Port of Auckland

Second baseline survey for non-indigenous marine species (Research Project ZBS2005/18)

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Contents

Executive summary

- This report describes the results of a repeat port baseline survey of the Port of Auckland undertaken in March 2006. The survey provides a second inventory of native, non indigenous and cryptogenic marine species within the port and compares the biota with that recorded during an earlier port baseline survey of the Port of Auckland undertaken in April 2003.

- The survey is part of a nationwide investigation of native and non-native marine biodiversity in 25 international shipping ports and five marinas of first entry for vessels entering New Zealand from overseas.

- To allow a direct comparison with the initial baseline survey of the Port of Auckland, the repeat survey used the same methodologies and sampled the same sites (where possible) as in the initial survey. To improve the description of the biota of the port, some additional survey sites were added during the repeat survey.

- Sampling methods used in both surveys were based on protocols developed by the Australian Centre for Research on Introduced Marine Pests (CRIMP) for baseline surveys of non-indigenous species (NIS) in ports. Modifications were made to the CRIMP protocols for use in New Zealand port conditions. These are described in more detail in the body of the report.

- A wide range of sampling techniques was used to collect marine organisms from habitats within the Port of Auckland. Fouling assemblages were scraped from hard substrata by divers, benthic assemblages were sampled using a sled and benthic grabs, and a gravity corer was used to sample for dinoflagellate cysts. Mobile predators and scavengers were sampled using baited fish, crab, seastar and shrimp traps.

- Sampling effort in the Port of Auckland was distributed according to priorities identified in the CRIMP protocols, which are designed to maximise the chances of detecting non-indigenous species. Most effort was concentrated on high-risk locations and habitats where non-indigenous species were most likely to be found.

- Organisms collected during the survey were sent to local and international taxonomic experts for identification.

- As a result of ongoing taxonomic work, some identifications made during the initial baseline survey of the Port of Auckland have undergone revision since the publication of that report. The revised data indicated that a total of 173 species or higher taxa were identified in the first survey of the Port of Auckland in April 2003. They consisted of 116 native species, 22 cryptogenic taxa, 14 non-indigenous species, and 21 indeterminate taxa

- During the repeat survey, 238 species or higher taxa were recorded, including 145 native species, 14 non-indigenous species, 34 cryptogenic species and 45 indeterminate taxa. Many species were common to both surveys. Around 51 % of the native species, 50 % of the non-indigenous species, and 41 % of the cryptogenic taxa recorded during the repeat survey were also found in the earlier survey.

- The 14 non-indigenous species found in the repeat survey of the Port of Auckland included representatives of 17 phyla. The non-indigenous species detected were: (Annelida) *Hydroides elegans, Paralepidontus ampuliferus*; (Arthropoda) *Apocorphium acutum, Charybdis japonica*; (Bryozoa) *Bugula flabellata, Watersipora subtorquata*; (Chordata) *Styela clava;* (Cnidaria) *Pennaria disticha;* (Mollusca) *Limaria orientalis, Crassostrea gigas, Theora lubrica*; (Porifera) *Amphilectus fucorum, Callyspongia robusta* and (Entoprocta) *Barentsia matsushimana*. Seven of these species – *P. ampuliferus, A. acutum, W. subtoquata, S. clava, L. orientalis, C. robusta* and *B. matsushimana* - were not recorded in the earlier baseline survey of the Port of Auckland. In addition, six non-indigenous species that were recorded in the first survey – (Bryozoa) *Bugula neritina, Celleporaria* sp. 1, *Anguinella palmate*; (Chordata) *Arenigobius bifrenatus*; (Cnidaria) *Obelia longissima* and (Porifera) *Halisarca dujardini*– were not found during the repeat survey.

- No species recorded in the repeat survey were new records for New Zealand waters.

- One species recorded during the second survey of the Port of Auckland – the club-shaped ascidan *Styela clava* - is on the New Zealand Register of Unwanted Organisms.

- Most non-indigenous species located in the Port are likely to have been introduced to New Zealand accidentally by international shipping or spread from other locations in New Zealand (including translocation by shipping).

- Approximately 47 % (nine of 19 species) of NIS recorded in the two Port of Auckland baseline surveys are likely to have been introduced in hull fouling assemblages, 10 % (two species) via ballast water, 36 % (seven species) could have been introduced by either ballast water or hull fouling vectors and the vectors of introduction for 10 % (two species) is currently unknown.

- The predominance of hull fouling species in the introduced biota of Port of Auckland (as opposed to ballast water introductions) is consistent with findings from similar port baseline studies overseas and in New Zealand.

Introduction

Introduced (non-indigenous) plants and animals are now recognised as one of the most serious threats to the natural ecology of biological systems worldwide (Wilcove *et al*. 1998; Mack *et al*. 2000). Growing international trade and travel mean that humans now intentionally and unintentionally transport a wide range of species outside their natural biogeographic ranges to regions where they did not previously occur. A proportion of these species are capable of causing serious harm to native biodiversity, industries and human health. Recent studies suggest that coastal marine environments may be among the most heavily invaded ecosystems, as a consequence of the long history of transport of marine species by international shipping (Carlton and Geller 1993; Grosholz 2002). Ocean-going vessels transport marine species in ballast water, in sea chests and other recesses in the hull structure, and as fouling communities attached to submerged parts of their hulls (Carlton 1985; Carlton 1999; AMOG Consulting 2002; Coutts *et al.* 2003). Transport by shipping has enabled thousands of marine species to spread worldwide and establish populations in shipping ports and coastal environments outside their natural range (Cohen and Carlton 1995; Hewitt *et al.* 1999; Eldredge and Carlton 2002; Leppakoski *et al.* 2002).

Like many other coastal nations, New Zealand is just beginning to document the numbers, identity, distribution and impacts of non-indigenous species in its coastal waters. A review of existing records suggested that by 1998, at least 148 marine species had been recorded from New Zealand, with around 90 % of these establishing permanent populations (Cranfield *et al*. 1998). Since that review, an additional 41 non-indigenous species or suspected non-indigenous species (i.e. Cryptogenic type 1 – see “Definitions of species categories”, in methods section) have been recorded from New Zealand waters. To manage the risk from these and other non-indigenous species, better information is needed on the current diversity and distribution of species present within New Zealand.

BIOLOGICAL BASELINE SURVEYS FOR NON-INDIGENOUS MARINE SPECIES

In 1997, the International Maritime Organisation (IMO) released guidelines for ballast water management (Resolution A868-20) that encouraged countries to undertake biological surveys of port environments for potentially harmful non-indigenous aquatic species. As part of its comprehensive five-year Biodiversity Strategy package on conservation, environment, fisheries, and biosecurity released in 2000, the New Zealand Government funded a national series of port baseline surveys. These surveys aimed to determine the identity, prevalence and distribution of native, cryptogenic and non-indigenous species in New Zealand’s major shipping ports and other high risk points of entry for vessels entering New Zealand from overseas. The government department responsible for biosecurity in the marine environment at the time, the New Zealand Ministry of Fisheries (MFish), commissioned NIWA to undertake biological baseline surveys in 13 ports and three marinas that are first ports of entry for vessels entering New Zealand from overseas (Figure 1). Marine biosecurity functions are now vested in MAF Biosecurity New Zealand.

