1Q	1P	
	Clytia stolonifera																
	Clytia serrulata																
Eireneidae	*Eirene* sp.																
Aglaopheniidae	*Gymnangium longirostre*											1P					
Haleciidae	*Halecium delicatulum*												2P			1P	
	Halecium vasiforme *																
Sertulariidae	*Stereotheca elongata*								1Q								

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample; * introduced species, ** cryptogenic species

TABLE 4.2.4: HYDROZOAN FAUNA COLLECTED FROM PORT KEMBLA (continued)

Family, etc.	Species	Outer Harbour			Inner Harbour Sites												
		ILB	NBI	MPO	PW1	DW1	DW2	ACI	WRR	PW2	MPB	GBI	B1I	ERR	BCB	OCB	MPI
Anthoathecatae																	
Aequoreidae	*Aequorea phillipensis*								1P						1P	2P	
Bougainvilliidae	*Bougainvillia macloviana* **						3P				1Q					1P	
Coryniidae	*Sarsia eximia* **				1Q												
Cladonematidae	*Staurocladia haswelli*														1P		
Clavidae	*Tubiclava* sp.					1P											
Family unknown	Anthoathecate sp.				1P												
Leptothecatae																	
Campanulariidae	*Clytia* sp. 1 **				3P		2P		1P	2P					2P	2P	
	Clytia hemisphaerica **				2Q					1P							
	Clytia stolonifera				1Q												
	Clytia serrulata				1P												
Eireneidae	*Eirene* sp.														1P		
Aglaopheniidae	*Gymnangium longirostre*																
Haleciidae	*Halecium delicatulum*				1Q										2P		
	Halecium vasiforme *														2P	1P	
Sertulariidae	*Stereotheca elongata*	1C															

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample; * introduced species, ** cryptogenic species

4.2.5. Anthozoans

The coelenterate Subphylum Anthozoa comprises the anemones, the hard and soft corals and the sea pens, which occur as either solitary polyps or colonies of polyps (Edgar 2000, Barnes 1987).

The scleractinians, or hexacorals, are hard or stony corals, the living polyps of which are encased inside a hard calcareous skeleton. They include the reef building corals which are most common in tropical waters. Non-reef building forms frequently occur in more temperate regions, such as at Port Kembla.

A total of 58 samples of hexacorals were collected during the Port Kembla survey. It appeared that all of the specimens were of the same type, identified as *Culicia c.f. tenella* (Table 4.2.5). This was confirmed by Dr Peter Harrison of Southern Cross University, Lismore, NSW.

The widespread (probably cryptogenic) species ***Culicia tenella*** is relatively common in temperate Australian waters, where it is found from Perth in Western Australia to the Solitary Islands in NSW, including around Tasmania (Edgar 2000).

TABLE 4.2.5: ANTHOZOAN FAUNA COLLECTED FROM PORT KEMBLA

Family, etc.	Species	Open Coast Sites								Outer Harbour Sites						
		BGI	NSS	NBO	EBO	SRS	SSS	WHB	WHH	EBI	BHO	J4O	J3O	SGO	WRW	J6O
Order Scleractinia																
Rhizangiidae	*Culicia c.f. tenella* **							1P		2Q			2P 3C			7P 2C

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample; ** cryptogenic species

TABLE 4.2.5: ANTHOZOAN FAUNA COLLECTED FROM PORT KEMBLA (continued)

Family, etc.	Species	Outer Harbour Sites				Inner Harbour Sites												
		WIO	ILB	NBI	MPO	PW1	DW1	DW2	ACI	WRR	PW2	MPB	GBI	B1I	ERR	BCB	OCB	MPI
Order Scleractinia																		
Rhizangiidae	*Culicia c.f. tenella* **					2P		7P 2C		4P	9P	1C	4P		1P 1C	6P	6P 3C	

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample; ** cryptogenic species

4.2.6. Polychaetes

The polychaete worms (Class Polychaeta) comprise the largest class of the annelid (or segmented) worms, with most species being marine. Polychaetes often dominate soft sediments in terms of both their abundance and numbers of species present.

Few previous studies have emphasised introduced polychaetes in Australian waters. A study by Hutchings *et al.* (1989) identified introduced species from various other invertebrate groups in Twofold Bay, New South Wales, but found no introduced polychaetes there. Records from the Australian Museum indicate a list of eight species which have been confirmed as introduced, or are likely to have been introduced, to Australian waters. These species include *Neanthes succinea* (possibly cosmopolitan*), Boccardia chilensis* (probably from Chile), *Pseudopolydora paucibranchiata* (probably from Japan*), Capitella capitata* (probably originally from California*), Sabella spallanzanii* (from the Mediterranean Sea), *Euchone limnicola* (probably from California*), Ficopomatus enigmaticus* (likely to be from Europe) and *Hydroides ezoensis* (thought to be from Japan). *Sabella spallanzanii* was introduced from southern Europe, and has been found in large numbers in Port Phillip Bay, Victoria. It has also been found in Northern Tasmania, Gulf St Vincent near Adelaide in South Australia, and Cockburn Sound in Western Australia (CSIRO Marine Research 1997), as well as in small numbers in Twofold Bay near Eden, New South Wales (D. Pollard and B. Rankin, pers. obs.).

The polychaetes collected from Port Kembla were examined by Dr Peggy O'Donnell from the Ecology Lab, Balgowlah, NSW (Table 4.2.6). A total of four introduced species were found amongst these samples. These were *Boccardia chilensis* and *B. proboscidea* (Fam. Spionidae) and *Hydroides ezoensis* and *H. dirampha* (Fam. Serpulidae).

Boccardia chilensis, was probably introduced to Australian waters from Chile, although Australian and New Zealand specimens differ slightly. In Australia it was previously found in New South Wales and Tasmania, and is found in various habitats, including on oysters, in benthos associated with oyster leases, in rock pools, among the tubes of other polychaetes (e.g. *Galeolaria caespitosa),* within mollusc shells and among coralline algae. It has frequently been found in estuaries with oyster leases, including the Cooks and Georges Rivers, both of which run into Botany Bay, New South Wales (P. O'Donnell, pers. comm.).

In the Port Kembla survey, five specimens of *Boccardia chilensis* were found from samples collected at the No 3 Jetty (J3O) site in the Outer Harbour. In the Inner Harbour, it was found at the No 1 Products Wharf (PW1), No 2 Discharge Wharf (DW2), No 2 Products Wharf (PW2) and No 1 (Bulk) Coal Berth (BCB) sites. This species was also collected during the introduced marine pests survey of Botany Bay in 1998 (Pollard and Pethebridge 2000).

Boccardia proboscidea was first recorded in Australian waters in Werribee Lagoon in Port Phillip Bay, Victoria (P. O'Donnell, pers. comm.). At this location it was found to be very abundant, being dominant in terms of numbers over other species present. Previously this species has been recorded from North America (California, Oregon and Panama) and Japan (P. O'Donnell, pers. comm.). *Boccardia proboscidea* has often been found among sediments which have been affected by sewage pollution, and therefore could become abundant in similar circumstances in other parts of Australia (P. O'Donnell, pers. comm.).

Only one specimen of this species was collected in the Port Kembla samples, from the Multi-Purpose Berth (MPB) site in the Inner Harbour.

Hydroides ezoensis is thought to have been introduced to Australian waters from Japan. It was previously collected from pylons on Glebe Island Bridge and other sites in Sydney Harbour, NSW (P. O'Donnell, pers. comm.).

At least three specimens of *Hydroides ezoensis* were found in the Port Kembla survey. These specimens were found in samples collected from the PW1 and MPB sites in the Inner Harbour. It is possible that more specimens may have been present, but positive identification was hindered because many of the specimens collected belonging to the Family Serpulidae were damaged.

Hydroides dirampha is thought to have been introduced to Australian waters via the hull fouling of ships arriving from tropical America. This species has probably only recently been introduced, having been first recorded from the hull of the replica tall ship "Bounty", which had sailed to Australia, retracing the original ship's journey, in 1998. Dr H. ten Hove was the polychaete researcher and serpulid specialist who collected the only previously confirmed Australian record of this species, which was found in Sydney Harbour. Dr ten Hove wrote the following account in relation to the world wide occurrence of *H. dirampha* (P. O'Donnell, pers. comm.):

"The species is fairly common in lagoonal habitats in the Caribbean (ten Hove, unpubl.). Almost all other records known to me (from literature, approx.40) are from harbours and ship's hulls. This might be an indication that the species originates from tropical American seas, and its distribution otherwise is man-made. The fact that *H. dirampha* is known under several specific names *(benzoni, cuminghii, cuminghii* var. *navalis*, *lunulifer, malleophorus, serratus)* is not as much an indication for variability, as well for the fact that its worldwide (sub) tropical distribution confused previous authors."

In the Port Kembla samples, *Hydroides dirampha* was the most common introduced polychaete species collected, with at least 63 specimens being found. This species has been known to form aggregations elsewhere, especially in lagoon habitats. The specimens collected during this survey were found at the No 4 (Bulk Liquids Berth) Jetty (J4O), J3O, No 6 Jetty (J6O) and the Inflammable Liquids Berth (ILB) in the Outer Harbour. In the Inner Harbour, it was found at the PW1, DW2, BHP Roll-on Roll-off Berth (western) (WRR), PW2, MPB, Grain Berth (GBI), BCB, and No 2 (Old) Coal Berth (OCB) sites.

TABLE 4.2.6: POLYCHAETE FAUNA COLLECTED FROM PORT KEMBLA

Family, etc.	Species	Open Coast Sites								Outer Harbour Sites						
		BGI	NSS	NBO	EBO	SRS	SSS	WHB	WHH	EBI	BHO	J4O	J3O	SGO	WRW	J6O
Ampharetidae																
Aphroditidae													1P			
Capitellidae								1C					2P			
Chaetopteridae								1P					2P			2P
Cirratulidae		1Q			1Q			1P	1Q			7P	8P 1C 1Q	1C		7P 1C 1Q
Dorvillidae																
Eunicidae								2P	1Q			4P	7P			6P
Flabelligeridae																
Goniadidae													1P 1C	1C		
Hesionidae								1P				1P	1P			6P
Lumbrineridae		1Q										3P	9P	1C	1Q	4P
Nephtyidae												2C	1C	1C		
Nereididae		1Q			1Q			1P 1C	1Q	1Q		7P	7P		2Q	8P
Onuphidae					1Q								4P 2C		1Q	
Orbiniidae												1P 1C	5P 1C			
Phyllodocidae												4P	5P			4P
Polynoidae												4P	8P		1Q	8P
Sabellidae												9P 1Q	9P		1Q	5P
Serpulidae	*Hydroides diramphа* *											4P	7P			6P
	Hydroides ezoensis *															
	Others	1Q						5P	1Q			8P 1Q	7P		1Q	6P 1C 1Q
Spionidae	*Boccardia chilensis* *												1P			
	Boccardia proboscidea *															
	Others	1Q										2P	6P			5P
Spirorbidae								2P	1Q							
Syllidae					1Q			4P	2Q			9P	8P			8P 1Q
Terebellidae												4P				
Trichobranchidae															1Q	

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample; * introduced species; ** cryptogenic species

TABLE 4.2.6: POLYCHAETE FAUNA COLLECTED FROM PORT KEMBLA (continued)

Family, etc.	Species	Outer Harbour Sites				Inner Harbour Sites											
		WIO	ILB	NBI	MPO	PW1	DW1	DW2	ACI	WRR	PW2	MPB	GBI	B1I	ERR	BCB	OCB	MPI
Ampharetidae													1P					
Aphroditidae																		
Capitellidae			4P					1P										
Chaetopteridae						3P		1P									2P	
Cirratulidae			9P			9P 1Q	1Q	7P 1C		9P	2P		3P	1Q		8P	9P	
Dorvillidae						1Q					1P							
Eunicidae			6P			7P 1Q		5P		1P	1P			2Q		2P	2P	
Flabelligeridae			1P															
Goniadidae			1P 2C															1C
Hesionidae						2P		1P		1P						1P	1P	
Lumbrineridae			6P			10P 1Q		4P		6P	2P		3P 1Q	1Q		6P	9P	
Nephtyidae			2C	1Q	1C	1C		1C		1L 1C			5C	1Q	1P 3C		4C	2C
Nereididae			8P	1Q		3P 1Q		7P		4P	2P		3P 1Q	1Q	1Q	4P		
Onuphidae																3P	5P 1C	
Orbiniidae			1C		3C	1C 1Q				1C	1P				1Q		1P 1C	2C
Phyllodocidae			1P							1P	1P		2P 1C		1C			
Polynoidae			7P	1C		8P 1Q	1Q	5P		2P	1P		2P 1C	1Q	1Q	4P	3P	
Sabellidae			6P	1C		5P 1Q	1Q	4P		5P	2P		3P			6P	7P	
Serpulidae	*Hydroides diramphа* *		5P			2P 1Q		6P 1C		3P	1P		3P			3P	6P	
	Hydroides ezoensis *					1P							4P 1Q		1Q	6P	8P	
	Others		8P			8P 1Q		7P		7P	2P							
Spionidae	*Boccardia chilensis* *					1P		1P								1P		
	Boccardia proboscidea *							6P		4P	1P							
	Others		4P			6P		1P					3P 1C		1Q	6P	4P	1Q
Spirorbidae						1P												
Syllidae			8P	1Q		8P 1Q	1Q	4P		7P	2P		4P 1C 1Q	1Q	1Q	8P	4P	
Terebellidae			6P			1Q	1Q			1P			1C	1Q		2P	1P	
Trichobranchidae															1C			

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample; * introduced species; ** cryptogenic species

4.2.7. Other worms

Other groups of worms collected from the Port Kembla samples included peanut worms (Phylum Sipunculida) and polyclad flatworms (Phylum Platyhelminthes, Order Polycladida).

The specimens belonging to these two groups were identified by Dr Leslie Newman of Southern Cross University, Lismore, NSW. Two species of sipunculids and ten species of polyclads were found in pile scrapings and qualitative samples (see Table 4.2.7). None of these were identified as being introduced. One polyclad species, **Enatiid sp. 1**, however, is a new record for Australia. Since enatiids have previously only been recorded from North America, this species is therefore considered to be cryptogenic.

The following summary has been extracted from Dr Newman's report on these samples:

A total of 12 taxa comprising 88 individuals were identified from 31 samples taken from Port Kembla. Of these, the polyclad flatworms were more abundant and diverse than the sipunculids.

Only two sipunculid species were collected from Port Kembla, from 4 sites (Table 4.2.7). This is surprising since they are detrital feeders and are usually found living within encrusting masses of tubiculous polychaetes and clumps of mussels, both of which were present on the pilings at Port Kembla. The most common species, *Phascolosoma annulatum* (Hutton 1879), was found in 3 samples, compared to *Themiste* sp., which was encountered in only one sample. The biodiversity of these worms was relatively low compared to Botany Bay (Newman, unpubl. data).

The peanut worm *Phascolosoma annulatum* is known from coastal areas around South Australia, Victoria and Tasmania (Edmunds 1980) and at Green Cape in NSW (P. Berents, pers. comm.). Records of this species from Port Kembla represent a northern extension of this species' range. It is not known whether or not this species may have been transported northwards into NSW by shipping. According to Berents (pers. comm.), there has never been a concerted study of these worms from coastal waters of NSW. Several species of *Themiste,* however*,* are known from NSW waters (Edmunds 1980).

Polyclad flatworms were relatively diverse in the Port Kembla samples, with a total of 10 taxa being collected from 11 separate sites (Table 4.2.7). Only one species was relatively abundant (Acotylean sp. 1), with 69 individuals collected from 8 sites. The remaining species were comparatively rare, with only 3 or less individuals of each being found at only 1 or 2 sites.

There are only two recent studies on polyclad flatworms from temperate Australian waters (Hyman 1959; Prudhoe 1982). Hyman (1959) reported 10 species from Collaroy, north of Sydney, NSW, and Prudhoe (1982) 18 species from southern Australian coasts (mainly South Australia). However, comparisons of these specimens with known records from this region cannot be made without detailed histological examination, including examination of morphological characters from whole mounts and anatomical features of the reproductive system from serial sections. Whether or not the species found may have been introduced to Port Kembla cannot be assessed without further such taxonomic studies.

It is not surprising that the majority of polyclads collected at Port Kembla belonged to the families Stylochidae and Planoceridae. Members of these families are commonly known as 'oyster leeches' and are notorious pests of commercial bivalves and barnacles (Prudhoe 1985, Jennings & Newman 1996).

The unusual occurrence of an extremely rare enatiid worm is a new record for Australia. Only two enatiid species are known, both from eastern North American coasts (Prudhoe 1985). The rarity of these worms precludes any conclusions on their possible distribution in Australian waters.

TABLE 4.2.7: "OTHER WORM" FAUNA COLLECTED FROM PORT KEMBLA

Family, etc.	Species	Open Coast Sites								Outer Harbour Sites							
		BGI	NSS	NBO	EBO	SRS	SSS	WHB	WHH	EBI	BHO	J4O	J3O	SGO	WRW	J6O	WIO
Order Sipunculida																	
Phascolosomidae	*Phascolosoma annulatum*															1P	
Golfingiidae	*Themiste* sp.																
Order Polycladida																	
Suborder Acotylea	Acotylean sp. 1	1Q										54P	3P			7P	
	Acotylean sp. 2																1P
	Acotylean sp. 4																
	Acotylean sp. 6																
	Acotylean sp. 9											1P					
Stylochidae	Stylochid sp. 2												2P				
Enatiidae	Enatiid sp. 1																
Suborder Cotylea																	
Eurylepidae	Eurylepid sp. 1												1P				
	Eurylepid sp. 2																
	Cotylean sp. 1																

Key: 1, 2 etc. = numbers of specimens collected; P: pile scraping sample; Q: qualitative sample

TABLE 4.2.7: "OTHER WORM" FAUNA COLLECTED FROM PORT KEMBLA (continued)

Family, etc.	Species	Outer Harbour			Inner Harbour Sites												
		ILB	NBI	MPO	PW1	DW1	DW2	ACI	WRR	PW2	MPB	GBI	B1I	ERR	BCB	OCB	MPI
Order Sipunculida																	
Phascolosomidae	*Phascolosoma annulatum*								2P		1P						
Golfingiidae	*Themiste* sp.														1P		
Order Polycladida																	
Suborder Acotylea	Acotylean sp. 1	1P							1P		1P				1P		
	Acotylean sp. 2																
	Acotylean sp. 4	1P															
	Acotylean sp. 6										1P						
	Acotylean sp. 9																
Stylochidae	Stylochid sp. 2						1P										
Enatiidae	Enatiid sp. 1											3Q					
Suborder Cotylea																	
Eurylepidae	Eurylepid sp. 1																
	Eurylepid sp. 2								2P								
	Cotylean sp. 1										1P						

Key: 1, 2 etc. = numbers of specimens collected; P: pile scraping sample; Q: qualitative sample

4.2.8. Crustaceans

More than 40,000 species of crustaceans (Phylum Crustacea) have been described worldwide, with probably around 100,000 species actually in existence (Edgar 2000). They occur in all marine and freshwater environments, and are often amongst the dominant groups of mobile animals in the plankton, seaweeds and sediments.

The crustaceans are divided into five main classes, including the Branchiopoda (water fleas), Cirripedia (barnacles), Copepoda (copepods), Ostracoda (mussel shrimps and seed shrimps) and Malacostraca (higher crustaceans).