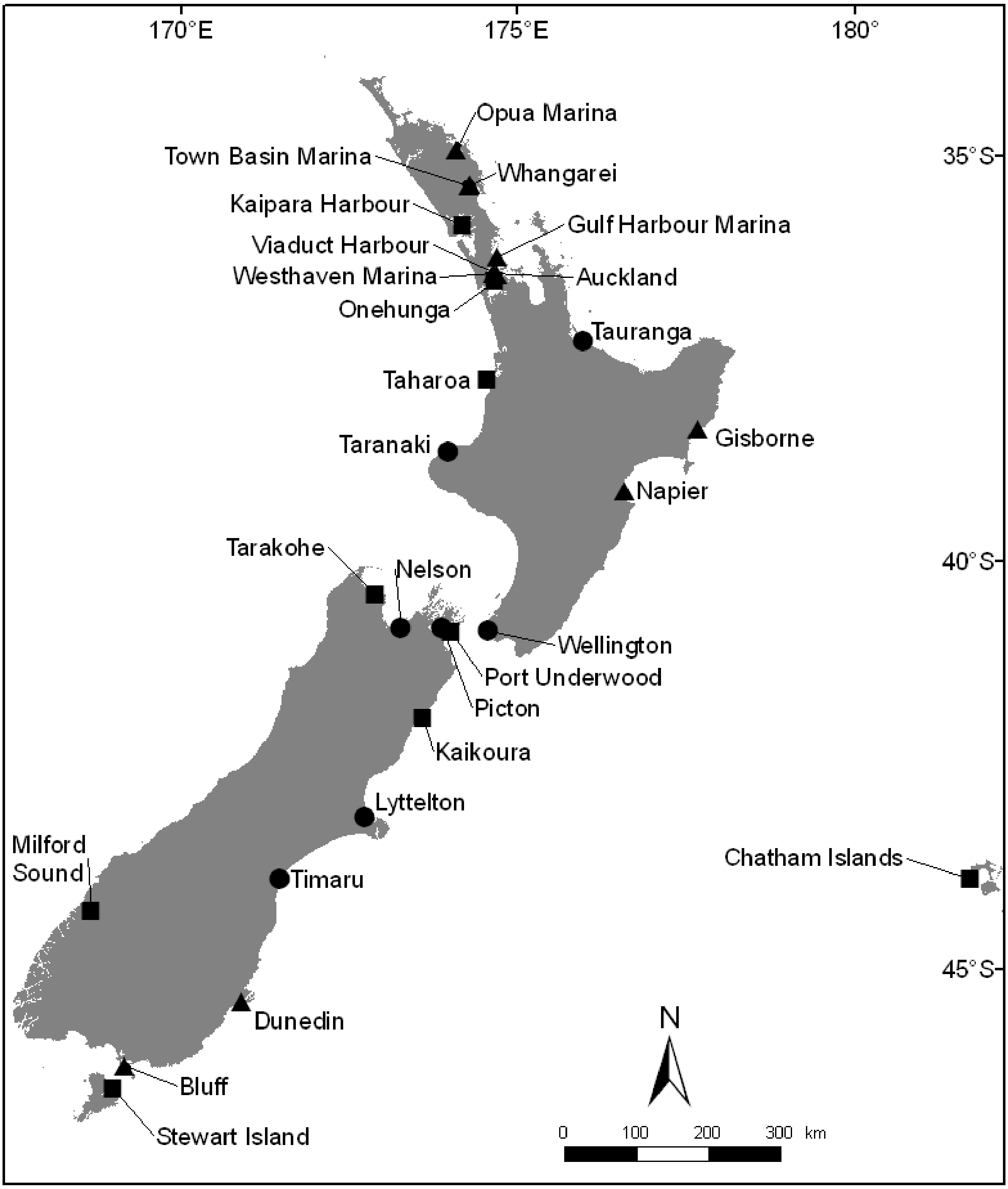

Figure 1: Commercial shipping ports in New Zealand where baseline non indigenous species surveys have been conducted. Group 1 ports (circles) were surveyed in the summer of 2001/2002 and resurveyed in the summer of 2004/2005, Group 2 ports (triangles) were surveyed in the summer of 2002/2003 and resurveyed in the summer of 2005/2006 (except for Viaduct and Westhaven marinas, which were surveyed for the first time during the 2005/2006 summer), and Group 3 ports (squares) were surveyed between May 2006 and December 2007.

The New Zealand baseline port surveys were based on protocols developed in Australia by the CSIRO Centre for Research on Introduced Marine Pests (CRIMP) for port surveys of introduced marine species (Hewitt and Martin 1996; Hewitt and Martin 2001). They are best described as "*generalised pest surveys*", as they are broad-based investigations whose primary purpose is to identify and inventory the range of non-indigenous species present in a port (Wittenberg and Cock 2001; Inglis *et al.* 2003).

The surveys have two stated objectives:

i. To provide a baseline assessment of native, non-indigenous and cryptogenic[1] species, and
ii. To determine the distribution and relative abundance of a limited number of target species in shipping ports and other high risk points of entry for non-indigenous marine species (Hewitt and Martin 2001).

Initial surveys were completed in New Zealand's 13 major shipping ports and 3 marinas of first entry during the summers of 2001/2002 ("Group 1" ports) and 2002/2003 ("Group 2" ports, Figure 1). These surveys recorded more than 1300 species; 124 of which were known or suspected to have been introduced to New Zealand. At least 18 of the non-indigenous species were recorded for the first time in New Zealand in the port baseline surveys. In addition, 106 species that are potentially new to science were discovered during the surveys and await more formal taxonomic description. These 16 locations were subsequently resurveyed in the summers of 2004/05 and 2005/06 to establish changes in the number and identity of non-indigenous species present.

In 2005, MAF Biosecurity New Zealand extended the national port baseline surveys to a range of secondary, domestic and international ports and marinas within New Zealand ("Group 3 ports"; Figure 1) to increase our knowledge of the non-indigenous marine species present in regional nodes for shipping.

Worldwide, port surveys based on the CRIMP protocols have been completed in at least 37 Australian ports, at demonstration sites in China, Brasil, the Ukraine, Iran, South Africa, India, Kenya, and the Seychelles Islands, at six sites in the United Kingdom, and are underway at 10 sites in the Mediterranean (Raaymakers 2003). Despite their wide use, there have been few evaluations of the survey methods or survey design to determine their sensitivity for individual unwanted species or to determine the completeness of biodiversity inventories based upon them. Inglis (2007) used a range of biodiversity metrics to evaluate the adequacy of sample effort and distribution during the initial New Zealand survey of the Port of Wellington and compared the results with those from seven Australian port baseline surveys. In general, they concluded that the surveys provided an adequate description of the richness of the assemblage of non-indigenous species present in the ports, but that the total richness of native and cryptogenic species present in the survey area was likely to be under estimated. The authors made a number of recommendations for future surveys that included increasing the sample effort for benthic infauna, maximising dispersion of samples throughout the survey area (rather than allocation based on CRIMP priorities) and modification of survey methods or design components which had high complementarity in species composition. Both Inglis *et al.* (2003) and a more recent study by Hayes *et al.* (2005) on the sensitivity of the survey methods concluded that generalised port surveys, such as these, are likely to under-sample species that are very rare or which have restricted distributions within the port environments and, as such, should not be considered surveys for early detection of unwanted species.

Instead, the port surveys are intended to provide a baseline for monitoring the rate of new incursions by non-indigenous marine species in port environments, and to assist international

[1] "Cryptogenic:" are species whose geographic origins are uncertain (Carlton 1996).

risk profiling of problem species through the sharing of information with other shipping nations (Hewitt and Martin 2001).

This report is intended as a stand-alone record of the second survey of the Port of Auckland and, as such, we reiterate background information on the port, including its history, physical environment, shipping and trading patterns, development and maintenance activities, and biological environment. Where available, this information is updated with new data that have become available in the time between the two surveys.

DESCRIPTION OF THE PORT OF AUCKLAND

General features

The Port of Auckland (36° 51'S, 174° 48'E) on the east coast of the North Island (Figure 1) is located on the southern shore of Waitemata Harbour (Figure 2). Waitemata Harbour is a deep embayment within the Hauraki Gulf (Thompson 1981). Auckland city extends along the southern shoreline of the harbour, and the cities of Takapuna, Birkenhead and Waitemata occupy the north shore. Waitemata Harbour occupies a drowned valley system with numerous ancillary tidal rivers and is connected to the Hauraki Gulf via the Rangitoto channel. The harbour is approximately 20 km long from North Head to the upper harbour bridge and varies in width from around two to 15 km. The Rangitoto channel curves south-west to enter the mouth of the harbour and then runs west for the length of Waitemata Harbour. Tidal currents help maintain water depths of around 15 m in this central channel.

The vast majority of the harbour area outside the Rangitoto channel is less than 5 m deep, with extensive areas such as Shoal Bay and Ngataringa Bay and most of the upper harbour being less than 2 m deep. The majority of the subtidal habitat in Waitemata Harbour is composed of mud and fine sand, with a few small areas of coarse sand/shell/gravel near the centre of the harbour (Hayward 1997a). Muddy intertidal flats are common around the harbour with mangroves present on the flats towards the northwest end of the harbour. Rocky coastline exists on the northern entrance to the harbour around north head, and patches of rocky reef exist in the upper harbour extending north from Point Chevalier.

The port area is the largest in the country with continuous wharves and jetties spanning over 2.5 km of coastline. Also located within Waitemata Harbour are the Royal New Zealand Navy Dockyard, located at Devonport, on the opposite side of the harbour from the port, and Westhaven and Hobson West Marinas. Westhaven Marina is one of the largest marinas in the southern hemisphere.

The Port of Auckland was first established in the early 1840's because of an urgent need to establish a suitable capital and trading port in New Zealand. By 1843, around 3,000 people lived in Auckland and most of them depended on the port to provide them with a living either directly or indirectly. By the end of the 1860's, Auckland's population had grown to more than 12,000 (Ports of Auckland Ltd 2007)

The Auckland Harbour Board was established by an Act of Parliament in 1870. The Board was governed by an elected Board with three-year terms of office and administered by permanent staff. It remained in existence until the Port Companies Act in 1988. By the 1860s the first harbour reclamation had been completed and Queen Street Wharf had become the port's main pier.

By the end of the 1860s overseas trade was growing, mainly with England and Australia, and a very active coastal shipping trade had been established. By 1920, Auckland was the busiest port in New Zealand. Development between Princes Wharf and Kings Wharf (now incorporated into Axis Bledisloe) was completed between 1904 and 1924. Bledisloe, Jellicoe and Freyberg Wharves were developed between 1940 and 1962, and Bledisloe was again extended in the 1970s (Ports of Auckland Ltd 2007).

The sea freight business began to change dramatically in the 1960's and 1970s, with container shipping becoming increasingly common. Fergusson Container Terminal (now called Axis Fergusson) was built as a specialist container operation in 1971. In the 1970s, Bledisloe Wharf (now Axis Bledisloe) was redeveloped to handle larger numbers of containers.

Ports of Auckland Ltd was formed in 1988 and took over the operations of the commercial port. The Port of Auckland (owned and operated by Ports of Auckland Ltd, which also operates the regional Port of Onehunga) is 100% owned by Auckland Regional Holdings, which is entirely accountable to the Auckland Regional Council (Ports of Auckland Ltd 2006). The Port of Auckland is still New Zealand's busiest shipping port, and the major hub port in the North Island (Inglis 2001). It is New Zealand's largest international container port (Ports of Auckland Ltd 2007).

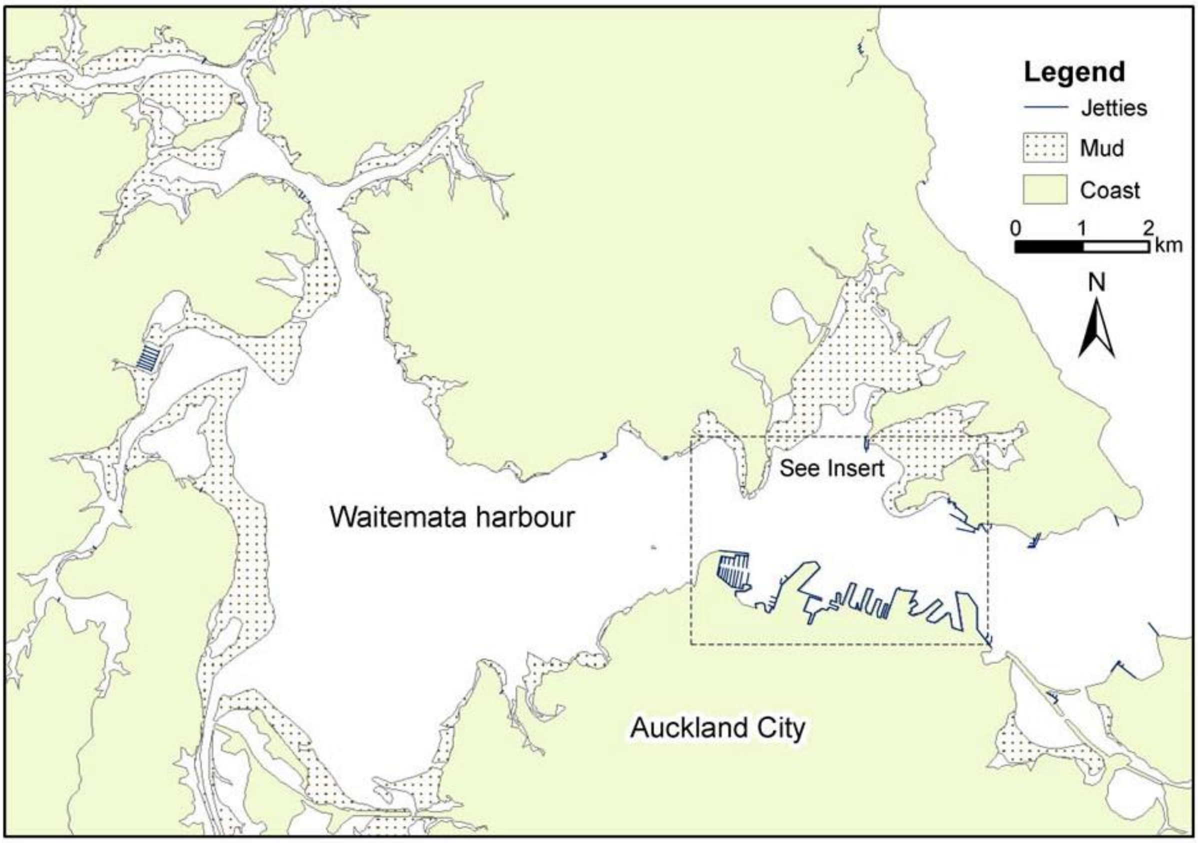

Figure 2: Map of Waitemata Harbour showing the location of the Port of Auckland (see Figure 3).

Port operation, development and maintenance activities

The Port of Auckland has nine major wharves (Figure 3) that handle a wide variety of cargo including containers, petroleum products, breakbulk (e.g. steel, imported vehicles and timber), and bulk cargo (e.g. gypsum and wheat). Berth construction is predominantly concrete deck (including the very early wharves) on concrete piling with hardwood fender piling. Details of the major berthing facilities are provided in Table 1.

Vessels unable to be berthed immediately in the port may anchor inside the port off Princes Wharf in the stream on their own anchors. This is not a common occurrence, and usually only occurs if the vessel is on layby. There are some pile moorings on the southwest corner of Waiheke Island for mooring vessel hulks (Murray Dennis, Port of Auckland Ltd, pers. comm.). Pilotage is compulsory on the Waitemata Harbour for vessels over 500 gross registered tonnes. Pilots board one to two nautical miles north of the Rangitoto Beacon, at 36° 46.9'S, 174° 49.3'E (Ports of Auckland Ltd 2007).

Within the port, there is on-going maintenance dredging as required, to maintain shipping berths at depths of around 11 m. This usually involves the dredging of approximately 30,000 m^3 annually within the port (Ports of Auckland Ltd 2007). Spoil disposal used to be 10-15 nautical miles east of Great Barrier Island; however, spoil is currently mudcreted to form part of the new 9.4 ha reclamation at the southeast corner of Axis Fergusson container terminal (see below). The reclamation will take several years to complete, and during this period all dredgings from both the Waitemata and Manukau Harbours will be mudcreted for use in this extension.