4.2.8.1. Cirripedes

The Class Cirripedia, or barnacles, comprises about 1000 species worldwide, and in the adult stage they mostly live on rocks or other hard surfaces (Edgar 2000).

Dr Diana Jones, of the Western Australian Museum, Perth, identified the barnacles collected from Port Kembla. A total of nine species occurred, and these are listed in Table 4.2.8.1. They included six known fouling species, *Balanus amphritrite, Balanus trigonus, Balanus variegatus*, *Megabalanus rosa, Megabalanus tintinnabulum and Megabalanus zebra*. Three of these fouling species, *Megabalanus rosa, Megabalanus tintinnabulum* and *Megabalanus zebra*, have not previously been recorded from Port Kembla. The other three species are common NSW/eastern Australian intertidal and shallow water species.

Of the fouling species, one is considered to be introduced, while three are considered to be cryptogenic in origin. *Megabalanus rosa* was introduced to Australian waters from Japan, and *Megabalanus amphitrite, Megabalanus tintinnabulum* and *Megabalnus zebra* are all of cryptogenic origin, with the first two being cosmopolitan species.

Megabalanus rosa (or acorn barnacle) was probably introduced to Australia from Japan. It is also native to China and Taiwan. It was first recorded in Australia in 1981, from Port Hedland and Shark Bay in Western Australia (Furlani 1996). Previous to the introduced marine pests survey of Botany Bay (Pollard and Pethebridge 2000), this species had only been recorded from Western Australia.

In the Outer Harbour, specimens of *Megabalanus rosa* were collected in pile scraping samples from the No 4 (Bulk Liquids Berth) Jetty (J4O), No 3 Jetty (J3O), No 6 Jetty (J6O) and Inflammable Liquids Berth (ILB) sites. They were also collected from core samples taken from the J3O site and from qualitative samples taken from the BHP Saltwater Intake (WIO) site. In the Inner Harbour, specimens of this species were collected from core samples taken at the Grain Berth (GBI) site, and from qualitative samples taken from the Tom Thumb Road Bridge (B1I) site.

According to Dr Jones, *Megabalanus rosa* had previously been recorded from the north-western and central-western coasts of Western Australia, and now also from the lower east coast of Australia, with ships' hull fouling being the most likely introduction vector. The appearance of this species in Western Australia appears to be relatively recent, with the first specimens having been collected in 1981. Allen (1953) recorded *M. rosa,* together with *M. volcano* and *B. albicostatus*, on aircraft carriers and other vessels returning to Australia after service in Korean and Japanese waters, though it was not known where these vessels docked. Allen did not, however, record these species as becoming established on the Australian coastline. Pope (1945), in her key to the sessile barnacles found on rocks, boats, wharf piles and other installations in Port Jackson and adjacent waters, did not record *M. rosa* from this locality.

TABLE 4.2.8.1: CIRRIPEDE FAUNA COLLECTED FROM PORT KEMBLA

Family, etc.	Species	Open Coast Sites								Outer Harbour Sites							
		BGI	NSS	NBO	EBO	SRS	SSS	WHB	WHH	EBI	BHO	J4O	J3O	SGO	WRW	J6O	WIO
Order Sessilia																	
Chthamalinae	*Chthamalus antennatus*																
Tetraclitidae	*Austrobalanus imperator*	1Q	1Q										1P			3P 1C	
	Tesseropora rosea																
Balanidae	*Balanus amphitrite* **																
	Balanus trigonus									2Q	1Q	15P	21P 2C	3C		21P 1C 1Q	
	Balanus variegatus				1Q			2P		1Q		12P	11P 3C		1Q	15P 1C	2Q
	Megabalanus rosa *											4P	8P 2C			12P	1Q
	Megabalanus tintinnabulum **																
	Megabalanus zebra **															1P	

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample; * introduced species; ** cryptogenic species

TABLE 4.2.8.1: CIRRIPEDE FAUNA COLLECTED FROM PORT KEMBLA (continued)

Family, etc.	Species	Outer Harbour			Inner Harbour Sites												
		ILB	NBI	MPO	PW1	DW1	DW2	ACI	WRR	PW2	MPB	GBI	B1I	ERR	BCB	OCB	MPI
Order Sessilia																	
Chthamalinae	*Chthamalus antennatus*												2Q				
Tetraclitidae	*Austrobalanus imperator*												3Q				
	Tesseropora rosea																
Balanidae	*Balanus amphitrite* **						1P		1C		1C	1C 1Q		1C		2P	
	Balanus trigonus	20P 1C	1Q		15P	2P	5P 1C		14P	16P	12P	9P 1C 2Q	4Q	1P 1Q	11P 1C	6P	
	Balanus variegatus	14P 2C	2Q		10P 1C	2P	11P		15P 3C	12P 2C	22P 1C	15P 2Q		3P 2C 3Q	11P 2C	12P	
	Megabalanus rosa *	1P			1Q							1C	1Q				
	Megabalanus tintinnabulum **						1C								1P 1C		
	Megabalanus zebra **											2C	1Q				

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample; * introduced species; ** cryptogenic species

4.2.8.2. Malacostracans

The remainder of the crustaceans collected from Port Kembla were identified as belonging to the Class Malacostraca. The malacostracans include the familiar prawns, lobsters and crabs. Dr Gary Poore from Museum Victoria, Melbourne, identified the malacostracans collected from Port Kembla. Table 4.2.8.2 lists the taxa collected during the survey. These included representatives from the Orders Isopoda, Amphipoda, Tanaidacea, Mysidacea, Brachyura, Caridea, Anomura, Thallassinidea, Dendrobranchiata and Pycnogonida.

The isopods are a very large group of crustaceans which includes the pill bugs and slaters, with most of the 10,000 or so described species being marine (Barnes 1987, Edgar 2000).

The isopods collected from Port Kembla during the present survey comprised eight species from five families, and included three introduced and five endemic species. The introduced species found were *Cirolana harfordi*, *Paracerceis sculpta* and *Sphaeroma walkeri.*

Cirolana harfordi (Lockington, 1877), from the Family Cirolanidae, originated from western North America, with a natural range from British Columbia to Baja California. It now also occurs in Japan, eastern Russia and Malaysia. The first Australian record was from 1972, when it was found amongst hull scrapings from a boat at Waverton in Sydney Harbour, NSW. In 1980 it was recorded in the Swan River at Fremantle in WA, and at Lorne in Victoria. In 1999 it was recorded from Port Phillip Bay in Victoria (Poore and Storey 1999).

This species tends to congregate around the lower intertidal zone. In the USA and Japan, very high densities of *Cirolana harfordi* have been found. It lives in sheltered positions, such as under rocks on beaches, or in the shells or tubes of dead animals (e.g. barnacles or polychaetes). In California, females produce eggs throughout the year. *Cirolana harfordi* is a scavenger, preying mostly on polychaetes and small crustaceans.

So far only low densities of this species have been recorded in Australia. However, if numbers were to increase it could compete with several native species of cirolanids (Poore and Storey 1999). This species was only found at one site in Port Kembla, at the No 6 Jetty (J6O) site, from a pile scraping sample taken just below the surface. Therefore, it seems that this species does not pose any threat to native fauna in this port at this stage.

Four isopod species from the Family Sphaeromatidae are known to have been introduced to Australian waters. Two of these, *Paracerceis sculpta* and *Sphaeroma walkeri,* were found during the Port Kembla survey. The other two known introduced species not found were *Paradella dianae* and *Sphaeroma serratum.* There are about 200 species of this family which are native to Australian waters (Poore and Storey 1999).

Paracerceis sculpta (Holmes, 1904) was introduced to Australian waters from California, with its natural range probably extending from California to Mexico. It was first recorded from Australia at Townsville, Queensland, in 1975, and is also found in Port Phillip Bay, Victoria (Poore and Storey 1999).

This species has been well studied in its native environment. It is nocturnal, with the juvenile stages living amongst subtidal coralline algae, and the adult stages living inside the cavities of sponges in the mid-intertidal zone (Poore and Storey 1999). The species is sexually dimorphic, with three male forms being known. These are the alpha-male, beta-male and gamma-male. All three forms will mate with female forms and alpha males form harems of up to 50 females while competing with individuals of the smaller forms for successful mating. Females only reproduce

once in their lifetime. It is difficult to identify females and juveniles of this species without accompanying males. This species is so rarely found in Australia that Poore and Storey (1999) consider that there may be no established breeding populations here.

During the Port Kembla survey, this species was only found at one site, in a qualitative sample collected at the Wollongong Harbour (Boat Basin) (WHB) on the Open Coast. One specimen of this species was also found in the samples collected during the introduced marine pests survey of Botany Bay (Pollard and Pethebridge 2000).

Sphaeroma walkeri Stebbing, 1905 is a sessile biofouling isopod with a body less than 10 mm in length. It lives in marine and estuarine intertidal areas, occupying empty barnacle shells and spaces amongst fouling communities on rock outcrops, rock jetties or other man-made structures. Its distribution is limited to waters with a minimum surface temperature of 15^{o}C (Furlani 1996).

This species is native to the northern Indian Ocean. The first Australian records were from NSW in 1927 and Queensland in 1967. The known Australian distribution is from Ross Creek, Townsville, in Queensland, to Sydney (Port Jackson, Darling Harbour and Blackwattle Bay) in NSW. The impact of this species in Australian waters is not known (Furlani 1996). It was probably introduced to Australia on ships' hulls.

In Port Kembla, *S. walkeri* was found in pile scraping samples collected from at a total of twelve sites. In the Outer Harbour, it was found in samples from the No 4 (Bulk Liquids Berth) Jetty (J4O), No 3 Jetty (J3O), J6O, the BHP Saltwater Intake (WIO) and the Inflammable Liquids Berth (ILB) sites. In the Inner Harbour, specimens of this species were collected from the No 1 Products Wharf (PW1), No 2 Discharge Wharf (DW2), No 2 Products Wharf (PW2), Multi-Purpose Berth (MPB), Grain Berth (GBI), No 1 (Bulk) Coal Berth (BCB) and No 2 (Old) Coal Berth (OCB) sites. Jetty 6 provided the most samples (17) containing specimens of this species. The PW2, GBI and MPB sites also provided substantial numbers of samples (9, 7 and 6, respectively) containing *S. walkeri*.

The amphipods, or beach hoppers, comprise about 8000 described and many times more undescribed species (Edgar 2000). The amphipods collected from Port Kembla included a total of 22 species from 15 families. Four of these species are known to have been introduced to Australian waters from overseas, and two species are cosmopolitan (i.e. found in waters throughout the world). The introduced species collected were *Corophium acutum* Chevreux, 1908, *Paradexamine pacifica* (Thompson, 1879*), Liljeborgia c.f. dellavallei* Stebbing, 1906, and *Elasmopus rapax* Costa, 1853. The cosmopolitan species were *Caprella equilibra* Say, 1818, and *Stenothoe valida* Dana, 1852.

Corophium acutum was probably introduced to Australian waters from the Mediterranean Sea. It was first recorded in New Zealand in 1880, and in Australia in 1937 (Poore and Storey 1999). The genus *Corophium* contains about 60 species that occur in freshwater, marine and estuarine waters in temperate and tropical latitudes. Several species of this genus have been transported to harbours around the world via shipping, and some have caused mass invasions. About six species of this genus have been introduced to Australian waters. Several undescribed native species also occur (Poore and Storey 1999).

In Port Kembla, *C. acutum* was collected from one pile scraping sample from the BHP Roll-on Roll-off Berth (western) (WRR) site and four pile scraping samples from the GBI site. This species was also extremely abundant in the samples collected during the introduced marine pests survey of Botany Bay (Pollard and Pethebridge 2000).

Paradexamine pacifica was introduced to Australia from New Zealand. This species was found in one pile scraping sample from the J3O site in the Outer Harbour of Port Kembla.

Liljeborgia c.f. dellavallei was introduced to Australia from the Mediterranean Sea. This species was found in qualitative and quantitative pile scraping samples from sixteen different sites in Port Kembla. These sites included two sites on the open coast (BGI and WHH); 5 sites in the Outer Harbour (J3O, J4O, J6O, ILB and NBI); and 9 sites in the Inner Harbour (PW1, DW2, WRR, PW2, MPB, GBI, ERR, BCB and OCB).

Elasmopus rapax was probably also introduced to Australia from the Mediterranean Sea. This species was extremely abundant throughout the samples collected from Port Kembla. It was found at 20 of the 32 sites sampled in and around the port. These sites included 3 on the Open Coast (BGI, WHB and WHH), 7 in the Outer Harbour (J4O, J3O, WRW, J6O, WIO, ILB and NBI), and 10 in the Inner Harbour (PW1, DW1, DW2, WRR, PW2, MPB, GBI, BII, BCB and OCB). Samples from each of these sites contained many specimens of this species. It was found in pile scraping samples as well as qualitative samples taken at these sites.

Caprella equilibra, from the Family Caprellidae, is a widespread cosmopolitan species of unknown origin. In the Port Kembla survey it was found in a qualitative sample from the Boat Harbour in Wollongong Harbour (WHH) on the Open Coast. This species was also found in the samples collected at two sites during the introduced marine pests survey of Botany Bay (Pollard and Pethebridge 2000).

Stenothoe valida is also a cosmopolitan species of unknown origin. In Port Kembla, it was found in a pile scraping sample taken at the J6O site in the Outer Harbour.

TABLE 4.2.8.2: MALACOSTRACAN FAUNA COLLECTED FROM PORT KEMBLA

Family, etc.	Species	Open Coast Sites								Outer Harbour Sites						
		BGI	NSS	NBO	EBO	SRS	SSS	WHB	WHH	EBI	BHO	J4O	J3O	SGO	WRW	J6O
ISOPODA																
Cirolanidae	*Cirolana harfordi* (Lockington, 1877) *															1P
	Cirolana australiense Hale, 1925								1Q				1P			2P
Leptanthuridae	*Accalathura* sp.				1Q											
Paranthuridae	*Paranthura senecio* Poore, 1984								1Q							
Seriolidae	*Seriolina eugeniae* (Nordenstam, 1933)													1C		1P
Sphaeromatidae	*Cymodoce coronata* (Haswell, 1882)															1P
	Paracerceis sculpta (Holmes, 1904) *							1P								
	Sphaeroma walkeri Stebbing, 1905 *											1P	2P			17P
AMPHIPODA																
Ampithoidae	*Ampithoe kava* Myers, 1985								1Q							
	Cymadusa setosa (Haswell, 1879)								2Q							
Aoridae	*Belmos ephippium* Myers, 1988				1Q											
	Belmos mollis Myers, 1988				1Q											
Caprellidae	*Caprella equilibra* Say, 1818 **								1Q							
Corophiidae	*Corophium acutum* Chevreux, 1908 *															
Cyproideiidae	*Cyproidea ornata* Haswell, 1879								1Q							
Dexaminidae	*Paradexamine pacifica* (Thomson, 1879) *												1P			
Eusiridae	Eusiriid sp.															
Hyalidae	*Hyale crassicornis* (Haswell, 1880)								1Q							
Iphimediidae	*Iphimedia discreta* Stebbing, 1910															
	Iphimedia sp.															
Ischyroceridae	*Ericthonius* sp.							1P	1Q				1P			2P
Leucothoidae	*Leucothoe brevidigitata* Miers, 1884				1Q								7P			
	Leucothoe commensalis Haswell, 1880															
Liljeborgiidae	*Liljeborgia c.f. dellavallei* Stebbing, 1906 *	1Q							2Q			5P	5P			3P
Melitidae	*Dulichiella australis* (Haswell, 1879)							3P	4Q				5P			1P
	Elasmopus rapax Costa, 1853 *	1Q						1P	3Q			6P	13P		1Q	14P 1Q
	Maera sp.								1Q			1P				
	Mallacoota subcarinata (Haswell, 1879)				1Q				2Q							
	Melita matilda Barnard, 1972															
Stenothoidae	*Stenothoe valida* Dana, 1852 **															1P
TANAIDACEA																
Paratanaidae	Australian spp. not described												2P			1P
Tanaidae	*Tanais* sp.															
MYSIDACEA																
Mysidae	*Heteromysis abrucei* Bacescu, 1979												1P			
BRACHYURA																
Grapsidae	*Plagusia chabrus* (Linnaeus, 1758)															
	Ilyograpsus paludicola (Rathburn,)								1Q							
Hymenosomatidae	*Elamenopsis octagonalis* (Kemp, 1917)															
	Halicarcinus ovatus Stimpson, 1853								1Q			2P	4P			3P
Leucosiidae	*Phlyxia dentifrons* (Miers, 1886)															
Majidae	*Hyastenas elatus* Griffin & Tranter, 1986															
	Notomithrax minor (Filhol, 1885)															
Ocypodidae	*Enigmaplax littoralis* Davie, 1993															
Pilumnidae	*Pilumneopeus serratifrons* (Kinahan,1856)	1Q						1P				3P	5P			2P 1Q
	Pilumnus fissifrons Stimpson 1858											1P	6P			2P
Pinnotheridae	Pinnotherid sp.				1Q											
Portunidae	*Charybdis feriata* (Linnaeus, 1758)															
	Charybdis sp.												1P			
	Nectocarcinus integrifrons (Latreille, 1825)															
	Ovalipes australiensis Stephenson & Rees, 1968						1S									
	Thalamita sp.							2P					1P			
Xanthidae	*Xanthias elegans*															
CARIDEA																
Alpheidae	*Alpheus euphrosyne* De Man, 1897															
	Alpheus socialis Heller, 1865											2P	10P			1P
Palaemonidae	*Macrobrachium intermedium* (Stimpson, 1860)															
	Macrobrachium novaehollandiae (De Man, 1908)															
Rhynchocinetidae	*Rhynchocinetes serratus* Milne Edwards, 1837															
ANOMURA																
Porcellanidae	*Pisidia dispar* (Stimpson, 1858)															
THALASSINIDEA																
Callianassidae	*Biffarius arenosus* (Poore, 1975)											1C				
DENDROBRANCHIATA																
Penaeidae	*Penaeus* sp.															
PYCNOGONIDA																
Ammotheidae	*Achelia assimilis*												1C			

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample; 1T 1 crab trap sample; * introduced species; ** cryptogenic species

TABLE 4.2.8.2: MALACOSTRACAN FAUNA COLLECTED FROM PORT KEMBLA (continued)