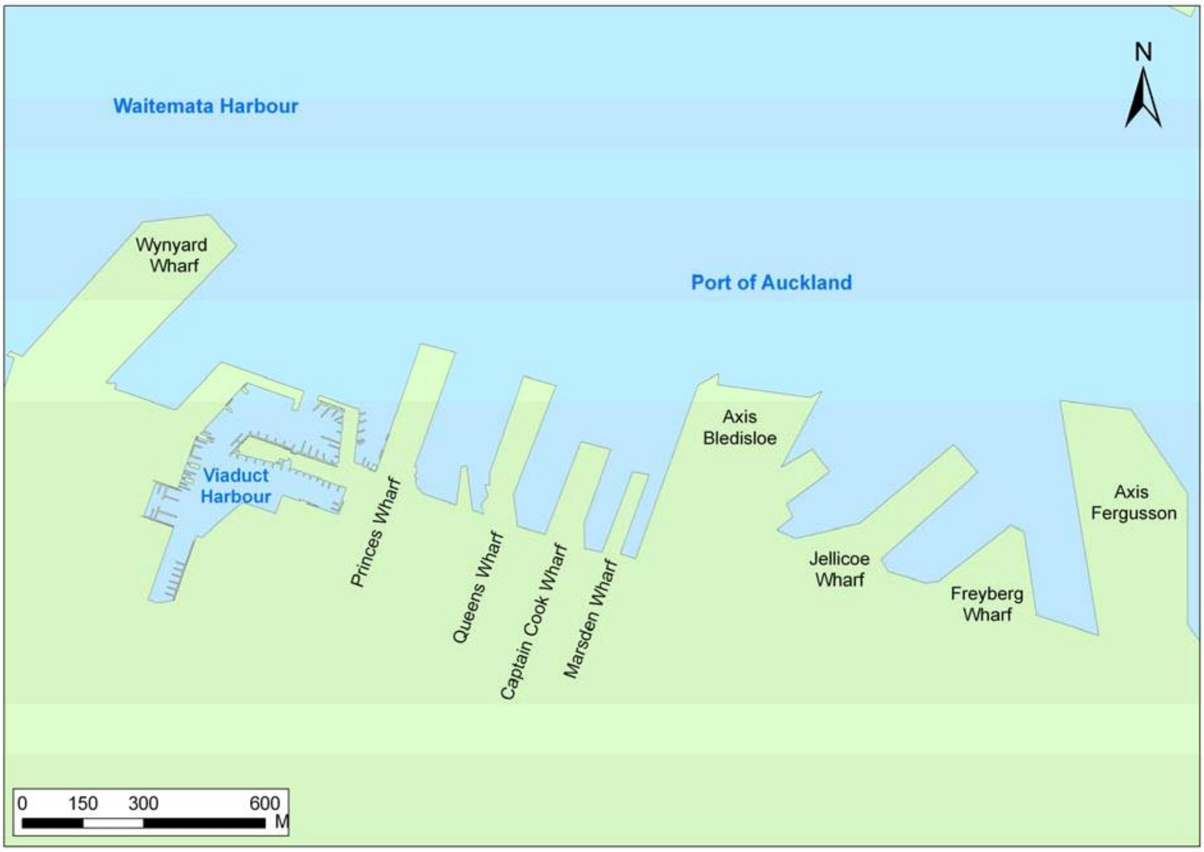

Figure 3: Port of Auckland showing the location of the main shipping wharves.

A trio of major infrastructure developments are occurring at the port. Work is well underway on a 9.5 ha reclamation extension at Axis Fergusson to accommodate new generation container ships and improve handling efficiency for the increasing container trade. Eleven new twin-lifting, straddle carriers were installed between March and October 2006 and three new container cranes in December 2006 (Ports of Auckland Ltd 2006).

The first stage of the expansion of the Axis Fergusson container terminal has been completed with 2 ha of land added in April 2007. Stage one has included dredging around 550,000 m^3 of sediment from the shipping lane in the Rangitoto Channel. Approximately 2,000 m^3 of dredgings per day were mudcreted and added to the reclamation. Seawall construction and a public walkway with viewing platforms on the eastern side of the reclamation are also due to be completed as part of stage one. The initial 5 ha extension of the terminal is expected to increase the current container handling capacity of 340,000 TEU by an additional 100,000 TEU per annum. The remaining 4.5 ha of reclamation are expected to be completed over a longer period of time using port maintenance dredgings. The port company has consents to reclaim another 4.4 ha from the seabed, which will proceed progressively as needed (Ports of Auckland Ltd 2006).

The dredged shipping channel was officially opened in August 2007, concluding a three-and–a-half-year project. The channel was deepened in order to widen the tidal window for larger container ships now calling at the port and also to provide for the next generation of vessels expected in the future. The deepened channel now extends the Ports capabilities to 11.3m at low water and 12.5 meters at high water. The potential exists to extend this depth to a maximum of 13.9m water as dredging of berths can be carried out on customer demand (Ports of Auckland eNote 2007).

Placement of new navigational aids in the harbour channel was also completed during the beginning of 2007. The GPS controlled buoys and their navigational lights are synchronised by satellite clocks and provide a lit 'runway' helping to improve passage safety (Ports of Auckland Ltd 2006).

Imports and exports

The Port of Auckland currently handles 4 million tonnes of breakbulk (non-containerised) cargo a year and over 670,000 TEUs a year. The containerised cargo represents 50% of the North Island container trade and 38% of New Zealand's total container trade. The containers passing through the port consist of 55% full import containers and 45% full export containers (Ports of Auckland Ltd 2006). Container volumes increased steadily from 2001 (567,172 TEUs) to 2004 (662,170 TEUs) but dropped the following year by 2.7% to 644,306 TEUs in the 2005 financial year (Ports of Auckland 2005). Breakbulk volumes (including imported vehicles) also increased steadily from 4.2 million tonnes in 2001 to 4.9 million tonnes in 2005 (Ports of Auckland 2005).

The volumes and value of goods imported and exported through the Port of Auckland are summarised below for the financial years ending June 2002 to June 2005 (ie. roughly the period between the first and second baseline surveys, and the same period that was analysed for the Group 1 port resurveys). These data describe only cargo being loaded for, or unloaded from, overseas ports and do not include domestic cargo (Statistics New Zealand 2006b). Also available from Statistics New Zealand (2006a) was a breakdown of cargo value by country of origin or destination and by commodity for each calendar year; we analysed the data for the period January 2002 to December 2005 inclusive.

Imports

Both the weight and value of overseas cargo unloaded at the Port of Auckland has increased each year since the financial year ending June 2002, with 3,783,654 tonnes gross weight valued at $14,776 million being unloaded in the year ended June 2005 (Statistics New Zealand 2006b). This represents an increase in weight of 13.1 and in value of 5.8% compared to the year ending June 2002 (Table 2). Between the 2002 and 2005 financial years, overseas cargo unloaded at the Port of Auckland accounted for around 20 to 23% by weight and approximately 53 to 58% value of the total overseas cargo unloaded at New Zealand's seaports (Table 2).

The Port of Auckland imported cargo in 97 different commodity categories between 2002 and 2005 inclusive (Statistics New Zealand 2006a). The dominant commodities by value imported at the Port of Auckland during this time were vehicles (26% of total value of imports), boilers, machinery and mechanical appliances (13%), iron and steel (6%), plastics and plastic articles (5%), and paper and paperboard and articles thereof (3%; Figure 4). These five commodity categories ranked in the same order each year (Statistics New Zealand 2006a). In the 2004-05 financial year, Ports of Auckland Ltd listed the major import products by volume as including bananas, pineapples, vehicles, steel, gypsum, cement, aggregate, palm kernel, sorghum, soy bean meal, wheat, silica sand, vegetable oil, molasses, heavy fuel and chemicals (Ports of Auckland 2005).

The Port of Auckland received imports from 189 countries of initial origin[2] between 2002 and 2005 inclusive (Statistics New Zealand 2006a). During this time, most imported cargo by value came from Australia (20%), Japan (15%), the People's Republic of China (12%), the USA (9%), Germany (7%) and the UK (4%; Figure 5). These top six countries ranked in the same order each year. Italy ranked seventh each year and the Republic of Korea eighth except in 2005 when their ranks were reversed (Statistics New Zealand 2006a).