Family, etc.	Species	Outer Harbour Sites				Inner Harbour Sites											
		WIO	ILB	NBI	MPO	PW1	DW1	DW2	ACI	WRR	PW2	MPB	GBI	B1I	ERR	BCB	OCB	MPI
ISOPODA																		
Cirolanidae	*Cirolana harfordi* (Lockington, 1877) *																	
	Cirolana australiense Hale, 1925		2P											1Q	1Q			
Leptanthuridae	*Accalathura* sp.																	
Paranthuridae	*Paranthura senecio* Poore, 1984																	
Seriolidae	*Seriolina eugeniae* (Nordenstam, 1933)																	
Sphaeromatidae	*Cymodoce coronata* (Haswell, 1882)																	
	Paracerceis sculpta (Holmes, 1904) *																	
	Sphaeroma walkeri Stebbing, 1905 *	2Q	2P			4P		3P			9P	6P	7P			3P	1P	
AMPHIPODA																		
Ampithoidae	*Ampithoe kava* Myers, 1985																	
	Cymadusa setosa (Haswell, 1879)			1Q														
Aoridae	*Belmos ephippium* Myers, 1988													1Q				
	Belmos mollis Myers, 1988																	
Caprellidae	*Caprella equilibra* Say, 1818 **																	
Corophiidae	*Corophium acutum* Chevreux, 1908 *									1P			4P					
Cyproideiidae	*Cyproidea ornata* Haswell, 1879		1P															
Dexaminidae	*Paradexamine pacifica* (Thomson, 1879) *																	
Eusiridae	Eusiriid sp.					1P								1Q				
Hyalidae	*Hyale crassicornis* (Haswell, 1880)																	
Iphimediidae	*Iphimedia discreta* Stebbing, 1910																	
	Iphimedia sp.			1Q						1P	1P						1P	
Ischyroceridae	*Ericthonius* sp.	1Q						1P										
Leucothoidae	*Leucothoe brevidigitata* Miers, 1884		2P	1Q		2P				2P		1P		1Q				
	Leucothoe commensalis Haswell, 1880		2P															
Liljeborgiidae	*Liljeborgia c.f. dellavallei* Stebbing, 1906 *		8P	1Q		2P		5P		1Q	3P	1P	9P		2Q	6P	1P	
Melitidae	*Dulichiella australis* (Haswell, 1879)		1P											1Q				
	Elasmopus rapax Costa, 1853 *	1Q	12P	2Q		1P	1Q	4P		5P	7P	4P	9P 2Q	2Q		3P	6P	
	Maera sp.					1P										1P		
	Mallacoota subcarinata (Haswell, 1879)																	
	Melita matilda Barnard, 1972												1P					
Stenothoidae	*Stenothoe valida* Dana, 1852 **																	
TANAIDACEA																		
Paratanaidae	Australian spp. not described																	
Tanaidae	*Tanais* sp.																	
MYSIDACEA																		
Mysidae	*Heteromysis abrucei* Bacescu, 1979		1P															
BRACHYURA																		
Grapsidae	*Plagusia chabrus* (Linnaeus, 1758)																	
	Ilyograpsus paludicola (Rathbun,)																	
Hymenosomatidae	*Elamenopsis octagonalis* (Kemp, 1917)		1P															
	Halicarcinus ovatus Stimpson, 1853		1P			1P		1P										
Leucosiidae	*Phlyxia dentifrons* (Miers, 1886)																	
Majidae	*Hyastenas elatus* Griffin & Tranter, 1986							1P										
	Notomithrax minor (Filhol, 1885)																	
Ocypodidae	*Enigmaplax littoralis* Davie, 1993																	
Pilumnidae	*Pilumneopeus serratifrons* (Kinahan,1856)		7P 1C	1Q		5P		9P		12P	10P	7P	5P			11P	7P	
	Pilumnus fissifrons Stimpson 1858		2P			4P						1P	2P				1P	
Pinnotheridae	Pinnotherid sp.																	
Portunidae	*Charybdis feriatus* (Linnaeus, 1758)											1T	1T					
	Charybdis sp.		1P															
	Nectocarcinus integrifrons (Latreille, 1825)																	
	Ovalipes australiensis Stephenson & Rees, 1968																	
	Thalamita sp.		1P			2P												
Xanthidae	*Xanthias elegans*			1P														
CARIDEA																		
Alpheidae	*Alpheus euphrosyne* De Man, 1897						1C			5P 2D			2P			1C		
	Alpheus socialis Heller, 1865		3P															
Palaemonidae	*Macrobrachium intermedium* (Stimpson, 1860)															1P		
	Macrobrachium novaehollandiae (De Man, 1908)								1CT									
Rhynchocinetidae	*Rhynchocinetes serratus* Milne Edwards, 1837		1P															
ANOMURA																		
Porcellanidae	*Pisidia dispar* (Stimpson, 1858)																	
THALASSINIDEA																		
Callianassidae	*Biffarius arenosus* (Poore, 1975)		2D		1C					1C		2C	1C		1C 1D	1C	2C	
DENDROBRANCHIATA																		
Penaeidae	*Penaeus* sp.		1C															
PYCNOGONIDA																		
Ammotheidae	*Achelia assimilis*																	

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample; 1T 1 crab trap sample; * introduced species; ** cryptogenic species

4.2.9. Molluscs

The molluscs (Phylum Mollusca) are invertebrates with bodies comprising a head and a muscular foot separated by a visceral mass containing the digestive, reproductive and excretory organs. This visceral mass is covered by a sheet of tissue called the mantle, with a space (the mantle cavity) between it and the visceral mass for the gills. In many groups a calcareous external shell, secreted by the mantle, protects the animal. However, in some forms this shell has been reduced or is internal or absent (Edgar 2000). Despite having the same overall morphological pattern, various mollusc groups include species with different body forms, such as clams, snails, squids and chitons.

John Pogonoski, from the Australian Museum, Sydney, identified the molluscs collected from Port Kembla. These molluscs are listed in Table 4.2.9. A total of 72 species were identified from these Port Kembla samples. These included 46 gastropod species from 21 families, and 26 bivalve species from 17 families. Other molluscs that commonly occur in Australian waters include the chitons (coat-of-mail shells) and the cephalopods (squid, octopus and cuttlefish). No species from these groups were collected in the Port Kembla samples during this survey.

The gastropods form the largest and most widespread class of molluscs. This group includes the abalones, limpets, periwinkles, cowries, tritons, whelks and many other sea snail families (Edgar 2000). Many gastropods possess a right handed, spirally-coiled shell into which the animal can withdraw. The entrance is sealed by a rounded lid-like structure, the operculum. Members of the bivalve class (also known as pelycepods or lamellibranchs) possess two valves, which are joined at the margin by an elastic ligament and associated hinge teeth (Edgar 2000).

Although no previous comprehensive survey of molluscs has been undertaken in Port Kembla, many more species (235) have been recorded previously from Shell Harbour, just to the south of Port Kembla. The smaller number of species collected from Port Kembla may be a result of the brief sampling period of the present study, as well as the fact that more species could have been collected there in soft sediments using other sampling techniques, such as benthic grabs. Many of the mollusc species collected in Port Kembla (67% of the gastropods and 26% of the bivalves) occurred in only small numbers and at only a single site (J. Pogonoski, pers. comm.).

A total of nine introduced mollusc species (7 gastropods and 2 bivalves) are known to occur in the greater Sydney Region. Some of these may possibly also occur in Port Kembla, though no introduced species were amongst those molluscs collected during the Port Kembla survey (J. Pogonoski, pers. comm.).

***Mytilus galloprovincialis*,** the blue mussel, was the single cryptogenic species collected in the Port Kembla samples. This species is known to have a wide distribution throughout the world, though the origin of the Australian form is unknown. It may have arrived in Australia during the early days of European colonisation, possibly carried there on the hulls of sailing ships from the Northern Hemisphere (Anon. 2001). This species was previously known as *Mytilus edulis* or *M. planulatus* in southern Australian waters, where it is farmed commercially.

In the Port Kembla survey collections, *Mytilus galloprovincialis* was the dominant mollusc found in terms of numbers of individuals, with 707 specimens being collected. It was also widely distributed amongst the sites, being found at 19 of the 32 sites surveyed. This species occurred at the Big Island (BGI) site on the Open Coast, and was also collected from most of the sites (7 out of 11) in the Outer Harbour. These included the No 4 (Bulk Liquids Berth) Jetty (J4O), No 3 Jetty (J3O), Western Revetment Wall (WRW), No 6 Jetty (J6O), BHP Saltwater Intake (WIO), Inflammable Liquids Berth (ILB) and Northern Breakwater (NBI) sites. In the Inner Harbour,

Mytilus galloprovincialis was also collected from most of the sites (11 out of 13) surveyed. These included the No 1 Products Wharf (PW1), No 1 Discharge Wharf (DW1), No 2 Discharge Wharf (DW2), BHP Roll-on Roll-off Berth (western) (WRR), No 2 Products Wharf (DW2), Multi-Purpose Berth (MPB), Grain Berth (GBI), Tom Thumb Road Bridge (B1I), ANL Roll-on Roll-off Berth (eastern) (ERR), No 1 (Bulk) Coal Berth (BCB) and No 2 (Old) Coal Berth (OCB) sites. The largest numbers of this species were collected at the J6O (322) and J3O (133) sites in the Outer Harbour.

Other numerically dominant bivalve species found in the Port Kembla samples included *Hiatella australis* (437 individuals), the native mud oyster *Ostrea angasi* (250 individuals), and the galeomatid *Kellia* sp. (17 individuals). Numerically dominant gastropods included the scavenging nassariids *Nassarius jonasii* (426 individuals) and *Nassarius burchardi* (78 individuals), as well as the trochid *Bankivia fasciata* (47 individuals). No more than 10 individuals of each of the other gastropod species found occurred in the samples (J. Pogonoski, pers. comm.).

TABLE 4.2.9: MOLLUSCAN FAUNA COLLECTED FROM PORT KEMBLA

Family, etc.	Species	Open Coast Sites								Outer Harbour Sites							
		BGI	NSS	NBO	EBO	SRS	SSS	WHB	WHH	EBI	BHO	J4O	J3O	SGO	WRW	J6O	WIO
GASTROPODA																	
Batillariidae	*Batillaria australis*		1(d)														
Calyptraeidae	*Crepidula aculeata*													1(d)			
Columbellidae	*Mitrella australis*								1(d)				1(d)			1(d)	
	Mitrella c.f. semiconvexa															1(d)	
	Mitrella c.f. tayloriana				2(d)				3(d)							1(d)	
	Mitrella sp.															3(d)	
Ellobiidae	*Ophicardelus ornatus*																
Fissurellidae	*Notomella candida*															1(d)	
	Montfortula rugosa								2(d)								
	Tugali parmophoidea																
Haliotidae	*Haliotis coccoradiata*																
	Haliotis rubra																
Hipponicidae	*Antisabia foliacea*											1(d)					
Janthinidae	*Janthina janthina*								1(d)								
Littorinidae	*Bembicium auratum*						1(d)										
	Bembicium nanum																
Lottiidae	*Scutellastra chapmani*																
Marginellidae	*Austroginella muscaria*															4(d)	
	Mesoginella translucida																
Muricidae	*Agnewia tritoniformis*						1(d)	2	1(d)			4				4	
	Bedeva hanleyi												1				
	Dicathais orbita						2(d)									1	
	Morula marginalba								1								
Nacellidae	*Cellana tramoserica*						1(d)		1(d)								
Nassariidae	*Nassarius burchardi*							1(d)				5(d)	15(d)	4(d)			
	Nassarius jonasii						1(d)	1(d)				25(d)	77	5(d)		9	
	Nassarius nigellus																
	Nassarius particeps																
	Nassarius sp.															1(d)	
Naticidae	*Conuber conicum*																
Olividae	*Cupidoliva nympha*															1(d)	
Ranellidae	*Cabestana spengleri*												1			4	1
	Cymatium parthenopeum											2	6			3	
Trochidae	*Austrocochlea porcata*							1(d)								1(d)	
	Bankivia fasciata													1(d)		46(d)	
	Cantharidella picturata								1								
	Clanculus plebejus																
	Eurytrochus strangei								1							1(d)	
	Granata imbricata						1 (d)										
	Herpetopoma aspersa																
	Leiopyrga lineolaris													1(d)		9(d)	
	Notogibbula bicarinata																
	Stomatella impertusa																
Turbinidae	*Astralium tentoriformis*								1								
	Turbo torquatus																
Turridae	*Austrodrilla c.f. angasi*											1(d)					
BIVALVIA																	
Anomiidae	*Anomia trigonopsis*																
	Monia zelandica									1pr							
Arcidae	*Barbatia pistachia*																
Cardiidae	*Fulvia tenuicostata*											1v(d)	1v(d)				
Carditidae	*Cardita excavata*													1pr 4v(d)			
Donacidae	*Donax deltoides*						1v(d)										
Galeommatidae	*Kellia* sp.											1pr	2v(d)			4pr 1v	
Hiatellidae	*Hiatella australis*	4pr								1pr		15pr	44pr 3v		3pr	35pr 4v	
Limidae	*Lima lima vulgaris*													1v(d)			
	Limatula strangei													1v(d)			
Lucinidae	*Codakia rugifera*																
Mactridae	*Spisula trigonella*													5v(d)			
Myochamidae	*Myadora* sp.													1pr(d)		1v(d)	
Mytilidae	*Musculus alganus*				3pr												
	Musculus cumingianus												1v(d)				
	Musculus sp. 1																
	Mytilus galloprovincilis **	1pr 5v										44pr	133pr 3v		7pr	322pr 1v	22pr
	Trichomusculus barbatus												2pr			2pr 4v	
	Trichomya hirsuta						3v(d)	2v(d)									
Ostreidae	*Ostrea angasi*				1v(d)			20pr 54v				3pr 2v	67pr 34v	1v(d)	15v(d)	43pr 4v	1pr
	Saccostrea glomerata																
Pectinidae	*Scaeochlamys livida*						1v(d)										
Pholadidae	*Pholas australasiae*																
Tellinidae	*Tellina deltoidalis*							1v(d)						1v(d)			
Veneridae	*Irus crenatus*														1pr		
	Venerupis anomala												1pr				

TABLE 4.2.9: MOLLUSCAN FAUNA COLLECTED FROM PORT KEMBLA (continued)

Family, etc.	Species	Outer Harbour			Inner Harbour Sites										
		ILB	NBI	MPO	PW1	DW1	DW2	WRR	PW2	MPB	GBI	B1I	ERR	BCB	OCB	MPI
GASTROPODA																
Batillariidae	*Batillaria australis*															
Calyptraeidae	*Crepidula aculeata*															
Columbellidae	*Mitrella australis*	1(d)														
	Mitrella c.f. semiconvexa															
	Mitrella c.f. tayloriana															
	Mitrella sp.															
Ellobiidae	*Ophicardelus ornatus*												1(d)			
Fissurellidae	*Notomella candida*															
	Montfortula rugosa															
	Tugali parmophoidea		1													
Haliotidae	*Haliotis coccoradiata*											1				
	Haliotis rubra											1(d)				
Hipponicidae	*Antisabia foliacea*															
Janthinidae	*Janthina janthina*															
Littorinidae	*Bembicium auratum*									1			1(d)			
	Bembicium nanum															
	Scutellastra chapmani											2(d)				
Marginellidae	*Austroginella muscaria*															
	Mesoginella translucida	1(d)														
Muricidae	*Agnewia tritoniformis*	3														
	Bedeva hanleyi															
	Dicathais orbita															
	Morula marginalba															
Nacellidae	*Cellana tramoserica*															
Nassariidae	*Nassarius burchardi*	34(d)		9(d)	1(d)				3(d)		1(d)		4(d)	1(d)		
	Nassarius jonasii	91(d)			26	21	1	16(d)	31(d)	16	35		35(d)	13	20	4(d)
	Nassarius nigellus			11(d)												
	Nassarius particeps											1(d)				
	Nassarius sp.															
Naticidae	*Conuber conicum*			1(d)												
Olividae	*Cupidoliva nympha*															
Ranellidae	*Cabestana spengleri*															
	Cymatium parthenopeum															
Trochidae	*Austrocochlea porcata*															
	Bankivia fasciata															
	Cantharidella picturata															
	Clanculus plebejus											4				
	Eurytrochus strangei															
	Granata imbricata															
	Herpetopoma aspersa	1(d)			1											
	Leiopyrga lineolaris	1(d)														
	Notogibbula bicarinata	1(d)										1				
	Stomatella impertusa											1				
	Astralium tentoriformis															
Turbinidae	*Turbo torquatus*											3(d)				
Turridae	*Austrodrilla c.f. angasi*															
BIVALVIA																
Anomiidae	*Anomia trigonopsis*	3v(d)						3pr 1v	7v(d)	1v(d)			1pr 1v(d)	1v(d)	1v(d)	1v(d)
	Monia zelandica				1pr			2v(d)		1v(d)						
Arcidae	*Barbatia pistachia*	1pr	1pr						2pr					1pr		
Cardiidae	*Fulvia tenuicostata*															
Carditidae	*Cardita excavata*															
Donacidae	*Donax deltoides*															
Galeommatidae	*Kellia* sp.	3pr 2v			2pr 1v			2pr	3pr	1v(d)				1v(d)	2pr	
Hiatellidae	*Hiatella australis*	50pr 4v			65pr 5v	1pr(d)	9pr 1v	22pr	69pr 15v	31pr	31pr	2pr	1pr 2v	39pr	15pr	
Limidae	*Lima lima vulgaris*														1v(d)	
	Limatula strangei											2v(d)				
Lucinidae	*Codakia rugifera*											2v(d)				
Mactridae	*Spisula trigonella*	3v(d)							2v(d)				4v(d)	1v(d)		
Myochamidae	*Myadora* sp.															
Mytilidae	*Musculus alganus*															
	Musculus cumingianus											1pr				
	Musculus sp. 1											4pr				
	Mytilus galloprovincilis **	4pr	1pr		65pr 6v	1pr	3pr	6pr 1v	29pr 1v	21pr 4v	10pr	1pr	5pr 2v	24pr 1v	8pr	
	Trichomusculus barbatus	1pr			8pr 1v		1pr(d)		1pr 1v(d)	1v(d)	1v(d)			2v(d)		
	Trichomya hirsuta				1pr			1pr	4v(d)		1pr					
Ostreidae	*Ostrea angasi*	96pr 35v			6pr 12v		4pr 20v	94pr 125	41pr 103	35pr 33v	6pr 39v	3pr 1v	19v	39pr 34v	23pr 23v	1v(d)
	Saccostrea glomerata						5pr				1v(d)		2v(d)			
Pectinidae	*Scaeochlamys livida*															
Pholadidae	*Pholas australasiae*			1v(d)												
Tellinidae	*Tellina deltoidalis*	2v(d)														1v(d)
Veneridae	*Irus crenatus*				4pr(d)		1v(d)	2pr 1v	1pr				1v(d)			
	Venerupis anomala															

Key: pr = pair, v = valves; (d)=only dead animals collected at this site; ** cryptogenic species

4.2.10. Bryozoans

The bryozoans, or moss animals (Phylum Bryozoa), are a group of invertebrates which, together with four other taxa, possess a food catching organ called a lophophore (Barnes 1987). In the bryozoans, the lophophore is a crown of tentacles which protrudes from a protective covering. Although each individual animal is minute, bryozoans are colonial animals and may form large aggregations up to a metre across. About 5000 species occur worldwide, with the southern and south-eastern coasts of Australia containing about 500 species (Edgar 2000). They are sessile animals, and mostly occur on hard substrates in marine environments. Only a few species have stalks, which allow them to live in the sand.

Dr R. Nair, taxonomic consultant of Wentworthville, NSW, identified the bryozoans collected from Port Kembla. Table 4.2.10 lists a total of 24 species identified from 13 families. In all, 15 of these species are introduced, with 1 species being cryptogenic in origin. A brief description of the introduced and cryptogenic species is as follows:

Two species from the Family Vesiculariidae identified from the Port Kembla samples have been introduced. These are *Amathia* sp. and *Bowerbankia* sp.

***Amathia* sp.** occurs throughout many parts of the world, including France, the Mediterranean Sea, Red Sea, Atlantic Coast of America, Java and Japan. It is uncertain as to when and where it was first recorded in Australia, and little is known of its ecology in southern Australia. It can be confused with native species of the same genus (Hewitt *et al.* 1999).

In the Port Kembla survey, *Amathia* sp. was collected from a single qualitative sample taken at the Wollongong Harbour (Boat Harbour) (WHH) site and in two qualitative samples from the Eastern Breakwater (EBO) site, both on the Open Coast.