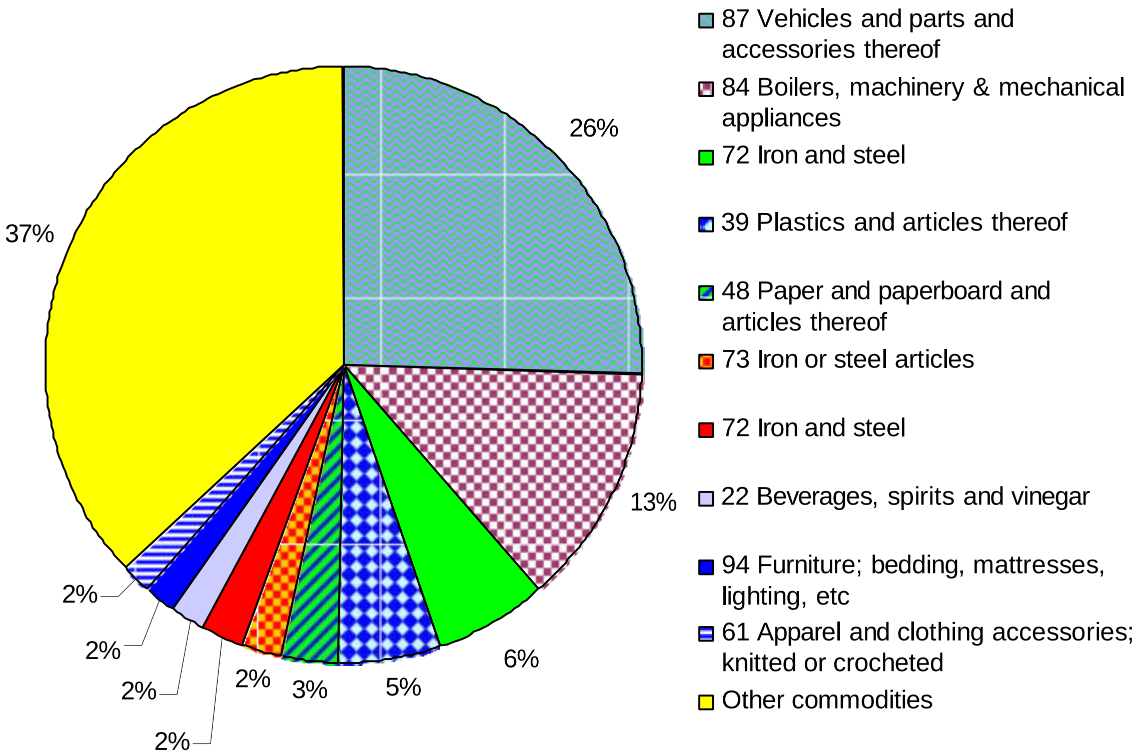

Figure 4: Top 10 commodities by value unloaded at the Port of Auckland summed over the period January 2002 to December 2005 inclusive (data sourced from Statistics New Zealand 2006a). Commodity category descriptions have been summarised for brevity; category numbers are provided in the legend and full descriptions are available at Statistics New Zealand (2006a).

[2] The country of initial origin is not necessarily the country that the ship carrying the commodity was in immediately before arriving at the Port of Auckland; for ship movements see the section on "Shipping movements and ballast discharge patterns"

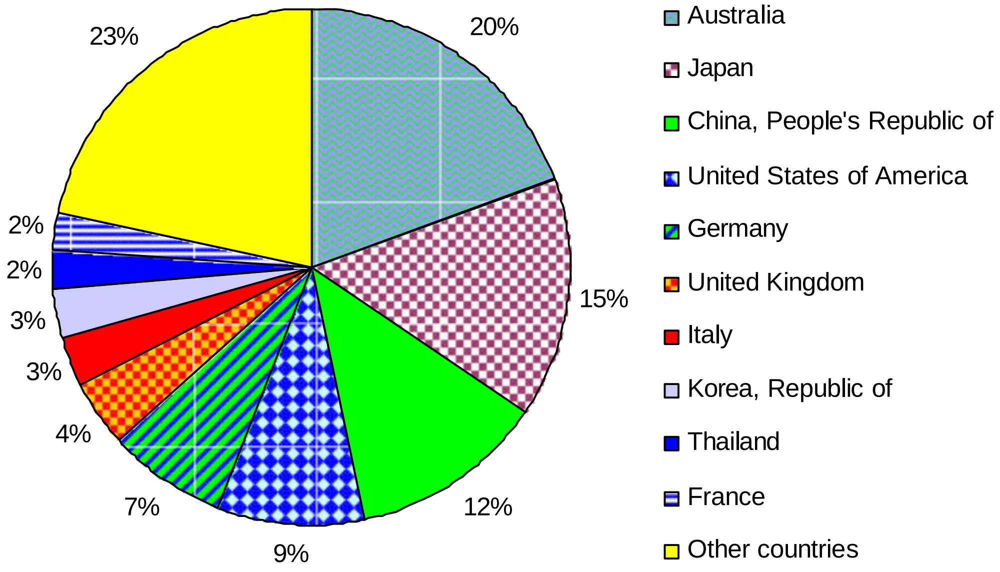

Figure 5: Top 10 countries of initial origin that cargo was unloaded from at the Port of Auckland. The data are percentages of the total value of cargo unloaded in the period January 2002 to December 2005 inclusive (data sourced from Statistics New Zealand 2006a).

Exports

In the financial year ending June 2005, the Port of Auckland loaded cargo for overseas export weighing 1,987,714 tonnes gross weight, valued at $5,700 million (Statistics New Zealand 2006b). This represented a 0.5 % decline by weight and a 12.3% decline by value compared to the year ending June 2002 (Table 3). For the financial years ending June 2002 to 2005, overseas cargo loaded at the Port of Auckland accounted for approximately 8 to 9% by weight and approximately 22 to 23% by value of the total overseas cargo loaded at New Zealand's seaports (Table 3).

The Port of Auckland exported cargo in 97 different commodity categories between 2002 and 2005 inclusive (Statistics New Zealand 2006a). The dominant commodity categories by value loaded at the Port of Auckland for export during this time were dairy produce, bird's eggs, natural honey and other edible animal products (17%), meat and edible meat offal (12%), boilers, machinery and mechanical appliances (10%), beverages, spirits and vinegar (6%), wood and articles of wood (5%) and albuminoidal substances, modified starches, glues and enzymes (5%; Figure 6). The top three commodities ranked in the same order each year. Beverages ranked fifth in 2002 and 2003 but fourth in 2004 and 2005. Wood ranked sixth in 2002 and 2003 and rose to fifth in 2004 and 2005. Albuminoidal substances ranked fourth in 2002 and 2003 but dropped to eighth in 2004 and sixth in 2005 (Statistics New Zealand 2006a).

The Port of Auckland loaded cargo for export to 192 countries of final destination[3] between 2002 and 2005 inclusive (Statistics New Zealand 2006a). During this time, the Port of Auckland exported most of its overseas cargo by value to Australia (29%), the USA (17%), Japan (6%), the UK (4%) and Canada (4%; Figure 7). The top three countries ranked in the same order each year. The UK ranked fourth each year except in 2002 when it ranked fifth after Canada.