***Bowerbankia* sp.** was first recorded in Australia in the 1970s, and was probably introduced through shipping (Hewitt *et al*. 1999). Specimens of this genus previously recorded from Victoria could be *B. imbricata* or *B. gracilis*, both of which are important fouling organisms.

In the Port Kembla samples, specimens of *Bowerbankia* sp. were collected from a single pile scraping sample taken from the No 2 Products Wharf (PW2) in the Inner Harbour.

Introduced species from the Family Bugulidae included *Bugula dentata, Bugula flabellata, Bugula neritina* and *Bugula stolonifera*.

Bugula dentata has a cosmopolitan distribution, probably having been transported around the world via the hulls of ships. It is green in colour and small in size, with a height that is rarely greater than 5 cm. In Australia it is known to occur in South Australia and in Port Phillip Bay in Victoria (Currie *et al.* 1999).

During the Port Kembla survey, this species was collected in a qualitative sample from the EBO site on the Open Coast. This species was also collected during the introduced marine pests survey of Botany Bay (Pollard and Pethebridge 2000).

Bugula flabellata was introduced to New South Wales and South Australia from southern Britain (it occurs in the North Atlantic Ocean and the Mediterranean Sea) in the late 1940s. This species commonly occurs on rocky shores and on dark sublittoral rock surfaces in warm-temperate Australian waters (Furlani 1996; Currie *et al*. 1999). It is now widely distributed in New South Wales, Victoria, South Australia and Western Australia. It probably arrived attached to the hulls

of ships, but this is not certain. *Bugula flabellata* is rarely confused with native species, though it may often be confused with other exotic species. There is little information on the impact of this species on other Australian fauna (Currie *et al*. 1999).

During the Port Kembla survey, specimens of this species were found in pile scraping samples from the No 6 Jetty (J6O) (Outer Harbour), and the No 2 Products Wharf (PW2) and No 1 (Bulk) Coal Berth (BCB) (Inner Harbour) sites. It was also found in a qualitative sample from the Northern Breakwater (NBI) site in the Outer Harbour. This species was also collected during the introduced marine pests survey of Botany Bay (Pollard and Pethebridge 2000).

Bugula neritina was first recorded from Victoria in the 1880s, and now occurs in many ports throughout southern Australia, including some in New South Wales, Victoria and South Australia. It is often present in isolated ports (e.g. Point Turton, Yorke Peninsula, South Australia) without occurring in nearby waters. This species was introduced to Australia from Europe, and has a wide distribution throughout the world, being only absent from cold polar and subarctic/subantarctic waters (Furlani 1996; Hewitt *et al*. 1999). The impact of this species on the native marine fauna in Australian waters is unknown (Furlani 1996).

Specimens of *Bugula neritina* were found in qualitative samples that were collected from the EBO and WHH Open Coast sites. In the Outer Harbour, it was collected from a pile scraping sample taken from the No 4 (Bulk Liquids Berth) Jetty (J4O) site and a qualitative sample taken from the NBI site. This species was also collected from a pile scraping sample taken from the Inner Harbour BCB site. *Bugula neritina* was also collected during the introduced marine pests survey of Botany Bay (Pollard and Pethebridge 2000).

Bugula stolonifera is native to Western Europe, southern Britain and the Mediterranean Sea, and also occurs in New Zealand. It has been present in Australian waters since the 1880s, and because of this early date of introduction, it probably arrived attached to ships' hulls (Currie *et al*. 1999). It is unlikely that this species has much impact on other animals in Australian waters.

Specimens of *Bugula stolonifera* were found in pile scraping samples taken from the PW2 and BCB sites in the Inner Harbour of Port Kembla. It was also collected during the introduced marine pests survey of Botany Bay (Pollard and Pethebridge 2000).

Cryptosula pallasiana, from the Family Cryptosulidae, is an encrusting species with pinkish-orange or orange crusts. It originated from the Mediterranean Sea, and is a widespread fouling species, being found in ports, harbours and estuarine situations worldwide. In Australia, this species was recorded previously from Tasmanian, Victorian and NSW waters (Gordon 1989; R. Nair, unpubl.).

Specimens of *Cryptosula pallasiana* were collected from a pile scraping sample taken at the No 1 Products Wharf (PW1) site in the Inner Harbour area. This species was also collected during the Botany Bay introduced marine pests survey (Pollard and Pethebridge 2000).

A total of five species from the Family Schizoporellidae were collected during the Port Kembla survey. All of these species have been introduced to Australian waters from overseas. They included ***Schizoporella errata*****, *Schizoporella* sp**. **A**, ***Schizoporella* sp. B**, ***Schizoporella* sp. C** and ***Schizoporella unicornis*****.**

Schizoporella unicornis is an encrusting form which lives in bays, harbours and on the open coast down to 60 m depth (Furlani 1996). It is native to Japan, and was introduced to Sydney in the 1940s. A subsequent introduction occurred after 1953 in both South Australian and Western Australian waters. Its introduction was probably via ship's hull fouling or oyster mariculture

(Furlani 1996). It now occurs in Port Jackson (Sydney), in South Australia, and at Fremantle in Western Australia.

Specimens of *Schizoporella unicornis* were found in a qualitative sample collected at the Open Coast site WHH. This species was also collected from pile scraping samples taken at the No 3 Jetty (J3O) and Inflammable Liquids Berth (ILB) sites, and in a core sample at the ILB site, all in the Outer Harbour area. The remaining species were mainly collected from pile scrapings sampled at various Outer Harbour sites.

Another member of the genus *Schizoporella,* probably *Schizoporella errata*, is the dominant fouling organism immediately below the waterline on the hulls of yachts and other small boats in Pittwater, just to the north of Sydney (D. Pollard and A. Afsar, pers. obs.). The ecological impacts of these *Schizoporella* species in Australian waters, however, are unknown.

Tricellaria occidentalis, from the Family Candidae, grows as "erect, bushy, buff coloured colonies". This species was originally described from Santa Barbara , California, and is found from British Columbia to southern California and Baja California (Mexico), and also in China, Japan, Venice (Italy) and New Zealand. Previous Australian reports are from South Australia, New South Wales and Victoria (R. Nair, pers. comm.).

Specimens of this species were found in pile scraping samples collected at the J4O, J3O and ILB sites in the Outer Harbour. They were also found in core samples collected from the J3O site. This species was also collected during the introduced marine pests survey of Botany Bay (Pollard and Pethebridge 2000).

Two species from the Family Watersiporidae were collected during the Port Kembla survey. These were *Watersipora arcuata* and *Watersipora subtorquata*. Both of these species are introduced.

Watersipora arcuata was first collected in Australian waters from NSW in the 1940s. This species is distinguished from the closely related *W. subtorquata* by the "arcuate" shape of its aperture, which is "roughly circular with a broad sinus at the proximal end" (Keough and Ross 1999). Like *W. subtorquata*, this species is encrusting, being made up of dark red-brown colonies. It settles on jetties and pylons around the low water mark (Furlani 1996). This species originated from the tropical waters of the eastern Pacific, and was transported to Australian waters via shipping. It is now known to be present in nearly all states in Australia, except Tasmania (Keough and Ross 1999).

During the Port Kembla survey, *Watersipora arcuata* was collected from pile scraping samples taken from the J4O, J3O and ILB sites in the Outer Harbour. It was also collected from qualitative samples taken from the J4O, J6O and NBI sites, and from core samples at the J3O site, in the Outer Harbour. In the Inner Harbour, *W. arcuata* was collected from pile scraping samples taken from the PW1, No 2 Discharge Wharf (DW2), Tom Thumb Road Bridge (B1I) and No 2 (Old) Coal Berth (OCB) sites. It was also collected from core samples taken from the OCB site in the Inner Harbour.

Watersipora subtorquata was introduced to Queensland, New South Wales, South Australia and Western Australia in about 1889. It probably originated from Mexico, and now comprises a significant component of the hull fouling cover in these areas. The species is colonial and encrusting, and lives on jetties and wharf piles around the low water mark (Furlani 1996). The impact of this species in Australian waters is unknown.

Specimens of *Watersipora subtorquata* were found in pile scraping samples taken at the J4O, J3O and J6O sites in the Outer Harbour. It was also collected in a qualitative sample taken from the NBI site in the Outer Harbour. In the Inner Harbour, this species was collected in qualitative samples taken from the No 1 Discharge Wharf (DW1), BHP Roll-on Roll-off Berth (western) (WRR) and Multi-Purpose Berth (MPB) sites. It was also collected from pile scraping samples taken at the PW2, MPB, Grain Berth (GBI), BCB and OCB sites, and from core samples taken at the WRR, MPB and GBI sites. This species was also collected during the introduced marine pests survey of Botany Bay (Pollard and Pethebridge 2000).

***Calyptotheca* sp**. was the only cryptogenic species identified from the Port Kembla samples. There are 12 species of *Calyptotheca* recorded from Australian waters, most of them being from Victoria. *Calyptotheca triangula* (Hincks,1881) and *Calyptotheca variolosa* (MacGillivray, 1869) have been recorded from NSW waters.

Calyptotheca species are usually colonial, encrusting, erect or discoidal forms, with the zooids having an evenly perforated frontal shield and dimorphic orifices. Because this bryozoan was not identified to species level, its origin is unknown. Species of this genus are known to occur in New Zealand, South Africa, India, Australia and Zanzibar.

In the Port Kembla samples, *Calyptotheca* sp. was found in one qualitative sample collected at the Inner Harbour GBI site.

TABLE 4.2.10: BRYOZOAN FAUNA COLLECTED FROM PORT KEMBLA

Family, etc.	Species	Open Coast Sites								Outer Harbour Sites						
		BGI	NSS	NBO	EBO	SRS	SSS	WHB	WHH	EBI	BHO	J4O	J3O	SGO	WRW	J6O
Arachnopusiidae	*Arachnopusia unicornis*															
Beaniidae	*Beania quadricornuta*															
Bugulidae	*Bugula dentata* *				1Q											
	Bugula flabellata *															1P
	Bugula neritina *				2Q				1Q			1P				
	Bugula stolonifera *															
Candidae	*Hopitella armata*															
	*Tricellaria occidentalis**											1P	1P 2C			
Celleporariidae	*Celleporaria fusca*				1Q					1Q		3P	5P 2C			1P 1C 2Q
	Celleporaria sp.															
Cryptosulidae	*Cryptosula pallasiana* *															
Hippoporinidae	*Calyptotheca* sp.**															
Phidoloporidae	*Tryphyllozoon* sp.				1Q				2Q	1Q			5P 3C	3C		3C 1Q
Schizoporellidae	*Schizoporella errata* *												1C			
	Schizoporella sp. A *									1Q		1P	1P 1C	1C		2P
	Schizoporella sp. B *											1P	2P			2P
	Schizoporella sp. C *											7P 1C	6P			12P
	Schizoporella unicornis *								1Q				1P			
Smittinidae	*Pleurocodonellina signata*															
Tubuliporidae	*Tubulipora* sp.															
Vesiculariidae	*Amathia* sp.*				2Q				1Q							
	Bowerbankia sp.*															
Watersiporidae	*Watersipora arcuata* *											3P 1Q	5P 2C			1C 1Q
	Watersipora subtorquata *											2P	1P			3P

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample; * introduced species; ** cryptogenic species

TABLE 4.2.10: BRYOZOAN FAUNA COLLECTED FROM PORT KEMBLA (continued)

Family, etc.	Species	Outer Harbour				Inner Harbour Sites											
		WIO	ILB	NBI	MPO	PW1	DW1	DW2	ACI	WRR	PW2	MPB	GBI	B1I	ERR	BCB	OCB	MPI
Arachnopusiidae	*Arachnopusia unicornis*													1Q				
Beaniidae	*Beania quadricornuta*		9P	1Q						4P				1Q				
Bugulidae	*Bugula dentata* *																	
	Bugula flabellata *			1Q							2P					1P		
	Bugula neritina *			1Q												1P		
	Bugula stolonifera *										1P					4P		
	Hopitella armata	1P																
Candidae	*Tricellaria occidentalis**		1P															
Celleporariidae	*Celleporaria fusca*																	
	Celleporaria sp.													1Q				
Cryptosulidae	*Cryptosula pallasiana* *	1P																
Hippoporinidae	*Calyptotheca* sp. **												1Q					
Phidoloporidae	*Tryphyllozoon* sp.		1P 1C	1Q									1C					
Schizoporellidae	*Schizoporella errata* *		1P															
	Schizoporella sp. A *																	
	Schizoporella sp. B *		1C															
	Schizoporella sp. C *			1Q		1Q												
	Schizoporella unicornis *		1P 1C															
Smittinidae	*Pleurocodonellina signata*					1P 1Q												
Tubuliporidae	*Tubulipora* sp.	1P																
Vesiculariidae	*Amathia* sp.*																	
	Bowerbankia sp.*										1P							
Watersiporidae	*Watersipora arcuata* *		1P	1Q		2P		1P					2P				1P 2C	
	Watersipora subtorquata *			1Q			1Q			1C 1Q	2P	5P 1C 1Q	1P 2C			3P	7P	

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample; * introduced species; ** cryptogenic species

4.2.11. Echinoderms

The echinoderms (Phylum Echinodermata) include the conspicuous and often brightly coloured sea stars and feather stars. Over 6000 species belong to this phylum, which is unique in its morphological features. Originally, scientists thought that the echinoderms may be related to the anenomes and jellyfishes, because they possessed structures that radiate out from a central disc (hence the one name Radiata was initially created to cover both of these groups). However, it is now thought that the echinoderms may be more closely related to the vertebrates, as they possess an internal calcareous skeleton (Edgar 2000).

Echinoderms are divided into five classes, including the crinoids (feather stars), asteroids (sea stars), ophiuroids (brittle stars), echinoids (sea urchins) and holothurians (sea cucumbers) (Edgar 2000).

Mr John Pogonoski, from the Australian Museum in Sydney, identified the echinoderms collected from Port Kembla. Three specimens belonging to three different sea urchin species were collected, all of which commonly occur in the coastal waters of central NSW, and none of which are introduced (Table 4.2.11).

TABLE 4.2.11: ECHINODERM FAUNA COLLECTED FROM PORT KEMBLA

Family, etc.	Species	Open Coast Sites								Outer Harbour Sites							
		BGI	NSS	NBO	EBO	SRS	SSS	WHB	WHH	EBI	BHO	J4O	J3O	SGO	WRW	J6O	WIO
Diadematidae	*Centrostephanus rodgersii*																
Echinometridae	*Heliocidaris erythrogramma*								1Q								
Temnopleuridae	*Holopneustes purpurascens*						1Q										

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample

TABLE 4.2.11: ECHINODERM FAUNA COLLECTED FROM PORT KEMBLA (continued)

Family, etc.	Species	Outer Harbour			Inner Harbour Sites												
		ILB	NBI	MPO	PW1	DW1	DW2	ACI	WRR	PW2	MPB	GBI	B1I	ERR	BCB	OCB	MPI
Diadematidae	*Centrostephanus rodgersii*												1Q				
Echinometridae	*Heliocidaris erythrogramma*																
Temnopleuridae	*Holopneustes purpurascens*																

Key: 1P: 1 pile scraping sample; 1C: 1 benthic core sample; 1Q: 1 qualitative sample

4.2.12. Chordates

Several groups of chordates belonging to the Subphylum Urochordata (or tunicates) do not have backbones, and all of these live in marine environments (Barnes 1987; Edgar 2000). These include three classes, the Ascidiacea, the Thaliacea and the Larvacea. The Ascidiacea, or ascidians, are the most common and make up the majority of the species of attached tunicates (Barnes 1987). The Phylum Chordata also includes the vertebrates, or animals with backbones (i.e. the fishes, amphibians, birds, reptiles and mammals).

4.2.12.1. Ascidians

The ascidians, or sea squirts (Class Ascidiacea), are primitive sessile chordates in which the body is encased in a complex secreted outer covering, the tunic.

Kirrily Moore, taxonomic consultant, of Hobart, Tasmania, identified the ascidians collected from Port Kembla. A total of at least 24 species from at least 7 families were identified from these collections (Table 4.2.12.1). Two of these species, *Ciona intestinalis* and *Styela plicata*, are considered to be introduced. A third species, *Botryllus schlosseri,* is considered to be cryptogenic.

Ciona intestinalis is a solitary ascidian which occurs as dense aggregations in marine and brackish estuaries, enclosed or semi-protected bays and harbours. It is often a dominant member of fouling

communities on wharves and piles, and is commonly found on ships' hulls. This species originates from the North Atlantic Ocean, and was first recorded in Australian waters from Port Jackson (Sydney), NSW, in 1899. It is now distributed in various isolated ports around Australia. These include Rockhampton in Queensland, Port Jackson in NSW, Portland, Port Melbourne and Port Phillip Bay in Victoria, the Derwent River at Hobart in Tasmania, Port Adelaide and Outer Harbour at Adelaide in South Australia, and the Canning River, Swan River, Fremantle and Albany in Western Australia (Furlani 1996).

In the Port Kembla survey, *Ciona intestinalis* was collected from pile scraping samples taken from the No 6 Jetty (J6O), No 3 Jetty (J3O) and Inflammable Liquids Berth (ILB) sites in the Outer Harbour. In the Inner Harbour it was collected from the No 1 Products Wharf (PW1), No 2 Products Wharf (PW2), Multi-Purpose Berth (MPB), the Old Coal Berth (OCB), BHP Roll-on Roll-off Berth (western) (WRR), No 2 Discharge Wharf (DW2), Grain Berth (GBI) and No 1 (Bulk) Coal Berth (BCB) sites. It was also found in qualitative samples from the Northern Breakwater (NBI) site in the Outer Harbour and the Big Island (BGI) site on the Open Coast.

Styela plicata is a simple, solitary ascidian with a hemispherical body that grows to around 4-7 cm in length (Furlani 1996). It is easily distinguished from native species by the conspicuous brown stripes which occur on its siphons (Keough and Ross 1999). It usually occurs from lower intertidal waters to 30m depth, on hard substrata in calm waters of bays and harbours. This species can also withstand polluted and brackish waters (Kott 1985).

Styela plicata was originally recorded from temperate waters of the Atlantic Ocean and Mediterranean Sea (Keough and Ross 1999). Because there are no early records from the general Indo-west Pacific area, this species is considered to have been introduced to Australian waters via ships' hulls or ballast water (Kott 1985). It was first recorded from Port Jackson and Port Hacking (Sydney), NSW, in the 1870s and in Port Phillip Bay, Victoria, in 1966 (Keough and Ross 1999).

In the Port Kembla Survey, *Styela plicata* was commonly collected from wharf pile scrapings taken from the J4O, PW1, J6O, PW2, MPB, OCB, ILB, J3O, WRR, DW2, GBI and BCB sites. It was also collected from qualitative samples taken from the MPB, NBI, ANL Roll-on Roll-off Berth (eastern) (ERR), GBI, BGI, and Wollongong Harbour (Boat Harbour) (WHH) sites.

Botryllus schlosseri is a colonial ascidian with a firm, fleshy test and stalked lobes. It inhabits mainly temperate waters, but also warmer waters of the Mediterranean Sea and sub-tropical Australia. It is a fouling organism, which occurs in estuaries and shallow waters, encrusting seagrasses, oysters and rocky breakwaters (Furlani 1996). It originates from the north-eastern Atlantic Ocean to the Mediterranean Sea, and was first recorded from Australian waters in Western Australia in 1928. It was subsequently recorded from Hobsons Bay in Port Phillip Bay, Victoria, in 1977 and from other parts of Port Phillip Bay in 1985 (Keough and Ross 1999).

In the Port Kembla survey, *Botryllus schlosseri* was collected from wharf pile scrapings taken from the J4O, J6O, OCB, J3O, BCB, and PW1 sites.

TABLE 4.2.12.1: ASCIDIACEAN FAUNA COLLECTED FROM PORT KEMBLA

Family, etc.	Species	Open Coast Sites								Outer Harbour Sites							
		BGI	NSS	NBO	EBO	SRS	SSS	WHB	WHH	EBI	BHO	J4O	J3O	SGO	WRW	J6O	WIO
Pyuridae	*Hermania momus*	1.00			1.00				1.00	1Q		7P	13P		1Q	6P 1Q	
	Microcosmus squamiger	44.00								18Q		201P	473P 12C		39Q	369P 4Q	46Q
	Pyura stolonifera	9.00								1Q		3P	31P		3Q	24P 1Q	
	Pyura elongata												3P			1P	
	Pyura irregularis											2P	1P				
	Pyura gibbosa				3.00												
	Pyura spinosa												1P			1P	
Styelidae	*Styela plicata* *	5.00										74P	38P		1Q	8P	
	Styela canopus	13.00			1.00					3Q		40P	82P 1C			3P 1Q	
	Cnemidocarpa areolata				1.00											1P	
	Cnemidocarpa sp. 1											6P	8P				
	Cnemidocarpa pedata				1.00												
	Cnemidocarpa stolonifera?																
	Cnemidocarpa oligocarpa?												1P				
	Polycarpa pedunculata				1.00												
	Polyandrocarpa australiensis							1.00				3P					
	Botrylloides magnicoecum															1Q	
	Botrylloides perspicuum				1.00												
	Botryllus schlosseri **																
	Unidentified juvenile											1P	3P			1P	1Q
	Damaged specimens																
Molgulidae	*Molgula ficus*	1.00										2P	29P 1C			3P	
Cionidae	*Ciona intestinalis* *	1.00										2P	7P			2P	
Ascidiidae	*Ascidia* sp.																
Didemnidae	Unidentified																
Polyzoinae	*Symplegma oceania?*																
Ascidiacea	Damaged specimens											1P					

Key: 1, 2 etc. = numbers of specimens collected; P: pile scraping sample; C**:** benthic core sample; Q: qualitative sample; * introduced species; ** cryptogenic species

TABLE 4.2.12.1: ASCIDIACEAN FAUNA COLLECTED FROM PORT KEMBLA (continued)

Family, etc.	Species	Outer Harbour			Inner Harbour Sites												
		ILB	NBI	MPO	PW1	DW1	DW2	ACI	WRR	PW2	MPB	GBI	B1I	ERR	BCB	OCB	MPI
Pyuridae	*Hermania momus*	6P2C											1Q				
	Microcosmus squamiger	542P	21Q		488P	19Q	135P		225P	225P	239P	147P		14Q	158P 1C	65P	
	Pyura stolonifera	10P	2Q		3P												
	Pyura elongata	5P			1P					2P							
	Pyura irregularis	7P			3P					1P					1P		
	Pyura gibbosa																
	Pyura spinosa																
Styelidae	*Styela plicata* *	9P	5Q		20P	3Q	2P		8P	4P	10P 1Q	13P1Q		2Q	5P	12P	
	Styela canopus	70P	3Q		271P	12Q	86P		82P	181P	196P	117P			134P	53P	
	Cnemidocarpa areolata								1P		2P						
	Cnemidocarpa sp. 1						1P										
	Cnemidocarpa pedata																
	Cnemidocarpa stolonifera?									1P							
	Cnemidocarpa oligocarpa?																
	Polycarpa pedunculata																
	Polyandrocarpa australiensis																
	Botrylloides magnicoecum																
	Botrylloides perspicuum																
	Botryllus schlosseri **																
	Unidentified juvenile																
	Damaged specimens											4P					
Molgulidae	*Molgula ficus*	136P	1Q		60P	7Q	5P		13P		2P	3P		1Q		1P	
Cionidae	*Ciona intestinalis* *	12P	1Q		11P		6P		19P	8P	10P	16P			13P	2P	
Ascidiidae	*Ascidia* sp.				1P				1P	1P	1P						
Didemnidae	Unidentified																
Polyzoinae	*Symplegma oceania?*																
Ascidiacea	Damaged specimens	9P			11P		1P		2P			2P			1P	3P	

Key: 1, 2 etc. = numbers of specimens collected; P: pile scraping sample; C**:** benthic core sample; Q: qualitative sample; * introduced species; ** cryptogenic species

4.2.12.2. Fishes

Mr Matthew Lockett from the University of Technology, Sydney, assisted with the identification of the fishes collected from Port Kembla during the present survey. The fishes (Class Osteichthyes) caught or observed comprised 48 species, two of which are known to be introduced (Table 4.2.12.1). Both of the introduced species, *Tridentiger trigonocephalus* (Japanese striped goby) and *Acentrogobius pflaumi* (Pflaum's goby), were East Asian gobies.

Tridentiger trigonocephalus originates from the rocky shores of bays throughout Japan, eastern China, the Korean Peninsula and south-eastern USSR. This species has colonised restricted areas in the coastal waters of both California and Australia. The first specimen collected in Australia

was in 1973, from Sydney Harbour. Subsequently, specimens were collected from the Swan River estuary near Perth and the Port of Fremantle and Cockburn Sound in WA, and Port Phillip Bay in Victoria. More recently this species has been collected in high densities from both Sydney Harbour and Port Kembla. The most likely vector for the transport of the species into Australian waters is the ballast water of ships arriving from Japan (Pollard and Hutchings 1990a).

In the present survey, *Tridentiger trigonocephalus* was quite common at several sites, and was the dominant fish species at the No 1 Discharge Wharf (DW1) and ANL Roll-on Roll-off Berth (eastern) (ERR) sites in the Inner Harbour, with very large numbers being found at these localities. This species was also common at the Boat Harbour (BHO), No 4 (Bulk Liquids Berth) Jetty (J4O), No 6 Jetty (J6O), Western Revetment Wall (WRW) and Inflammable Liquids Berth (ILB) sites in the Outer Harbour, and at the Grain Berth (GBI) and Old Coal Berth (OCB) sites in the Inner Harbour.

Acentrogobius pflaumi occurs naturally in Japan, the Korean Peninsula, Taiwan and the Philippines (Lockett and Gomon 1999). Previously, this species was only known to occur in Australia in Port Phillip Bay near Melbourne, Victoria. It was first recorded there in 1996, and although it is the most recently known introduced goby species in Port Phillip Bay, it appears to be the most successful of the four fish species introduced there (Lockett and Gomon 1999).

During the Port Kembla survey, one specimen of *Acentrogobius pflaumi* was found in a clove oil (fish anaesthetic) sample collected at the OCB site in the Inner Harbour.

A third species of East Asian goby, the yellowfinned goby *Acanthogobius flavimanus,* had previously been recorded from Port Kembla (Pollard and Hutchings 1990a), but was not found during the present survey.

The ecological implications of introduced marine fishes in Australia are discussed in some detail in a review by Pollard and Hutchings (1990a).

TABLE 4.12.2: FISH FAUNA COLLECTED FROM PORT KEMBLA

Family, etc.	Species	Common Name	Open Coast Sites								Outer Harbour Sites						
			BGI	NSS	NBO	EBO	SRS	SSS	WHB	WHH	EBI	BHO	J4O	J3O	SGO	WRW	J6O
Clupeidae	*Hyperlophus vittatus*	Sandy sprat						24				2					
Notocheiridae	*Iso rhothophilus*	Surf sardine			2												
Plotosidae	*Cnidoglanis macrocephalus*	Estuary catfish															
Scorpaenidae	*Centropogon australis*	Fortescue														6	
Platycephalidae	*Platycephalus bassensis*	Sand flathead															
	Platycephalus sp.	Flathead															
	Platycephalus fuscus	Dusky flathead															
Ambassidae	*Ambassis jacksoniensis*	Glass perchlet										16					
	Ambassis sp.	Perchlet															
Terapontidae	*Pelates quadrilineatus*	Four-lined trumpeter														PR	
Sillaginidae	*Sillago ciliata*	Sand whiting						1									
	Sillago maculata	Trumpeter whiting						1									
	Sillago sp.	Whiting															
Pomatomidae	*Pomatomus saltatrix*	Tailor										1					
Carangidae	*Pseudocaranx dentex*	Silver trevally			1												
	Trachinotus coppingeri	Swallowtail dart															
Sparidae	*Acanthopagrus australis*	Yellowfin bream														PR	
	Rhabdosargus sarba	Tarwhine										4					
Gerreidae	*Gerres subfasciatus*	Silver biddy										23					
Pempheridae	*Pempheris multiradiata*	Common bullseye										1					
Girellidae	*Girella tricuspidata*	Luderick										8					
Scorpididae	*Atypichthys strigatus*	Australian mado														PR	
	Scorpis lineolatus	Silver sweep														PR	
Chaetodontidae	*Chaetodon auriga*	Threadfin butterflyfish										2					
	Chaetodon plebeius	Bluespot butterflyfish										2					
Enoplosidae	*Enoplosus armatus*	Old wife															
Cheilodactylidae	*Cheilodactylus fuscus*	Red morwong														PR	
Mugilidae	*Myxus elongatus*	Flat tail mullet										26					
Labridae	Labrid sp.	Wrasse														PR	
Odacidae	*Odax cyanomelas*	Herring cale														PR	
Blenniidae	*Parablennius tasmanianus*	Tasmanian blenny															
	Petroscirtes lupus	Brown sabretooth blenny										1					
	Norfolkia clarkei	Common threefin											2				
Callionymidae	*Synchiropus calauropomus*	Common stinkfish															
Gobiidae	*Acentrogobius pflaumi* *	Pflaum's goby															
	Arenigobius bifrenatus	Bridled goby															
	Bathygobius kreffti	Krefft's goby										40	2			3	
	Callogobius depressus	Flathead goby														1	
	Favonigobius lateralis	Long-finned goby										8				1	
	Istigobius hoesei	Sloth goby											8			2	
	Nesogobius sp.	Goby															
	Tridentiger trigonocephalus *	Japanese striped goby										2	5			3	
Uranoscopidae	*Leseurena platycephala*	Flathead pygmy stargazer						1									
Acanthuridae	*Acanthurus nigrofuscus*	Dusky surgeonfish										1					
Bothidae	*Pseudorhombus jenynsii*	Small-toothed flounder										1					
Monacanthidae	*Pervagor janthinosoma*	Earspot filefish										1					
	Scobinichthys granulatus	Rough leatherjacket										3					
Tetraodontidae	*Tetractenos glaber*	Smooth toadfish			1												

Key: 1,2,3..etc. = the numbers of fish caught or observed, and the letters in brackets indicate the method by which the fish were caught
(CO: clove oil; CT: crab trap; R: rotenone; S: seine); PR: = fish present with no indication of numbers; * introduced species

TABLE 4.2.2: FISH FAUNA COLLECTED FROM PORT KEMBLA (continued)

Family, etc.	Species	Common Name	Outer Harbour Sites					Inner Harbour Sites												
			SSB*	WIO	ILB	NBI	MPO	PW1	DW1	DW2	ACI	WRR	PW2	MPB	GBI	NBS	B11	ERR	BCB	OCB	MP1
Clupeidae	*Hyperlophus vittatus*	Sandy sprat	3													2					
Notocheiridae	*Iso rhothophilus*	Surf sardine																			
Plotosidae	*Cnidoglanis macrocephalus*	Estuary catfish															1				
Scorpaenidae	*Centropogon australis*	Fortescue																			
Platycephalidae	*Platycephalus bassensis*	Sand flathead	1																		
	Platycephalus sp.	Flathead														1					
	Platycephalus fuscus	Dusky flathead														1					
Ambassidae	*Ambassis jacksoniensis*	Glass perchlet	1													400+					
	Ambassis sp.	Perchlet																			
Terapontidae	*Pelates quadrilineatus*	Four-lined trumpeter															1				
Sillaginidae	*Sillago ciliata*	Sand whiting	1																		
	Sillago maculata	Trumpeter whiting	1													2					
	Sillago sp.	Whiting														4					
Pomatomidae	*Pomatomus saltatrix*	Tailor	2																		
Carangidae	*Pseudocaranx dentex*	Silver trevally																			
	Trachinotus coppingeri	Swallowtail dart	1																		
Sparidae	*Acanthopagrus australis*	Yellowfin bream																			
	Rhabosargus sarba	Tarwhine														2					
Gerreidae	*Gerres subfasciatus*	Silver biddy	2													2					
Pempheridae	*Pempheris multiradiata*	Common bullseye																			
Girellidae	*Girella tricuspidata*	Luderick																			
Scorpididae	*Atypichthys strigatus*	Australian mado																			
	Scorpis lineolatus	Silver sweep																			
Chaetodontidae	*Chaetodon auriga*	Threadfin butterflyfish																			
	Chaetodon plebeius	Bluespot butterflyfish																			
Enoplosidae	*Enoplosus armatus*	Old wife															1				
Cheilodactylidae	*Cheilodactylus fuscus*	Red morwong																			
Mugilidae	*Myxus elongatus*	Flat tail mullet															1				
Labridae	Labrid sp.	Wrasse																			
Odacidae	*Odax cyanomelas*	Herring cale																			
Blenniidae	*Parablennius tasmanianus*	Tasmanian blenny																1			
	Petroscirtes lupus	Brown sabretooth blenny																			
	Norfolkia clarkei	Common threefin																			
Callionymidae	*Synchiropus calauropomus*	Common stinkfish	1																		
Gobiidae	*Acentrogobius pflaumi* *	Pflaum's goby																			1
	Arenigobius bifrenatus	Bridled goby																1			
	Bathygobius kreffti	Krefft's goby																			
	Callogobius depressus	Flathead goby																			
	Favonigobius lateralis	Long-finned goby														45	6				
	Istigobius hoesei	Sloth goby				2			1									1			1
	Nesogobius sp.	Goby							2												
	Tridentiger trigonocephalus *	Japanese striped goby				4			1000+							11		1000+			38
Uranoscopidae	*Leseurena platycephala*	Flathead pygmy stargazer																			
Acanthuridae	*Acanthurus nigrofuscus*	Dusky surgeonfish																			
Bothidae	*Pseudorhombus jenynsii*	Small-toothed flounder																			
Monacanthidae	*Pervagor janthinosoma*	Earspot filefish																			
	Scobinichthys granulatus	Rough leatherjacket																			
Tetraodontidae	*Tetractenos glaber*	Smooth toadfish																			

Key: 1,2,3..etc. = the numbers of fish caught or observed, and the letters in brackets indicate the method by which the fish were caught
(CO: clove oil; CT: crab trap; R: rotenone; S: seine); PR: = fish present with no indication of numbers; * introduced species

** An additional site in the Outer Harbour (SSB, or Southern Sandy Beach, located to the west of J3O and inshore from J6O) was also sampled for fish by seine netting, and is included here.*

4.3. Environmental data recorded during the port survey

The environmental data recorded in conjunction with the sampling operations is summarised in Table 4.3. Sampling was carried out during daylight hours (between 10.00 and 16.00 hours) between 8 and 14 May 2000. The shallowest bottom sampling depth recorded was 1.0 metres at the Northern Beach (NSS), Boat Harbour (BHO) and Northern Breakwater (Inner) (NBI) sites. The deepest bottom sampling depth recorded was 16.7 metres at the No 2 Discharge Wharf (DW2) site. The Secchi depth (a measure of turbidity) ranged from 1.8 metres at the DW2 and Grain Berth (GBI) sites to greater than 12 metres at the Big Island (BGI) site. The air temperature ranged from 18°C (at the No 1 Discharge Wharf (DW1), Multi-Purpose Berth (MPB), No 1 (Bulk) Coal Berth (BCB) and the Mid-Port Inner Harbour (MPI) sites) to 20°C (at the No 6 Jetty (J6O) and GBI sites)). The surface water temperature ranged from 19.1°C (at the BHP Roll-on Roll-off Berth (western) (WRR) site) to 20.5°C (at the MPB site). The bottom water temperature ranged from 18.5°C (at the MPB site) to 18.6°C (at the No 1 Products Wharf (PW1), DW1, WRR and ANL Roll-on Roll-off Berth (eastern) (ERR) sites). The surface salinity ranged from 33.0 ‰o (at the DW1 site) to 36.0 ‰o (at the WRR site). The bottom salinity ranged from 35.0 ‰o (at the DW1 site) to 35.9‰o (at the PW1 and MPB sites).

TABLE 4.3: ENVIRONMENTAL DATA COLLECTED FROM PORT KEMBLA

Sample Site	Site Number	Sample Date	Sample Time	Bottom Depth (m)	Secchi Depth (m)	Air Temp. (°C)	Surface Water Temp. (°C)	Bottom Water Temp. (°C)	Surface Salinity (‰)	Bottom Salinity (‰)
BGI	1	13/05/00	**10.00**		**>12.0**					
NSS	2			**1.0**						
NBO	3	10/05/00	15.00	6.0						
EBO	4									
SRS	5									
SSS	6	12/05/00	12.00	1.5						
WHB	7									
WHH	8									
EBI	9									
BHO	10	12/05/00	**16.00**	**1.0**						
J4O	11									
J3O	12									
SGO	13	12/05/00	15.00		4.5					
WRW	14	14/05/00	11.30	3.0						
J6O	15	14/05/00	12.00	10.0	3.4	**20.0**				
WIO	16	10/05/00	**16.00**							
ILB	17	13/05/00	14.00	11.7	3.1					
NBI	18	12/05/00	14.00	**1.0**						
MPO	19	12/05/00	**10.00**	17.0						
PW1	20	10/05/00			2.4	**18.0**	19.9	**18.6**	35.0	**35.9**
DW1	21	08/05/00	11.00	12.0	3.5		20.0	**18.6**	**33.0**	**35.0**
DW2	22	08/05/00	10.15	**16.7**	**1.8**	19.0				
WRR	23	12/05/00	**10.00**		2.8		**19.1**	**18.6**	**36.0**	35.8
PW2	24									
MPB	25	09/05/00	12.10	15.8	2.0	**18.0**	**20.5**	**18.5**	35.7	**35.9**
GBI	26	08/05/00		10.5	1.8	**20.0**				
BI1	27									
ERR	28	10/05/00		7.0	2.3		19.5	**18.6**	34.0	35.2
BCB	29	08/05/00		12.0		**18.0**				
OCB	30	09/05/00		11.0	2.5					
MPI	31	10/05/00			2.4	**18.0**				

Note: Numbers in bold indicate highest and lowest readings for each column

5. POTENTIAL IMPACTS OF INTRODUCED SPECIES FOUND IN THE PORT

5.1. Species found in Port Kembla

The analysis of specimens collected during the present survey has detected only two ABWMAC target introduced marine pest species (Appendix 1, Schedule 1) as being present in Port Kembla: the toxic dinoflagellates *Alexandrium* sp. *(catenella* type) and *Alexandrium ostenfeldii/peruvianum.*

An additional 47 introduced (33) and/or cryptogenic (i.e. of unknown origin) (14) species were also detected in the port. These comprised one alga, five species of hydrozoans, one anthozoan, four species of polychaetes, one polyclad worm, thirteen species of crustaceans, one mollusc, sixteen species of bryozoans, three species of ascidians and two species of fish (see Table 5.1). Many (20 out of the 33) of these additional introduced species recorded from Port Kembla were not included in, and should now be added to, the official list of exotic species known to be present in Australian waters (see Appendix 1, Schedule 3).