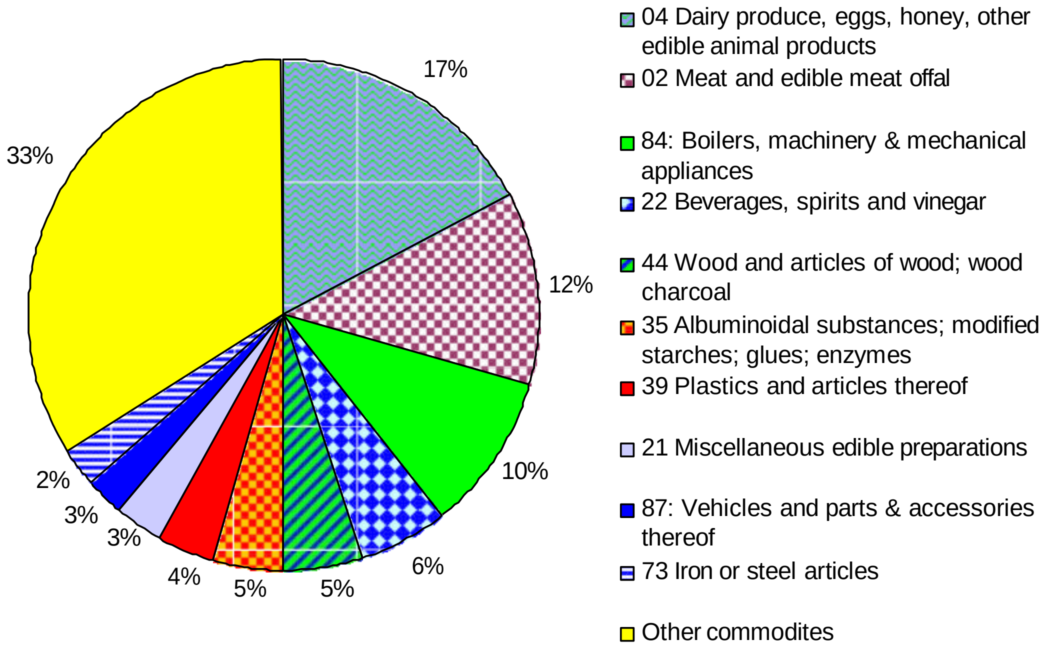

Figure 6: Top 10 commodities by value loaded at the Port of Auckland summed over the period January 2002 to December 2005 inclusive (data sourced from Statistics New Zealand 2006a). Commodity category descriptions have been summarised for brevity; category numbers are provided in the legend and full descriptions are available at Statistics New Zealand (2006a).

[3] The country of final destination is not necessarily the country that the ship carrying the commodity goes to immediately after departing from the Port of Auckland; it is the final destination of the goods. For ship movements see "Shipping movements and ballast discharge patterns"

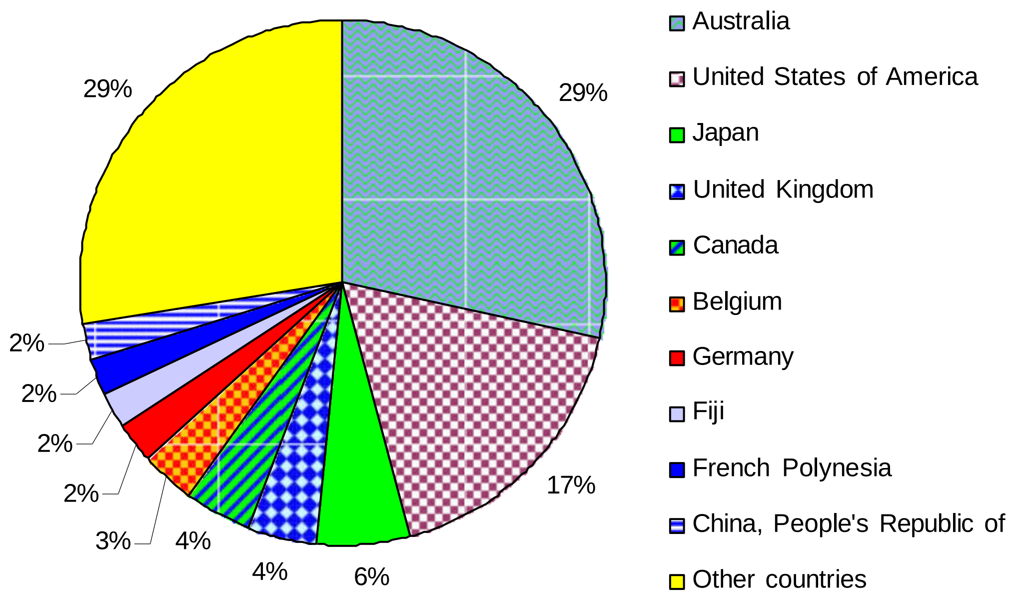

Figure 7: Top 10 countries of final destination that cargo was loaded for at the Port of Auckland. The data are percentages of the total cargo value loaded at the port for the period January 2002 to December 2005 inclusive (data sourced from Statistics New Zealand 2006a).

Shipping movements and ballast discharge patterns

New Zealand has strict conditions regarding the discharge of ballast water within its coastal waters. A Ballast Water Import Health Standard, issued under Section 22 of the Biosecurity Act 1993, requires all vessels entering New Zealand waters to formally submit their intentions to discharge ballast water at least 48 hours before they arrive (http://www.biosecurity.govt.nz/files/ihs/ballastwater.pdf). Discharge of ballast water is only permitted if the vessel can satisfy an inspector that:

- the ballast water has been exchanged en route to New Zealand in the open-ocean, or
- the ballast water is fresh water.

According to Inglis (2001), a total volume of 20,571 m^3 of ballast water was discharged in the Port of Auckland in 1999, with the largest country-of-origin volumes of 3,656 m^3 from Australia, 3,475 m^3 from Taiwan, 1,466 m^3 from Hong Kong, and 9,681 m^3 unspecified sources.

Shipping services calling at the Port of Auckland travel to ports worldwide, including other ports in New Zealand, Australia, the Pacific Islands including Fiji, New Caledonia, Norfolk Island, Papua New Guinea, Solomon Islands and Vanuatu, Micronesia including Guam, North, East and South East Asia including Hong Kong, Singapore, Malaysia, Japan, China, Taiwan, and Korea, the UK, northern Europe, Mediterranean, Middle East, the Indian Sub-continent, South Africa, West Africa, East and Western North America, and Central and South America (Cummings *et al*. 2002). In November 2006, the major shipping company Maersk Line announced that more of its North Island services will be handled by the Port of Auckland. To be phased in from mid-January 2007, these services include a weekly South East Asia service, which will also call in at Napier and Port Chalmers; a weekly east and west bound Oceania U.S. east coast service connecting with Europe, which will also call in at New Plymouth, Timaru and Port Chalmers; and a Pacific Island and Feeder Service calling weekly at Auckland, Lyttelton, Nelson, Wellington and Tauranga, and fortnightly at the Pacific Islands (Ports of Auckland Ltd 2007).

Cruise ship visits to the Port of Auckland numbered 48 during both the 2005/06 and 2006/07 seasons, representing a 50% increase on the 2004/05 season (Ports of Auckland Ltd 2006).

To gain a more detailed understanding of international and domestic vessel movements to, and from, the Port of Auckland between 2002 and 2005 inclusive, we analysed a database of vessel movements generated and updated by Lloyds Marine Intelligence Unit (LMIU), called 'SeaSearcher.com'. Drawing on real-time information from a network of Lloyd's agents and other sources around the world, the database contains arrival and departure details of all ocean going merchant vessels larger than 99 gross tonnes for all of the ports in the Group 1 and Group 2 surveys. The database does not include movement records for domestic or international ferries plying scheduled routes, small domestic fishing vessels or recreational vessels. Cruise ships, coastal cargo vessels and all other vessels over 99 gross tonnes are included in the database. The database therefore gives a good indication of the movements of international and domestic vessels involved in trade. Definitions of geographical area and vessel type categories are given in Appendix 1.

International vessel movements

Based on an analysis of the LMIU database, there were 4,026 vessel arrivals to the Port of Auckland from overseas ports between 2002 and 2005 inclusive (Table 4). These came from 49 different countries represented by most regions of the world. The greatest number of overseas arrivals during this period came from the following areas: Australia (1,375), Pacific Islands (1,258), Japan (437), east Asian seas (314), the west coast of North America (203) and the northwest Pacific (203; Table 4). The previous ports of call for 11 of the international arrivals were not stated in the database. Vessels arriving from Australia came mostly from ports in Queensland (589 arrivals), Victoria (407) and New South Wales (325; Table 5). The major vessel types arriving from overseas at the Port of Auckland were container ships and ro/ro (1,727), general cargo vessels (1,315) and passenger/ vehicle/ livestock vessels (577; Table 4).

According to the LMIU database, during the same period 2,325 vessels departed from the Port of Auckland to 47 different countries, also represented by most regions of the world. The greatest number of departures for overseas went to ports in the Pacific Islands as their next port of call (1,199 departures) followed by Australia (681) and Japan (237; Table 6). The major vessel types departing to overseas ports from the Port of Auckland were container ships and ro/ro (1,062 movements), general cargo vessels (831) and passenger / vehicle / livestock carriers (191; Table 6).

Domestic vessel movements

The LMIU database contains movement records for 1,541 vessel arrivals to the Port of Auckland from New Zealand ports between 2002 and 2005 inclusive. These arrived from 18 different ports in both the North and South Islands (Table 7). The greatest number of domestic arrivals during this period came from Tauranga (511 arrivals). The next greatest number was from Auckland; the vessels making these closed-loop trips were mainly fishing vessels and general cargo vessels. Other ports that contributed large numbers of vessels to the domestic arrivals at the Port of Auckland were Nelson (164), Whangarei (124), Napier (122) and Lyttelton (105). General cargo vessels (479 arrivals) and container ships and ro/ro's (450 arrivals) were the dominant vessel type arriving at the Port of Auckland from New Zealand ports, followed by bulk / cement carriers (228) and fishing vessels (156; Table 7).

During the same period, the LMIU database contains movement records for 3,229 vessel departures from the Port of Auckland to 18 New Zealand ports in both the North and South Islands (Table 8). Most domestic movements departed the Port of Auckland for Tauranga (918 departures), Wellington (548), Lyttelton (517), Napier (322), and Auckland (i.e. closed-loop trips, 226 departures mostly by fishing vessels). Container ships and ro/ro's dominated the vessel types leaving the Port of Auckland on domestic voyages (1,116 departures), followed by general cargo vessels (962), passenger / vehicle / livestock carriers (456) and bulk / cement carriers (301; Table 8).

EXISTING BIOLOGICAL INFORMATION

Over the last two decades, a variety of biological surveys have been carried out in Waitemata Harbour and around the Port of Auckland, some of which contain information on non-indigenous species present within the marine environments. One of these surveys (Hayward 1997a) specifically focused on collecting and identifying non-indigenous species in the harbour. We briefly review these studies and their major findings below.

Dromgoole and Foster (1983) reviewed studies of the marine biota of Waitemata Harbour. They noted some marked biological changes as a result of reclamation around the port, namely the loss of mangrove and saltmarsh communities, and also suggested that *Zostera* seagrass beds and the abundance of the green-lipped mussel *Perna canaliculus* were in decline. They concluded, however, that there was a lack of information to make quantitative assessments of the changes that may have occurred with the development of the Port of Auckland.

Read and Gordon (1991) reported the occurrence of the adventive fouling serpulid worm *Ficopomatus enigmaticus* in the Auckland and Whangarei harbours. It was first recorded in New Zealand around 1967, where it appeared suddenly and extensively on piles, pontoons and pleasure craft in the Town Basin Marina, Whangarei. In 1980 it caused fouling problems on the intake pipes of the Otahuhu Power station in the upper reaches of the Tamaki estuary. The fouling bryozoan *Conopeum seurati*, of European origin, was also noted as an opportunistic associate of *F. enigmaticus*, and was recorded in the Auckland region as early as 1969 (Gordon and Mawatari 1992).

Hayward *et al*. (1997) undertook a resurvey of Powell's (1937) study of subtidal, soft-bottom communities in the Waitemata harbour to determine the nature of faunal change over a 60-year period and the impacts of invasive species on the natural fauna. Dredge samples were collected from 152 stations between 1993 and 1995. The authors concluded that the soft-bottom fauna was still diverse away from the wharves and marinas, and retained a similar spatial distribution pattern to that described in Powell's 1930's study. However they noted that fourteen mollusc species (predominantly carnivorous gastropods) seemed to have disappeared or significantly declined in abundance within the harbour. The gastropod *Maoricolpus roseus* and several species associated with the shelly channel sediments in the harbour showed a reduction in abundance. Furthermore, since the 1930's at least nine native New Zealand mollusc species and one crab appeared to have colonised the harbour, and nine others had increased in relative abundance. The establishment of extensive horse mussel (*Atrina zelandica*) beds was thought to be the most significant of these changes in native abundance over this 60 year period. It was also noted that three non-indigenous bivalves (*Limaria orientalis*, *Theora lubrica*, *Musculista senhousia*) became established in Waitemata harbour in the 1960's and 1970's. By the late 1990's these molluscs had become so abundant they were dominant components of six of the eight fauna associations recognised in the harbour benthos by Hayward *et al*. (1997).

Hayward (1997a) identified 39 non-indigenous marine or intertidal species that had established populations in Waitemata Harbour. These were the foraminiferan *Siphogenerina raphanus*, the sea anemone *Sagartia luciae*, the polychaetes *Ficopomatus enigmaticus*, *Hydroides norvegicus* and *Polydora cornuta*, the gastropods *Microtralia occidentalis*, *Okenia plana*, *Phytia myosotis* and *Thecacera pennigera*, the bivalves *Crassostrea gigas*, *Musculista senhousia*, *Limaria orientalis* and *Theora lubrica*, the Californian majid crab *Pyromaia tuberculata*, the barnacle *Balanus amphitrite*, the isopod *Limnoria tripunctata*, the bryozoans *Anguinella palmata, Aeverrillia armata, Amathia distans, Bowerbankia gracilis, Bowerbankia imbricata, Bugula flabellata, Bugula neritina, Bugula simplex, Bugula stolonifera, Buskia socialis, Conopeum seurati, Cryptosula pallasiana, Electra tenella, Schizoporella errata, Tricellaria occidentalis, Watersipora arcuata, Watersipora subtorquata* and *Zoobotryon verticillatum*, the ascidian *Ciona intestinalis*, the green alga *Codium fragile tomentosoides*, the brown algae *Cutleria multifida* and *Hydroclathrus clathratus*, the red alga "Solieriaceae indet." and the cord grasses *Spartina alterniflora* and *Spartina* x *townsendii*. Many of these species have become dominant components of biotic assemblages in different parts of the harbour and appear to have had major (but largely unquantified) impacts on native assemblages. For example, the Pacific oyster *Crassostrea gigas*, now forms large reefs of shell that dominate areas of the intertidal shoreline and which blanket rocky reefs, wharf piles and other hard substrata (Hayward 1997). Other habitat-modifiers, such as the bivalves *M. senhousia* and *T. lubrica*, the bryozoan *W. subtorquata*, and the cord grasses, *Spartina* sp. are dominant components of the flora and fauna in some areas of the harbour.