Various species of dinoflagellates, such as *Alexandrium* spp., can form extensive blooms, which can, in turn, produce potent neurotoxins. These neurotoxins are concentrated by shellfish, and when these are eaten by humans they can cause Paralytic Shellfish Poisoning (PSP). Toxicity may develop in both wild and cultured shellfish. Marine animals may also be affected during such blooms as a result of physical damage, oxygen depletion and the effects of the toxins, either directly or through the food chain (White 1980 and 1982, Gosselin *et al.* 1989, Geraci *et al.* 1989, Jones 1991). Impacts of these toxic dinoflagellates are likely to be greatest on shellfish mariculture activities, though no such aquaculture takes place in the waters of Port Kembla.

Alexandrium catenella is commonly recorded in coastal bays and estuaries from Port Phillip Bay, Victoria (Hallegraeff *et al*. 1991), and northwards along the Victorian and NSW coasts (Sonnemann and Hill 1996) to the Hunter River at Newcastle. Although this species has caused toxic blooms in Sydney Harbour, there is no indication that this dinoflagellate has in the past caused toxic blooms in Port Kembla.

The vast majority of the remaining introduced and cryptogenic species detected in Port Kembla (Table 5.1) are not presently known to have any significant impacts on native aquatic animal and plant communities.

The most diverse and abundant group of introduced fouling organisms found in Port Kembla was the bryozoans. Out of the 24 bryozoan species collected during the present survey, 15 are considered to be introduced and one is considered cryptogenic. The arborescent bryozoans *Bugula flabellata* and *Bugula neritina* are found in port regions throughout the world. In Australia, *Bugula flabellata* is also known from Gulf St Vincent in SA and from Jervis Bay to Eden in NSW (Furlani 1996). *Bugula neritina* has been found previously in Spencer Gulf and Gulf St Vincent in SA (Furlani 1996) and also previously in Port Kembla in NSW (Moran and Grant 1993). A number of species of the widespread genus *Schizoporella* were also found to be common in Port Kembla, and a member of this genus is a dominant bryozoan hull fouling organism in Pittwater (Broken Bay, to the north of Sydney) (Afsar 2000). Several of the other species of bryozoans found in Port Kembla are also widespread, both in other Australian port environments and worldwide.

Of the introduced fishes collected from Port Kembla, *Tridentiger trigonocephalus* appears to have successfully colonised the deeper waters around many of the port structures. Even though this species is only one out of 48 species of fishes caught in the area during the present study, it was the most abundant species at two of the sites where it was collected.

5.2. Comparisons with other NSW ports

With regard to the distributions of introduced and cryptogenic marine species throughout some of the major ports in NSW, Table 5.2 provides a comparison of four such ports along the southern half of the NSW coastline, between Newcastle and the Victorian border. These are, from south to north, the ports of Eden, Port Kembla, Botany Bay and Newcastle. The only other major port in this region, Sydney Harbour (located between Botany Bay and Newcastle) is currently under study, and at this stage no comprehensive results on its introduced and cryptogenic marine species are available.

From this table it can be seen that Port Kembla has the largest numbers of introduced and cryptogenic marine species listed, followed by Botany Bay, Newcastle and Eden, in that order. This may to some extent reflect more thorough and comprehensive sampling during the more recent surveys (i.e. of Port Kembla and Botany Bay), compared with those carried out earlier (i.e. of Newcastle and Eden). This could be expected as the survey teams gained increasing experience in this type of study over this period. However, in spite of this possible bias, some inferences can be drawn from the comparisons presented. Also, although some additional introduced species have been recorded from each of these ports in the past, only those found during the current series of port surveys are listed here.

Overall, from the results of these four port surveys, Port Kembla was found to support 49 introduced and/or cryptogenic species (including 2 ABWMAC listed introduced marine pest species, 33 other introduced species and 14 cryptogenic species); Botany Bay had 29 species (1, 19 and 8 species, respectively, in these three categories); Newcastle 26 (2, 18 and 6, respectively); and Eden 12 (3, 8 and 1, respectively).

The toxic dinoflagellate *Alexandrium catenella* (or *"catenella* type") was found in all four ports, together with one other *Alexandrium* species in each of Port Kembla and Newcastle.

Bryozoans were generally dominant amongst the introduced and cryptogenic species in most of the ports, together with significant numbers of hydrozoans. Malacostracans and cirripedes (crustaceans) and polychaete worms were also significant in Port Kembla.

Apart from toxic dinoflagellates, the port of Eden also contained two ABWMAC listed introduced marine invertebrate pest species, the giant European fanworm *Sabella spallanzanii* and the European green shore crab *Carcinus maenas*. Both of these species are much more common further to the south (especially in Victoria) and may be approaching the northern limits of their temperature tolerance ranges around Eden. No such introduced marine invertebrate pest species were found in either Port Kembla or the two other ports studied to its north.

TABLE 5.1: LIST OF INTRODUCED AND CRYPTOGENIC SPECIES COLLECTED FROM PORT KEMBLA IN MAY 2000

Phylogenetic Group	ABWMAC Target Pest Species	Introduced Species	Cryptogenic Species
Dinoflagellates	*Alexandrium* sp. (*catenella* type) *Alexandrium ostenfeldii/peruvianum*		
Macroalgae			*Caulerpa filiformis*
Hydrozoans		*Halecium delicatulum* *	*Bougainvillia macloviana* *Sarsia eximia* *Clytia* sp. *Clytia hemisphaerica*
Anthozoans			*Culicia c.f. tenella*
Polychaetes		*Boccardia chilensis* * *Boccardia proboscidea* *Hydroides dirampha* * *Hydroides ezoensis* *	
Polyclad Worms			Enatiid sp.1
Cirripedes		*Megabalanus rosa*	*Balanus amphitrite* *Megabalanus tintinnabulum* *Megabalanus zebra*
Malacostracans		*Cirolana harfordi* *Paracerceis sculpta* *Sphaeroma walkeri* *Corophium acutum* * *Paradexamine pacifica** *Liljeborgia c.f. dellavallei* * *Elasmopus rapax**	*Caprella equilibra* *Stenothoe valida*
Molluscs			*Mytilus galloprovincialis*
Bryozoans		*Amathia* sp.* *Bowerbankia* sp.* *Bugula dentata** *Bugula flabellata* *Bugula neritina** *Bugula stolonifera** *Cryptosula pallasiana* *Schizoporella errata* * *Schizoporella* sp. A* *Schizoporella* sp. B * *Schizoporella* sp. C * *Schizoporella unicornis* *Tricellaria occidentalis* * *Watersipora arcuata* *Watersipora subtorquata**	*Calyptotheca* sp.
Ascidians		*Styela plicata* *Botryllus schlosseri* * *Ciona intestinalis*	
Fishes		*Acentrogobius pflaumi* *Tridentiger trigonocephalus*	

** Introduced species found in Port Kembla during the present study but not yet listed in Schedule 3 of Appendix 1*

TABLE 5.2: LIST OF INTRODUCED AND CRYPTOGENIC SPECIES COLLECTED DURING NSW PORT SURVEYS FOR THE PORTS OF EDEN, PORT KEMBLA, BOTANY BAY AND NEWCASTLE (LISTED SOUTH TO NORTH)

Port	Eden [1]	Port Kembla	Botany Bay [2]	Newcastle [3]
ABWMAC Introduced Target Pest Species	**3 species**	**2 species**	**1 species**	**2 species**
Dinoflagellates	*Alexandrium catenella*	*Alexandrium* sp. *(catenella* type) *Alexandrium ostenfeldii/peruvianum*	*Alexandrium* sp. *(catenella* type)	*Alexandrium catenella* *Alexandrium minutum*
Polychaetes	*Sabella spallanzanii*			
Malacostracans	*Carcinus maenus*			
Other Introduced Species	**8 species**	**33 species**	**19 species**	**18 species**
Hydrozoans		*Halecium delicatulum*		*Clytia paulensis* *Ectopleura crocea* *Halecium delicatulum*
Polychaetes		*Boccardia chilensis* *Boccardia proboscidea* *Hydroides dirampha* *Hydroides ezoensis*	*Boccardia chilensis* *Capitella capitata*	*Hydroides ezoensis* *Hydroides norvegica*
Cirripedes		*Megabalanus rosa*	*Megabalanus rosa*	*Megabalanus rosa* *Tetraclita rosea*
Malacostracans	*Cancer novaezelandiae*	*Cirolana harfordi* *Corophium acutum* *Elasmopus rapax* *Liljeborgia c.f. dellavallei* *Paracerceis sculpta* *Paradexamine pacifica* *Sphaeroma walkeri*	*Corophium acutum* *Corophium ascherusicum* *Paracerceis sculpta*	*Pinnotheres novaezelandiae*
Molluscs	*Crassostrea gigas* *Maoricolpus roseus* *Polycera capensis* *Theora fragilis*			*Thecacera pinnigera*
Bryozoans	*Bugula flabellata* *Bugula neritina* *Cryptosula pallasiana*	*Amathia* sp. *Bowerbankia* sp. *Bugula dentata* *Bugula flabellata* *Bugula neritina* *Bugula stolonifera* *Cryptosula pallasiana* *Schizoporella errata* *Schizoporella* sp. A *Schizoporella* sp. B *Schizoporella* sp. C *Schizoporella unicornis* *Tricellaria occidentalis* *Watersipora arcuata* *Watersipora subtorquata*	*Amathia distans* *Bowerbankia* sp. *Bugula flabellata* *Bugula neritina* *Bugula stolonifera* *Conopeum seurati* *Cryptosula pallasiana* *Schizoporella unicornis* *Tricellaria occidentalis* *Watersipora subtorquata* *Zoobotryon verticillatum*	*Amathia* sp. *Bowerbankia* sp. *Bugula flabellata* *Bugula neritina* *Conopeum seurati* *Tricellaria occidentalis* *Watersipora subtorquata* *Zoobotryon verticillatum*
Ascidians		*Botryllus schlosseri* *Ciona intestinalis* *Styela plicata*	*Botrylloides leachi*	*Botrylloides leachi*
Fishes		*Acentrogobius pflaumi* *Tridentiger trigonocephalus*	*Acanthogobius flavimanus*	
Cryptogenic Species	**1 species**	**14 species**	**9 species**	**6 species**
Macroalgae		*Caulerpa filiformis*	*Caulerpa filiformis* *Pterosiphonia bipinnata*	
Hydrozoans		*Bouganvillia macloviana* *Clytia hemisphaerica* *Clytia* sp. *Sarsia eximia*	*Antenella secundaria* *Clytia hemisphaerica* *Obelia dichotoma* *Phialella quadrata*	*Antenella secundaria* *Clytia hemisphaerica* *Clytia paulensis* *Obelia dichotoma* *Phialella quadrata* *Sarsia radiata*
Anthozoans		*Culicia c.f. tenella*	*Culicia c.f. tenella*	
Platyhelminthes		Enatiid sp. 1		
Cirripedes		*Balanus amphitrite* *Megabalanus tintinnabulum* *Megabalanus zebra*		
Malacostracans		*Caprella equilibra* *Stenothoe valida*		
Molluscs		*Mytilus galloprovincialis*		
Bryozoans	*Membranipora membranacea*	*Calyptotheca* sp.	*Electra tenella* *Fenestrulina* sp.	

[1] See CSIRO Marine Research (1997), [2] see Pollard and Pethebridge (2000), [3] see CSIRO Marine Research (1998)

6. ORIGINS OF AND POSSIBLE VECTORS FOR THE INTRODUCTION OF EXOTIC SPECIES FOUND IN THE PORT

Exotic marine species found in Port Kembla are likely to have been introduced to the port by one of the following three mechanisms:

by natural range expansion of species introduced to other parts of the south-eastern coast of the Australian mainland;

directly to the port by shipping using the port, either in ballast water or through hull fouling; or

by domestic translocation via commercial fishing and recreational vessels.

Those species likely to have become established in Port Kembla as a result of natural range expansion may include some of the bryozoans and other species with a planktonic phase in their life history. For all species, however, additional domestic translocations may have occurred through human activities (e.g. coastal shipping). The exotic or cryptogenic bryozoans, hydroids, barnacles and ascidians found in the port generally have broad distributions throughout south-eastern Australia and are well known to establish on the hulls of vessels, as well as having a planktonic life history phase which could live in ballast water tanks. These species are likely to have been introduced through multiple invasion events.

Several species are also likely to have been introduced either directly via international shipping or indirectly from other first-entry ports via commercial, recreational and fishing vessels or slower moving vessels such as dredges. Extensive hull fouling can develop on such slow-moving vessels due to longer port residence times and the relative infrequency of dry-docking and brush-cart service (in-water hull cleaning). The survival of encrusting species on the hulls of slower moving vessels is likely to increase the potential colonisation of the port by a diverse adult invertebrate community.

Because of the high frequency of ship visits to the port, several species are likely to have been introduced directly to Port Kembla via either international or domestic shipping. The toxic dinoflagellates *Alexandrium* spp. are likely to have been translocated either from within Australia by domestic transfer of ballast water from infected ports, or in ballast water received directly from overseas ports. The origin of this toxic dinoflagellate genus in Port Kembla, however, remains problematic. The resting cysts of *Alexandrium* species survive for 5-10 years in sediments but fossilisation of cysts is not known to occur. The origin of cysts therefore cannot be inferred from fossil records. *Alexandrium catenella* is known from other coastal estuaries and embayments in NSW (Hallegraeff *et al.* 1991) and may have been transported via coastwise ballast water movements. The distribution of *Alexandrium* spp. within the port may also indicate multiple inoculations over time or from bloom forming events that may have occurred unnoticed in the past.

Japanese shipping may pose the biggest threat of transporting such exotic pathogens into Australia because of the large number of ships visiting and the prevalence of these pathogens in many Japanese ports. Introduced marine organisms are thought to arrive in Australia from Japan at a rate of twice that from all other countries combined (Anon. 1998).

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

The resident fauna of Port Kembla is indicative of a relatively marine-dominated estuarine environment, partly enclosed and sheltered from the open coast, but in places with significant exposure to variations in wind and wave height. Of the introduced species detected in the port, the majority are not normally restricted to sheltered environments and some may be capable of extending their ranges beyond the Port Kembla locale.

Port enhancement activities such as maintenance dredging, berth development and revetment construction create disturbed and novel habitats, which may in turn lead to increased invasion success. Many introduced species appear to require some form of disturbance in order to enter and survive in an existing native community. These activities in the port may have influenced the establishment of some encrusting or fouling species in the past.

Hull cleaning activities, either in the water (brush-cart service) or in dry dock, can have significant influences on the inoculation and establishment of introduced species. However, neither of these activities currently take place in Port Kembla.

Maintenance dredging practices are unlikely to influence the distribution of most species in the port, with the exception of possibly redistributing the cysts of toxic dinoflagellate species. In this latter regard, however, a major sewage outfall planned for construction immediately to the north of the port (Sydney Water Corporation 1999) could greatly increase nutrient levels in the port waters under southward flowing inshore current conditions. Under these conditions, suspension in the water column of dinoflagellate cysts from the bottom sediments due to dredging activities or shipping movements in conjunction with such elevated nutrient levels could result in the occurrence of toxic dinoflagellate blooms in these enclosed port waters.

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

The successful introduction of an exotic species to a port through hull fouling or ballast water discharge requires some level of environmental matching between the donor and receiving ports; the degree of matching required and those characteristics which are most important will depend on the environmental (e.g. temperature) tolerances of individual species. In the absence of this species-level information, some general observations can still be made relative to the possible risks of new introductions to Port Kembla.

The periodic presence of slow-moving, long-residence vessels, such as dredging vessels, in a port may present an opportunity for significant fouling communities to establish themselves while these ships reside in that port. Previous work in the North Pacific has demonstrated the ability for such vessels to transport complete assemblages over long distances (Carlton 1985). Long residence times may allow for reproductive populations of such marine organisms to establish themselves. The presence of dredging vessels in Port Kembla, however, is a rare occurrence.

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

An assessment of the risks of translocation of introduced marine species from Port Kembla to other ports by shipping involves similar considerations to those discussed in assessing the risks of new introductions. Any vessels loading ballast water in Port Kembla are therefore likely to discharge this Port Kembla water in or near other Australian or overseas ports. The likelihood of the transport to and successful establishment of such species in those new environments will be determined by their presence in the water column during ballast water uptake in Port Kembla, as well as their survival during the voyage to and the environmental regime in the recipient port. This information is outlined in Hayes and Hewitt (1998) as a foundation of the risk assessment-based Decision Support System recently developed and adopted by the Australian Quarantine and Inspection Service (AQIS).

Some vessels, and particularly slower moving and longer residence ones, are likely to move organisms around via hull fouling. These organisms are likely to include various encrusting bryozoans, hydroids, barnacles and ascidians. The majority of domestic traffic to and from port Kembla occurs within south-eastern Australia and is thus likely to be between ports with relatively similar environments (see Table 1.3). Consequently, the risk of translocation and establishment of introduced marine species through this vector can be relatively high.

10. RECOMMENDATIONS

10.1. Management and monitoring of existing introduced species in the port

Most of the introduced species detected during this survey of Port Kembla appear to be well established in the port. For these species in general, their eradication from the port by physical removal ceases to be a realistic option. Many of them are now widespread in south-eastern Australian waters and controls aimed at limiting their spread are unlikely to be effective.

The following recommendations, however, are made in relation to the results of this study:

That an on-going (possibly bi-annual, in December and March) phytoplankton (net sampling) monitoring program should be undertaken in the port to establish the presence and seasonality of any toxic dinoflagellate species which may either be released by ballast water discharge or periodically bloom from cysts already present in the port's sediments. (As an *Alexandrium* species of the "*catenella* type" is already established in the port, the formation of blooms either directly from extant cysts or from future ballast water discharge of this species could contribute directly to fish kill events.). Although no toxic blooms have previously been recorded in Port Kembla, any blooms which may occur in the future in this port should be monitored and sampled for the presence of toxic algal species.

That a longer-term dinocore monitoring program should be initiated for encysted dinoflagellates, with qualitative evaluations of the main berth areas being undertaken on an annual basis.

That the extent to which these cysts may be transferred via ballast water uptake could be ascertained by sampling of sediments and water prior to and during any future dredging activities and dredge spoil discharge.

Based upon the frequency of ship visits and ballast water discharges, that a more targeted survey of introduced species in the port, including dinoflagellate coring, should be undertaken sometime in the future, particularly targeting areas of active ballast water discharge and any dredge spoil disposal sites.

10.2. Prevention of new introductions to the port

There is currently no information available on which to base any estimates of the risks of further introductions to the port via hull fouling, though this should not be a serious problem in view of more modern hull cleaning management approaches (see ANZECC 1997 and Appendix 4).

New mandatory arrangements for managing international ballast water have recently been introduced by the Australian Quarantine and Inspection Service (AQIS), from 1 July 2001. These require exchange of ballast water in mid-ocean, and the individual assessment of ballast water loads as low-risk or high-risk for introducing toxic organisms to Australian waters. Contingency deballasting zones, where high risk ballast water can be safely discharged, are to be established following research to map suitable areas. These measures should reduce the likelihood of future marine pest species introductions into and between Australian ports, including Port Kembla, through this vector (AQIS 2001, Geeves 2001).

In relation to future shipping activities in the port, current activity by AQIS should also result in additional database development concerning vessel movements and ballast water origins and discharges on a per tank basis. In order to facilitate consistency between databases, it would also be useful to incorporate an agreed upon set of port names of the world. This list should be available in the near future and would provide for accurate naming and identification of last and next ports of call.

11. REFERENCES

Afsar, A. 2000. A quantitative study of the localised on-vessel distribution of boat hull fouling organisms and the significance of introduced fouling species. Master of Marine Science Thesis, Centre for Marine and Coastal Studies, University of New South Wales, Sydney, 72 pp.

Allen, F.E. 1953. Distribution of marine invertebrates by ships. *Aust. J. Mar. Freswat. Res.* 4(2): 307-316.

Anon. 1998. Introduced species in Botany Bay. *NSW Regional Ripples* (Marine and Coastal Community Network, Sydney) 5(3): 2.

Anon. 1999. Port Kembla 1999. Port guide and tide tables. Port Kembla Port Corporation, 62 pp.

Anon. 2001. Farming blue mussels. Fisheries Western Australia Web Site.

ANZECC. 1997. Code of practice for antifouling and in-water hull cleaning and maintenance. Australian and New Zealand Environment and Conservation Council, Canberra, 12pp.

AQIS 2001. Ballast water brochure. Australian Quarantine and Inspection Service, Canberra, 4 pp.

Barnes, R.D. 1987. Invertebrate Zoology. Saunders College Publishing, Philadelphia, 360 pp.

Bolch, C.J. & Hallegraeff, G.M. 1990. Dinoflagellate cysts in recent marine sediments from Tasmania, Australia. *Botan. Mar*. 33: 173-192.

Carlton, J.T. 1985. Transoceanic and interoceanic dispersal of coastal marine organisms: the biology of ballast water. *Oceanog. Mar. Biol. Ann. Rev*. 23: 313-371.

Christianson, I.G., Clayton, M.N. & Allender, B.M. 1981. Seaweeds of Australia. Reed, Sydney, 112 pp.

CSIRO Marine Research. 1997. Introduced species survey, Eden and Twofold Bay, New South Wales. CSIRO Marine Research, Hobart, Tasmania, 50 pp.

CSIRO Marine Research. 1998. Introduced species survey, Newcastle, New South Wales. CSIRO Marine Research, Hobart, Tasmania, 53 pp.

Currie, D.R., McArthur, M.A. & Cohen, B.F. 1999. Exotic marine pests in the port of Geelong, Victoria. In Hewitt, C.L., Campbell, M.L., Thresher, R.E. and Martin, R.B., Marine Biological Invasions of Port Phillip Bay, Victoria, pp. 227-246. CRIMP Technical Report No. 20, CSIRO Marine Research, Hobart, Tasmania.

Ecology Lab Pty Ltd. 1993. A survey of cysts of toxic dinoflagellates in sediment in Port Jackson, Botany Bay and Port Kembla, 1993. Report Prepared for AQIS, Canberra.

Edgar, G.J. 2000. Australian Marine Life - the Plants and Animals of Temperate Waters. Reed Books, Kew, Victoria, 544 pp.

Edmunds, S.J. 1980. A revision of the systematics of Australian sipunculans (Sipuncula). *Rec. S. Aust. Mus*. 18: 1- 74.

Edmunds, S.J. 2000. Phylum Sipuncula. In: Polychaetes and Their Allies. The Southern Synthesis. Vol. 4A. Fauna of Australia. Australian Biological Resources Survey, Department of Environment and Heritage, Canberra.

Furlani, D. M. 1996. A guide to the introduced marine species in Australian waters. CRIMP Technical Report No. 5, CSIRO Marine Research, Hobart, Tasmania.

Geeves, W. 2001. The latest news on the battle against introduced marine pests. *Waves* (Marine and Coastal Community Network, Sydney) 8(2): 13.

Geraci, J.R., Anderson, D.M., Timperi, R.J., St Aubin, D.J., Early, G.A., Prescott, J.H. & Mayo, C.A. 1989. Humpback whales (*Megaptera novaeangliae*) fatally poisoned by dinoflagellate toxin. *Can. J. Fish. Aquat. Sci.* 46: 1895-1898.

Gordon, D.P. 1986. The marine fauna of New Zealand: Bryozoa: Gymnolaemata (Ctenostomata and Cheilostomata Anasca) from the western South Island continental shelf and slope. New Zealand Oceanographic Institute Memoir No. 95, New Zealand Department of Scientific and Industrial Research, 121 pp.

Gordon, D.P. 1989. The marine fauna of New Zealand: Bryozoa: Gymnolaemata (Cheilostomida Ascophorina) from the western South Island continental shelf and slope. New Zealand Oceanographic Institute Memoir No. 97, New Zealand Department of Scientific and Industrial Research, 158 pp.

Gosselin, S., Fortier, L. & Gagné, J.A. 1989. Vulnerability of marine fish larvae to the toxic dinoflagellate *Protogonyaulax tamarensis*. *Mar. Ecol. Prog. Ser.* 57: 1-10.

Hallegraeff, G.M., Bolch, C.J., Blackburn, S.I. & Oshima, Y. 1991. Species of the toxic dinoflagellate genus *Alexandrium* in south eastern Australian waters. *Bot. Mar.* 34: 575-587.

Hayes, K.R. & Hewitt, C.L. 1998. Risk assessment framework for ballast water introductions. CRIMP Technical Report No. 14, CSIRO Marine Research, Hobart, Tasmania.

Hewitt, C.L. & Martin, R.B. 1996. Port surveys for introduced marine species - background considerations and sampling protocols. CRIMP Technical Report No. 4, CSIRO Marine Research, Hobart, Tasmania, 40 pp.

Hewitt, C.L., Campbell, M.L., Thresher, R.E. & Martin, R.B. 1999. Marine biological invasions of Port Phillip Bay, Victoria. CRIMP Technical Report No. 20, CSIRO Marine Research, Hobart, Tasmania, 344 pp.

Hoogendoorn, W. 1999. Port of Port Kembla 1898-1998. World class roadstead to port. Celebrating the port's centenary of service to the Illawarra. Port Kembla Port Corporation, 120 pp.

Hutchings, P.A., van der Velde, J.T. & Keable, S.J. 1989. Baseline study of the benthic macrofauna of Twofold Bay, NSW, with a discussion of the marine species introduced into the Bay. *Proc. Linn. Soc. NSW* 110: 339-367.

Hyman, L.H. 1959. Some Australian polyclads. *Rec. Aust. Mus*. 25: 1-17.

Jennings, K.A. & Newman, L.J. 1996. Two new stylochids (Plathyhelminthes, Polycladida) from the Great Barrier Reef, Australia. *Raffles Bull. Zoo*. 44: 135-142.

Jones, M.M. 1991. Marine organisms transported in ballast water: A review of the Australian scientific position. Bureau of Rural Resources Bulletin No. 11. BRR, Canberra, 48 pp.

Jones, D.S. & Morgan, G.J. 1994. A Field Guide to Crustaceans of Australian Waters. Western Australian Museum. Reed, Chatswood, NSW, 216 pp.

Jones, D.S., Anderson, J.T. & Anderson, D.T. 1990. A checklist of the Australian Cirripedia. *Tech. Rep. Aust. Mus.* 3: 1-38.

Keough, M.J. & Ross, J. 1999. Introduced fouling species in Port Phillip Bay. In Hewitt, C.L., Campbell, M.L., Thresher, R.E. & Martin, R.B., Marine Biological Invasions of Port Phillip Bay, Victoria. CRIMP Technical Report No. 20, CSIRO Marine Research, Hobart, Tasmania, pp.193 - 226.

Kott, P. 1985. The Australian Ascidiacea. Part I. Phlebobranchia and Stolidobranchia. *Mem. Qld Mus.* 23: 1-440.

Lockett, M.M. & Gomon, M.F. 1999. Occurrence and distribution of exotic fishes in Port Phillip Bay. In Hewitt, C.L., Campbell, M.L., Thresher, R.E. and Martin, R.B., Marine Biological Invasions of Port Phillip Bay, Victoria, pp.178-192. CRIMP Technical Report No. 20, CSIRO Marine Research, Hobart, Tasmania.

Macdonald, Wagner & Priddle Pty Ltd 1978. Port Kembla coal loader environmental impact statement. Report to the Department of Public Works, NSW, 298 pp.

Marine Science & Ecology. 1978. Benthic Survey of Port Kembla Harbour New South Wales. Report to Australian Iron and Steel Pty Ltd.

Marine Science & Ecology and Coastal Environmental Consultants Pty Ltd 1992. Port Kembla Harbour Study 1991. Report prepared for BHP Steel Slab and Plate Products Division.

Marine Science & Ecology and Coastal Environmental Consultants Pty Ltd 1996. Allans Creek Study 1995. Report prepared for BHP Steel Slab and Plate Products Division.

Millar, A.J.K. & Kraft, G.T. 1993. Catalogue of the marine and freshwater red algae (Rhodophyta) of New South Wales, including Lord Howe Island, South-western Pacific. *Aust. Syst. Bot.* 6: 1-90.

Millar, A.J.K. & Kraft, G.T. 1994a. Catalogue of the marine benthic green algae (Chlorophyta) of New South Wales, including Lord Howe Island, South-western Pacific. *Aust. Syst. Bot.* 7: 419-453.

Millar, A.J.K. & Kraft, G.T. 1994b. Catalogue of the marine brown algae (Phaeophyta) of New South Wales, including Lord Howe Island, South-western Pacific. *Aust. Syst. Bot.* 7: 1-46.

Moran, P.J. & Grant, T.R. 1993. Larval settlement of marine fouling organisms in polluted water from Port Kembla Harbour, Australia. *Mar. Poll. Bull.* 26: 512-514.

Paxinos, R. 2000. Harmful algal blooms. *Waves* (Marine and Coastal Community Network, Sydney) 7(2): 10-12.

Pillman, A., Woolcott, G.W., Olsen, J.L., Stam, W.T. & King, J. 1997. Inter- and intraspecific genetic variation in *Caulerpa* (Chlorophyta) based on nuclear rDNA ITS sequences. *Eur. J. Phycol*. 32: 379-386.

Pollard, D.A. & Hutchings, P.A. 1990a. A review of exotic marine organisms introduced to the Australian Region. I. Fishes. *Asian Fish. Sci.* 3: 205-221.

Pollard, D.A. & Hutchings, P.A. 1990b. A review of exotic marine organisms introduced to the Australian Region. II. Algae and invertebrates. *Asian Fish. Sci.* 3: 223-250.

Pollard, D.A. & Pethebridge, R.P. 2000. Report on Port of Botany Bay introduced marine pest species survey. Report to Sydney Ports Corporation. NSW Fisheries Final Report Series, Fisheries Research Institute, Cronulla, 64 pp.

Poore, G.C.B. & Storey, M. 1999. Soft sediment crustacea of Port Phillip Bay. In Hewitt, C.L., Campbell, M.L., Thresher, R.E. and Martin, R.B., Marine Biological Invasions of Port Phillip Bay Victoria, pp.150-170. CRIMP Technical Report No. 20, CSIRO Marine Research, Hobart, Tasmania.

Pope, E. 1945. A simplified key to the sessile barnacles found on rocks, boats, wharf piles and other installations in Port Jackson and adjacent waters. *Rec. Aust. Mus.* 21 (6): 351-372.

Port Kembla Port Corporation. 1999. Port Guide and Tide Tables. Port Kembla Port Corporation, 62 pp.

Prudhoe, S. 1982. Polyclad turbellarians from the southern coasts of Australia. *Rec. S. Aust. Mus.* 18: 361 - 384.

Prudhoe, S. 1985. A monograph on polyclad turbellaria. Oxford University Press, Oxford.

Sonnemann, J.A. & Hill, D.R.A. 1997. A taxonomic survey of cyst-producing dinoflagellates from coastal waters of Victoria, Australia. *Botan. Mar.* 40: 149-177.

Sydney Water Corporation. 1999. Illawarra waste strategy. Consolidation of Bellambi, Wollongong and Port Kembla sewage treatment plants. Sydney Water Waterplan 21. Volume 1.

White, A.W. 1980. Recurrence of fish kills of the Atlantic herring (*Clupea harengus harengus*) caused by dinoflagellate toxins transferred through herbivorous zooplankton. *Can. J. Fish. Aquat. Sci.* 37: 2262-2265.

White, A.W. 1982. The scope of impact of toxic dinoflagellate blooms on finfish of Canada. *Can. Tech. Rep. Fish. Aquat. Sci.* 1063: 103-109.

APPENDICES

APPENDIX 1. SCHEDULE OF INTRODUCED SPECIES

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

Gymnodinium & *Alexandrium* spp. (toxic dinoflagellates)
Undaria pinnatifida (Japanese seaweed)
Sabella spallanzanii (European fan worm)
Carcinus maenas (European shore crab)
Maoricolpus roseus (New Zealand screw shell)
Corbula gibba (European clam)
Mytilopsis sallei (Central American striped mussel)
Asterias amurensis (Northern Pacific seastar)
Vibrio cholera (cholera bacterium)
Fish pathogens (various)

Schedule 2. Marine pest species that may pose a significant threat in Australian waters

Mnemiopsis leidyi (North American comb jelly)
Philine auriformis (New Zealand sea slug)
Potamocorbula amurensis (Chinese clam)
Mytilus galloprovincialis (Mediterranean mussel)

Schedule 3. Known exotic species present in Australian waters

ANIMALS

Species	Possible Origin	Australian Distribution
Bougainvillea ramosa (hydroid)	N. Hemisphere	NSW
Hydroides elegans(serpulid)	Europe	WA, Vic, Tas, NSW
Boccardia proboscidea (spionid)	Japan/N.E. Pacific	Vic
Polydora ciliata (spionid)	Europe	WA, NSW
Pseudopolydora paucibranchiata (spionid)	Japan/N.E. Pacific/NZ	Vic
Euchone (?) sp. (fan worm)	?	Vic?
Sabella spallanzanii (fan worm)	Mediterranean	WA, SA, Vic, Tas, NSW
Balanus improvisus (barnacle)	Atlantic	SA?
Megabalanus rosa (barnacle)	Japan	WA
Megabalanus tintinnabulum (barnacle)	cosmopolitan	WA
Notomegabalanus algicola (barnacle)	S. Africa	NSW
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

Synidotea laevidorsalis (isopod)	?	?
Cancer novaezelandiae (crab)	NZ	Vic, Tas
Carcinus maenas (crab)	Europe	WA, SA, Vic, Tas, NSW
Halicarcinus innominatus (crab)	NZ	Tas
Petrolisthes elongatus (half crab)	NZ	Tas
Pyromaia tuberculata (crab)	E. Pacific	WA
Palaemon macrodactylus (shrimp)	N. Pacific	NSW
Sergiella angra (shrimp)	?	?
Maoricolpus roseus (screw shell)	NZ	Tas, NSW
Zeacumantis subcarinatus (screw shell)	NZ	NSW
Aeolidiella indica (sea slug)	widespread	NSW
Godiva quadricolor (sea slug)	S. Africa	WA
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
Thecacera pennigera (sea slug)	?	NSW
Crassostrea gigas (oyster)	Japan	WA, SA, Vic, Tas, NSW
Ostrea lutaria (oyster)	NZ	Vic
Corbula gibba (clam)	Europe/Mediterranean	Vic
Neilo australis (clam)	NZ	Tas
Paphirus largellierti (clam)	NZ	Tas
Musculista senhousia (mussel)	Pacific/Asia	WA, Vic, Tas
Mytilopsis sallei (striped mussel)	Central America	NT
Perna canaliculus (mussel)	NZ	Tas
Soletellina donacoides (tellinid)	NZ?	Tas?
Theora lubrica (semelid)	Pacific/Asia	WA, Vic
Amaurochiton glaucus (chiton)	NZ	Tas
Anguinella palmata (bryozoan)	Atlantic	NSW
Bugula flabellata (bryozoan)	Atlantic/Mediterranean	SA, NSW
Conopeum tubigerum (bryozoan)	Atlantic	Qld
Cryptosula pallasiana (bryozoan)	?	WA, SA, Tas, NSW
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)	N.W. Pacific/Europe	Vic
Styela plicata (ascidian)	widespread	WA, SA, NSW, Qld
Lateolabrax japonicus (sea bass)	Japan	NSW
Triso dermopterus (grouper)	W. Equat. Pacific	Qld
Sparidentex hasta (sea bream)	Arabian Gulf	WA
Acanthogobius flavimanus (goby)	N.W. Pacific	Vic, NSW
Acentrogobius pflaumi (goby)	Japan	Vic, NSW
Tridentiger trigonocephalus (goby)	N.W. Pacific	WA, Vic, NSW
Fosterygion varium (blenny)	NZ	Tas
Oncorhynchus mykiss (trout)	California (via NZ)	Tas
Oreochromis mossambicus (tilapia)	S.E. Asia	WA, Qld
Salmo salar (salmon)	N. America	Tas
Salmo trutta (trout)	UK	Tas

PLANTS

Species	Possible Origin	Australian Distribution
Alexandrium catenella (dinoflagellate)	Japan?	WA, SA, Vic, NSW
Alexandrium minutum (dinoflagellate)	Mediterranean?	WA, SA, Vic, NSW
Alexandrium tamarense (dinoflagellate)	Europe? Japan?	WA, SA, Vic, Tas
Gymnodinium catenatum (dinoflagellate)	Japan?	WA, Vic, Tas
Caulerpa taxifolia (green alga)	Atlantic/Indo Pacific	NSW, Qld
Codium fragile tomentosoides (green alga)	Atlantic Europe	Vic, NSW
Antithamnionella spirographidis (red alga)	N. hemisphere	?
Arthrocladia villosa (red alga)	N. hemisphere	?
Polysiphonia brodiaei (red alga)	N. hemisphere	?
Polysiphonia pungens (red alga)	N. hemisphere	?
Sperococcus compressus (red alga)	N. hemisphere	?
Discosporangium mesarthrocarpum (brown alga)	Mediterranean	SA
Spacella subtilissima (brown alga)	Mediterranean	SA
Undaria pinnatifida (brown alga)	Japan	Vic, Tas
Zosterocarpus spp. (brown alga)	Mediterranean	SA

APPENDIX 2. SAMPLING PROCEDURES

3.1. ABWMAC Target Species

3.1.1. Dinoflagellates

3.1.1.1. Sediment sampling for cyst-forming species

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

3.1.1.2. Sediment preparation and cyst identification

The top 6 cm of the sediment core is 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 are mixed with filtered seawater to obtain a watery slurry. Subsamples (5–10 ml) are sonicated for 2-3 min (Bransonic sonicator) to dislodge detritus particles. The sample is then screened through a 100 µm sieve and collected onto a 20 µm sieve. Subsamples (1 ml) are examined and counted on wet-mount slides, using a compound light microscope. Where possible, a total of at least 100 cysts is counted in each sample. Identification of species follows Bolch and Hallegraeff (1990) and Sonnemann and Hill (1997). Cysts of suspected toxic species are photographed with a Zeiss Axioplan light microscope using bright field or phase contrast illumination.

3.1.1.3. Phytoplankton sampling and culture

Phytoplankton samples are collected by vertical tows of a hand-deployed plankton net (25 cm diam. opening, 20 µm Nytal mesh; Swiss Screens, Melbourne, Vic.). The samples are sealed in plankton jars, placed in a cool container, and returned to the laboratory within 48 hours for light and fluorescent microscopic examination. In the laboratory, net samples are diluted 1:1 with growth medium. Germanium dioxide (10 mg l^{-1}) is added to inhibit overgrowth by diatom species and these enrichment cultures incubated. Incubations are examined regularly by light microscopy, and single cells of suspected toxic species isolated by micropipette for further culture and toxicity determination.

3.1.2. Carcinus maenas

3.1.2.1. Trapping

The European shore crab *(Carcinus maenas)* and other crab (and some fish) species are 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 is through slits at the apex of inwardly-directed V-shaped panels at each end of the trap. The internal bait bag is baited with

pilchards. Traps are weighted with chain and deployed with surface buoys. Whenever possible, traps are deployed in the late afternoon and recovered early the next morning.

3.1.2.2. Visual searches

Visual searches for crabs and other target species are also made at selected wharves in the port area. Divers swim the length of the wharf, searching structures between the surface and the bottom, to provide a complete visual survey of the outer wharf. Surveys of beach wrack are made on beaches to collect crab exuviae (shed shells).

3.1.3. Asterias amurensis, Sabella spallanzanii and Undaria pinnatifida

3.1.3.1. Visual searches

Visual searches for the northern Pacific seastar *(Asterias amurensis),* the Japanese kelp *(Undaria pinnatifida)* and the European fan worm *(Sabella spallanzanii)* are carried out by divers in rocky reef and wharf areas, and over soft bottoms. Divers are free swimming. Diver searches in wharf areas and surveys for *Undaria* in beach wrack follow procedures described for *Carcinus* above.

3.2. Non Target Species

3.2.1. Hard substrate invertebrates

3.2.1.1. Wharf pile communities

Piles or projecting steel facings are selected from wharves having different types of shipping activity. Three piles or facings are 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 pile or facing. Three piles or facings are sampled from all wharves selected for study. The selected piles or facings are marked and their positions recorded and photographed. For each pile divers then take:

(i) video film of the outer surface of the pile/facing from approximately high-water level down to the deepest exposed part of the pile/facing using a Hi-8 video camera recorder (Sony CCD-TR3000E) in an underwater housing (Sony MPK-TRB Handycam Marine Pack). The housing is 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 ensures that the camera is a constant distance (approx. 50 cm) from the pile or sea floor. The scale and depth meters are positioned so that they fall within the field of view of the camera and provide 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; and

(iii) representative quantitative (0.1 m^2 quadrat) samples of the fouling communities present at three depths (0.5, 3.0 and 7.0 m) by scraping attached animals and algae as carefully as possible into plastic bags. These samples are first rough-sorted and then preserved in 5% buffered formalin or ethanol for subsequent sorting and identification in the laboratory.

3.2.1.2. Breakwater communities

Using equipment detailed in section 3.2.1.1 above, divers take video and still photographs, and collect representative samples of the attached plant and invertebrate communities on breakwater wall substrates.

3.2.2. Soft substrate invertebrates

3.2.2.1. Epibenthos

Visual searches by divers to locate and collect non-target, soft-bottom, epibenthic species are carried out at selected sites as described for target species in sections 3.1.2 and 3.1.3 above. At each wharf sampled, if underwater visibility allows, divers video film a 50 m transect between one of the piles and the outer series of infaunal benthic cores (see section 3.2.2.2 below), along a weighted transect line marked at 1 m intervals.

3.2.2.2. Benthic infauna

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

When sampling around wharves, a core is taken within 1 m of the bottom of each outer pile and facing sampled, and a second set of three cores 50 m directly out from the wharf. For each wharf area sampled this provides 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 are taken 1 m from the base of the pile. Each sample is transferred to a 1 mm mesh bag with drawstring mouth and then sieved underwater, either *in situ* or after the diver has returned to the surface. The retained material is then washed into a plastic bag and preserved in 5% buffered formalin for subsequent sorting and identification in the laboratory.

3.2.3. Fish

3.2.3.1. Netting surveys

Seine nets are used to collect fish (and some mobile invertebrates) from sandy beaches. Seine netting is carried out using a 20 m seine with 10 mm mesh. All species taken with the seine nets are recorded.

During the Port Kembla survey, both rotenone (a fish poison) and clove oil (a fish anaesthetic) were also used around wharf piles, rocky shores and breakwaters to collect fish from these habitats.

3.3. Environmental Data

3.3.1. Temperature and salinity

A temperature/salinity meter is used to record data on water temperature and salinity, usually at 1 m intervals from the surface to near the bottom. Water visibility (turbidity) is measured using a Secchi disk.

APPENDIX 3. BALLAST WATER ACTIVITY AT THE BERTHS IN PORT KEMBLA

The discharge and take up of ballast water (de-ballasting and ballasting, respectively) is directly associated with the quantity of cargo loading and/or discharge being undertaken by the vessel. As a general rule, as a vessel loads cargo it de-ballasts and when discharging cargo it ballasts.

The Summary Table below identifies the berths present in the Port of Port Kembla, the cargo they handle and the consequential ballast water activity that can be anticipated at that berth (see also Table 3.2).

SUMMARY TABLE OF BERTH ACTIVITY AND RELATED BALLAST WATER ACTIVITY IN PORT KEMBLA [1]		
Outer Harbour		
No.4 Bulk Liquids Berth	Export bulk liquid	Vessels normally de-ballast, all Handysize, 75% coastal ballast water
No.3 Jetty	Tug berth	No cargo – no ballasting operations
Oil Berth	Import bunker fuel	Vessels ballast
No.6 Jetty	Import and export	Vessels ballast or de-ballast depending upon if loading or discharging cargo – when required the quantities are small as the ships (Handysize) and their cargo quantities are also usually smaller
Inner Harbour		
BHP No.1 Products Berth	Export steel products	Vessels de-ballast, predominantly Handysize on international trades
BHP No.2 Products Berth	Export steel products	Vessels de-ballast, predominantly Handysize on international trades
BHP No.1 Bulk Discharge Berth	Import raw materials for steel making	Vessels ballast. Vary in size from Handysize to Panamax
BHP No.2 Bulk Discharge Berth	Import iron ore for steel making	Vessels ballast, predominantly Capesized
BHP Roll On Roll Off (BHP RoRo) Berth	Domestic export of steel products	Vessel de-ballasts water from Western Port, Victoria
Multipurpose Berth (MPB)	Import and export of various cargoes	Vessels ballast or de-ballast depending upon if loading or discharging cargo – when required the quantities are small to medium as the ships and their cargo quantities are also usually small to medium (Handysize to Panamax). Some vessels that both load and discharge do not undertake any ballasting
Grain Berth	Export grain	Vessels de-ballast – predominantly international trade. Vessels small to medium (Handysize to Panamax)
Port Kembla Coal Terminal Berth 1	Export coal, slag and sand; import coal	Quantity of cargo through this berth is small. Exporting vessels de-ballast. Importing vessels ballast. Vessels Handysize to Panamax

Port Kembla Coal Terminal Berth 2	Export coal	Port's major coal export facility. Vessels de-ballast. Vessels range from Handysize through to Capesized
ANL Roll On Roll Off (ANL RoRo) Berth, also known as Eastern Basin No.4 (EB4)	Not in use for cargo operations – only used to moor the occasional small vessel when waiting	No cargo – no ballasting operations

[1] *Information provided by Captain W. Hoogendoorn, Port Kembla Port Corporation*

GLOSSARY:

Ballast:	To take up ballast water from the port.
De-ballast:	To discharge ballast water into the port.
Handysize:	Vessels up to about 185m in length with cargo capacity up to about 35,000t.
Panamax:	Vessels between 210 and 235m in length with cargo capacity up to about 70,000t.
Capesized:	Vessels above about 250m in length with cargo capacity up to about (for Port Kembla) 160,000t.
Export:	The export of cargo from the port, irrespective of it being intrastate, interstate or international.
Import:	The import of cargo to the port, irrespective of it being intrastate, interstate or international.

APPENDIX 4. CODE OF PRACTICE FOR IN-WATER HULL CLEANING AND MAINTENANCE

The following *Code of Practice for In-water Hull Cleaning and Maintenance* was prepared and adopted by the Australian and New Zealand Environment and Conservation Council (ANZECC 1997).

5.1. Background

In recent years much attention has been focussed on the introduction of exotic marine organisms via ship's ballast. Another way of transporting exotic marine organisms is via a ship's hull.
To minimise the risk of further exotic organisms establishing in marine waters, ANZECC in consultation with the Australian Quarantine Inspection Service has established the following *Code of Practice for In-water Hull Cleaning and Maintenance*.

5.2. Application

These requirements shall apply in Australian waters and are applicable to all commercial vessels. These requirements are to be used with any relevant state environmental protection agency requirements.

5.3. Procedures

No part of a vessel's hull treated with antifoulant is to be cleaned in Australian waters without the written permission of the Harbour Master, local government or state environmental protection agency (administering authority).

In-water hull cleaning is prohibited except under extra-ordinary circumstances, and permission will not normally be granted.

The cleaning of sea chests, sea suction grids and other hull apertures may be permitted provided that any debris removed (including encrustation, barnacles, weeds) is not allowed to pass into the water column or fall to the sea bed and subject to any other conditions attached to the permit. An application seeking permission to carry out this work must be lodged with the administering authority at least five (5) working days prior to commencement of the anticipated start date. Such application will detail how encrustations, barnacles and other debris will be contained and or collected for disposal as well as the method of disposal.

The polishing of ship's propellers may be permitted subject to any conditions attached to the permit. An application seeking permission to carry out "propeller polishing" must be lodged with the administering authority at least five (5) working days prior to commencement of the work.
Applications for permits may be facsimiled to the administering authority.

Other titles in this series:

ISSN 1440-3544

No. 1 Andrew, N.L., Graham, K.J., Hodgson, K.E. and Gordon, G.N.G., 1998. Changes after 20 years in relative abundance and size composition of commercial fishes caught during fishery independent surveys on SEF trawl grounds. Final Report to Fisheries Research and Development Corporation. Project No. 96/139.

No. 2 Virgona, J.L., Deguara, K.L., Sullings, D.J., Halliday, I. and Kelly, K., 1998. Assessment of the stocks of sea mullet in New South Wales and Queensland waters. Final Report to Fisheries Research and Development Corporation. Project No. 94/024.

No. 3 Stewart, J., Ferrell, D.J. and Andrew, N.L., 1998. Ageing Yellowtail (*Trachurus novaezelandiae*) and Blue Mackerel (*Scomber australasicus*) in New South Wales. Final Report to Fisheries Research and Development Corporation. Project No. 95/151.

No. 4 Pethebridge, R., Lugg, A. and Harris, J., 1998. Obstructions to fish passage in New South Wales South Coast streams. Final report to Cooperative Research Centre for Freshwater Ecology. 70pp.

No. 5 Kennelly, S.J. and Broadhurst, M.K., 1998. Development of by-catch reducing prawn-trawls and fishing practices in NSW's prawn-trawl fisheries (and incorporating an assessment of the effect of increasing mesh size in fish trawl gear). Final Report to Fisheries Research and Development Corporation. Project No. 93/180. 18pp + appendices.

No. 6 Allan, G.L., and Rowland, S.J., 1998. Fish meal replacement in aquaculture feeds for silver perch. Final Report to Fisheries Research and Development Corporation. Project No. 93/120-03. 237pp + appendices.

No. 7 Allan, G.L., 1998. Fish meal replacement in aquaculture feeds: subprogram administration. Final Report to Fisheries Research and Development Corporation. Project No. 93/120. 54pp + appendices.

No. 8 Heasman, M.P., O'Connor, W.A., O'Connor, S.J., 1998. Enhancement and farming of scallops in NSW using hatchery produced seedstock. Final Report to Fisheries Research and Development Corporation. Project No. 94/083. 146pp.

No. 9 Nell, J.A., McMahon, G.A., and Hand, R.E., 1998. Tetraploidy induction in Sydney rock oysters. Final Report to Cooperative Research Centre for Aquaculture. Project No. D.4.2. 25pp.

No. 10 Nell, J.A. and Maguire, G.B., 1998. Commercialisation of triploid Sydney rock and Pacific oysters. Part 1: Sydney rock oysters. Final Report to Fisheries Research and Development Corporation. Project No. 93/151. 122pp.

No. 11 Watford, F.A. and Williams, R.J., 1998. Inventory of estuarine vegetation in Botany Bay, with special reference to changes in the distribution of seagrass. Final Report to Fishcare Australia. Project No. 97/003741. 51pp.

No. 12 Andrew, N.L., Worthington D.G., Brett, P.A. and Bentley N., 1998. Interactions between the abalone fishery and sea urchins in New South Wales. Final Report to Fisheries Research and Development Corporation. Project No. 93/102.

No. 13 Jackson, K.L. and Ogburn, D.M., 1999. Review of depuration and its role in shellfish quality assurance. Final Report to Fisheries Research and Development Corporation. Project No. 96/355. 77pp.

No. 14 Fielder, D.S., Bardsley, W.J. and Allan, G.L., 1999. Enhancement of Mulloway (*Argyrosomus japonicus*) in intermittently opening lagoons. Final Report to Fisheries Research and Development Corporation. Project No. 95/148. 50pp + appendices.

No. 15 Otway, N.M. and Macbeth, W.G., 1999. The physical effects of hauling on seagrass beds. Final Report to Fisheries Research and Development Corporation. Project No. 95/149 and 96/286. 86pp.

No. 16 Gibbs, P., McVea, T. and Louden, B., 1999. Utilisation of restored wetlands by fish and invertebrates. Final Report to Fisheries Research and Development Corporation. Project No. 95/150. 142pp.

No. 17 Ogburn, D. and Ruello, N., 1999. Waterproof labelling and identification systems suitable for shellfish and other seafood and aquaculture products. Whose oyster is that? Final Report to Fisheries Research and Development Corporation. Project No. 95/360. 50pp.

No. 18 Gray, C.A., Pease, B.C., Stringfellow, S.L., Raines, L.P. and Walford, T.R., 2000. Sampling estuarine fish species for stock assessment. Includes appendices by D.J. Ferrell, B.C. Pease, T.R. Walford, G.N.G. Gordon, C.A. Gray and G.W. Liggins. Final Report to Fisheries Research and Development Corporation. Project No. 94/042. 194pp.

No. 19 Otway, N.M. and Parker, P.C., 2000. The biology, ecology, distribution, abundance and identification of marine protected areas for the conservation of threatened Grey Nurse Sharks in south east Australian waters. Final Report to Environment Australia. 101pp.

No. 20 Allan, G.L. and Rowland, S.J., 2000. Consumer sensory evaluation of silver perch cultured in ponds on meat meal based diets. Final Report to Meat & Livestock Australia. Project No. PRCOP.009. 21pp + appendices.

No. 21 Kennelly, S.J. and Scandol, J. P., 2000. Relative abundances of spanner crabs and the development of a population model for managing the NSW spanner crab fishery. Final Report to Fisheries Research and Development Corporation. Project No. 96/135. 43pp + appendices.

No. 22 Williams, R.J., Watford, F.A. and Balashov, V., 2000. Kooragang Wetland Rehabilitation Project: History of changes to estuarine wetlands of the lower Hunter River. Final Report to Kooragang Wetland Rehabilitation Project Steering Committee. 82pp.

No. 23 Survey Development Working Group, 2000. Development of the National Recreational and Indigenous Fishing Survey. Final Report to Fisheries Research and Development Corporation. Project No. 98/169. (Volume 1 – 36pp + Volume 2 – attachments).

No.24 Rowling, K.R and Raines, L.P., 2000. Description of the biology and an assessment of the fishery of Silver Trevally *Pseudocaranx dentex* off New South Wales. Final Report to Fisheries Research and Development Corporation. Project No. 97/125. 69pp.

No. 25 Allan, G.L., Jantrarotai, W., Rowland, S., Kosuturak, P. and Booth, M., 2000. Replacing fishmeal in aquaculture diets. Final report to the Australian Centre for International Agricultural Research. Project No. 9207. 13pp.

No. 26 Gehrke, P.C., Gilligan, D.M., Barwick, M., 2001. Fish communities and migration in the Shoalhaven River – Before construction of a fishway. Final report to Sydney Catchment Authority. 126pp.

No. 27 Rowling, K.R., and Makin, D.L., 2001. Monitoring of the fishery for Gemfish *Rexea solandri*, 1996 to 2000. Final report to the Australian Fisheries Management Authority. 44pp.

No. 28 Otway, N.M., 1999. Identification of candidate sites for declaration of aquatic reserves for the conservation of rocky intertidal communities in the Hawkesbury Shelf and Batemans Shelf Bioregions. Final report to Environment Australia for the Marine Protected Areas Program (Project No. OR22). 88pp.

No. 29 Heasman, M.P., Goard, L., Diemar, J. and Callinan, R. 2000. Improved Early Survival of Molluscs: Sydney Rock Oyster (*Saccostrea glomerata*). Final report to the Aquaculture Cooperative Research Centre (Project No. A.2.1.). 63pp.

No. 30 Allan, G.L., Dignam, A and Fielder, S. 2001. Developing Commercial Inland Saline Aquaculture in Australia: Part 1. R&D Plan. Final Report to Fisheries Research and Development Corporation. Project No. 1998/335.

No. 31 Allan, G.L., Banens, B. and Fielder, S. 2001. Developing Commercial Inland Saline Aquaculture in Australia: Part 2. Resource Inventory and Assessment. Final report to Fisheries Research and Development Corporation. Project No. 1998/335. 33pp.

No. 32 Bruce, A., Growns, I. and Gehrke P. 2001. Woronora River Macquarie Perch Survey. Final report to Sydney Catchment Authority, April 2001. 116pp.

No. 33 Morris, S.A., Pollard, D.A., Gehrke, P.C. and Pogonoski, J.J. 2001. Threatened and Potentially Threatened Freshwater Fishes of Coastal New South Wales and the Murray-Darling Basin. Report to Fisheries Action Program and World Wide Fund for Nature. Project No. AA 0959.98. 17pp.

No. 34 Heasman, M.P., Sushames, T.M., Diemar, J.A., O'Connor, W.A. and Foulkes, L.A. 2001. Production of Micro-algal Concentrates for Aquaculture Part 2: Development and Evaluation of Harvesting, Preservation, Storage and Feeding Technology. Final report to Fisheries Research and Development Corporation. Project No. 1993/123 and 1996/342. 150pp + appendices.

No. 35 Stewart, J. and Ferrell, D.J. 2001. Mesh selectivity in the NSW demersal trap fishery. Final report to Fisheries Research and Development Corporation. Project No. 1998/138. 86pp.

No. 36 Stewart, J., Ferrell, D.J., van der Walt, B., Johnson, D. and Lowry, M. 2001. Assessment of length and age composition of commercial kingfish landings. Final report to Fisheries Research and Development Corporation. Project No. 1997/126. 49pp.

No. 37 Gray, C.A. and Kennelly, S.J. 2001. Development of discard-reducing gears and practices in the estuarine prawn and fish haul fisheries of NSW. Final report to Fisheries Research and Development Corporation. Project No. 1997/207. 151pp.

No. 38 Murphy, J.J., Lowry, M.B., Henry, G.W. and Chapman, D. 2002. The Gamefish Tournament Monitoring Program – 1993 to 2000. Final report to Australian Fisheries Management Authority. 93pp.

No. 39 Kennelly, S.J. and McVea, T.A. (Ed) (2002). Scientific reports on the recovery of the Richmond and Macleay Rivers following fish kills in February and March 2001. 325pp.

No. 40 Pollard, D.A. and Pethebridge, R.L. (2002). Report on Port of Botany Bay Introduced Marine Pest Species Survey. Final report to Sydney Ports Corporation. 69pp.

No. 41 Pollard, D.A. and Pethebridge, R.L. (2002). Report on Port Kembla Introduced Marine Pest Species Survey. Final report to Port Kembla Port Corporation. 73pp.