Cranfield *et al*. (1998) conducted a desktop review to compile a list of species that are adventive in New Zealand. They reported 151 adventive species and provided an indication of their current ranges within New Zealand, the likely means of introduction, and their probable native ranges. Those listed as having been recorded from Auckland, Waitemata Harbour, the Hauraki Gulf or attributed the general range of the east coast of the North Island were the algae *Cutleria multifida*, *Hydroclathrus clathratus* and an unidentified species of the Solieriacae, the cord grass *Spartina x townsendi*, the protozoans *Elphidium vellai* and *Siphogenerina raphanus*, the sponges *Halichondria panicea*, *Halisarca dujardini*, and *Tethya aurantium*, the cnidarians *Coryne pusilla*, *Diadumene liniata*, *Ectopleura crocea*, *Eudendrium ritchiei* and *Pennaria disticha*, the polychaetes *Ficopomatus enigmaticus*, *Hydroides elegans* and *Polydora cornuta*, the molluscs *Cuthona beta*, *Eubranchus agrius*, *Limaria orientalis*, *Lyrodus mediolobatus*, *Lyrodus pedicellatus*, *Microtralia* sp. (= *M. insularis*), *Musculista senhousia*, *Okenia pellucida*, *Polycera hedgpethi*, *Theora lubrica* and *Thecacera pennigera*, the Xiphosuran *Carcinoscopius rotundicauda*, the barnacles *Balanus amphritrite*, *Balanus trigonus* and *Balanus variegatus*, the isopod *Limnoria tripunctata*, the amphipods *Chelura terebrans* and *Corophium acutum*, the decapods *Dromia wilsoni*, *Merocryptus lambriformis*, *Pilumnopeus serratifrons*, *Plagusia chabrus* and *Pyromaia tuberculata*, the bryozoans *Amathia distans*, *Anguinella palmata*, *Bowerbankia gracilis*, *Bowerbankia imbricata*, *Bugula flabellata*, *Bugula neritina*,*Bugula stolonifera*, *Buskia nitens*, *Conopeum seurati*, *Cryptosula pallasiana*, *Electra tenella*, *Schizoporella errata*, *Tricellaria porteri*, *Watersipora arcuata*, *Watersipora subtorquata* and *Zoobotryon verticillatum*, and the ascidians *Asterocarpa cerea*, *Botrylloides leachii*, *Botrylloides magnicoecum*, *Botryllus schlosseri*, *Cystodytes dellechiajei*, *Didemnum "candidum"*, *Diplosoma listerianum* and *Styela plicata*. Several others were reported to occur throughout New Zealand, including the cord grass *Spartina anglica*, the sponges *Clathrina coriacea*, *Cliona celata*, *Dendya poterium*, *Leucosolenia botryoides*, *Sycon ciliata* and *Tethya aurantium*, the hydroids *Amphisbetia operculata* and *Plumularia setacea*, and the ascidian *Corella eumyota*.

Taylor and MacKenzie (2001) examined the Waitemata Harbour for the presence of the toxic blooming dinoflagellate *Gymnodinium catenatum*, and did not detect any resting cysts in sediment samples or motile cells in phytoplankton samples.

In view of the plans for increased urban development in the upper Waitemata Harbour, Cummings *et al*. (2002) reported on a study designed to define the benthic ecological values of the area's intertidal and subtidal habitats (74 sites). Based on information on the distribution and densities of taxa postulated as being sensitive to long term habitat change (e.g. the bivalve *Paphies australis*), they provided a qualitative assessment of the potential effect on benthic communities to long-term habitat change, and identified specific ecologically important areas of the upper Waitemata Harbour. They found the intertidal and subtidal benthic communities in the area to be generally in good condition, and although the sediment organic content was notably high in some areas that communities at these sites did not show characteristics of highly organically enriched areas.

Nicholls *et al*. (2002) reported on a long-term State of the Environment monitoring programme established in 2000 in the Waitemata Harbour. This programme was set up to monitor the ecological status and trends in marine macrobenthic species representative of the region, and to monitor habitats that have the potential to be affected by sedimentation, pollution and other anthropogenic impacts. Common taxa (e.g. the bivalve *Nucula hartvigiana*) and sediments at five monitored intertidal sites showed considerable temporal variability. There was suggestion of cyclic patterns and trends in abundance for some taxa at some sites, caused by natural fluctuations related to recruitment events and storm disturbance, although the data series was not long enough to confirm these trends. The results from continued monitoring of the macrobenthic communities in the Central Waitemata during October 2000 to February 2006 were reported by Halliday *et al*. (2006). A number of changes in abundance of the monitored taxa were observed, but none of these trends were consistent with either increased sedimentation or contamination. Of the list of species found in the Waitemata Harbour by the study, the non-indigenous bivalves *Musculista senhousia* and *Theora lubrica* and cryptogenic polychaete *Chaetopterus sp*. and non-indigenous polychaete *Pseudopolydora corniculata* were commonly recorded during sampling.

The large (100 mm carapace width) non-indigenous portunid crab, *Charybdis japonica* was discovered in Waitemata Harbour, by commercial fishermen in September 2000 (Webber 2001). Trapping surveys, undertaken in 2002 and 2003 revealed that *Charybdis* was abundant throughout the Waitemata Harbour and in two nearby estuaries (Tamaki and Weiti), but there was no evidence it had spread outside the Hauraki Gulf or to other New Zealand shipping ports (Gust and Inglis 2006). Like other large portunids, *C. japonica* is a generalist predator and scavenger and may have significant impacts on estuarine populations of epibenthic and shallow-burrowing bivalves such as cockles (*Austrovenus stutchburyi*), pipi (*Paphies australis*), scallops (*Pecten novaezelandiae*), and mussels (*Perna canaliculus*) (Gust and Inglis 2006). Miller *et al*. (2006) compared the parasite fauna of *C. japonica* from Waitemata Harbour with sympatric populations of the native paddle crab, *Ovalipes catharus*. They reported an unidentified juvenile ascaridoid nematode from the hindgut of *C. japonica* that was not present in sympatric populations of *O. catharus*. Melanised lesions were also observed in the muscle tissue of almost half (46.6%) of the *C. japonica* examined, but the provenance of both the nematode and lesion-causing agent could not be determined.

Read (2006) reported on the presence of the scale-worm *Paralepidonotus ampulliferus* in the Waitemata harbour. This Indo-Pacific species was first described from Bohol Island in the Philippines. Scale worms of the genus *Paralepidonotus* have no prior New Zealand records. *P. ampulliferus* was found to be widespread around the soft shores of Waitemata Harbour and were also found subtidally in Whangarei Harbour. Earliest records date from late 1998, although no surveys carried out around New Zealand prior to 2003 detected the species. Read (2006) concluded that human mediated transport is the most likely mechanism of introduction of *P. ampulliferus* in northern New Zealand, and further monitoring and study of this species in New Zealand is warranted.

Two non-native gobies, the Asian goby *Acentrogobius pflaumii* and the bridled goby *Arenigobius bifrenatus*, have both been found in the Waitemata harbour (Francis *et al*. 2003). These species are thought to have been introduced by release of ballast water from passing ships. *A. pflaumii* appears to be a relatively recent introduction, being found only in the Waitemata and Whangapoa harbours, whereas *A. bifrenatus* is more widespread, its current recorded range spanning around 150 km of coastline. The exotic species overlap in both range and habitat with two native New Zealand gobies, *Favonigobius lentiginosus* and *F. exquisitus*. Further research is required to determine the ecological impact of the invasive gobies (Francis *et al*. 2003). Another small non-indigenous fish, the Australian oyster blenny, *Omobranchus anolius*, was reported from Waitemata Harbour in 2003. (Francis *et al*. 2004). The oyster blenny lives predominantly inside the shells of dead oysters (*Crassostrea gigas*) and in, or under, submerged objects such as large boulders in lower intertidal habitats.

The Asian kelp, *Undaria pinnatifida*, was discovered in Waitemata Harbour in September 2004 (Stuart and McClary 2004). The density and distribution of *U. pinnatifida* suggest that translocation of the invasive kelp to Auckland by fouled barge or associated vessel was the most likely mode of introduction. *Undaria pinnatifida* has been detected in parts of Westhaven Marina, Viaduct Harbour, along the breakwall at Wynyard Wharf and at the Caltex and BP service station floating berths on the north-western side of Wynyard Wharf (Stuart and McClary 2004).

The clubbed tunicate, *Styela clava*, was discovered in Viaduct Harbour in Waitemata Harbour, in September 2005. An initial delimiting survey showed that it was present throughout Viaduct Harbour, Freeman's Bay and Westhaven Marina (Gust *et al*. 2005) and subsequent surveys showed that it was present throughout the Hauraki Gulf and in the Port of Lyttelton in the South Island (Gust *et al*. 2006).

Inglis *et al*. (2006v) and Morrisey *et al* (2007) presented the results of MAF-Biosecurity New Zealand's surveillance program to detect marine pest species on the New Zealand register of unwanted marine organisms (i.e. *Undaria pinnatifida, Caulerpa taxifolia, Asterias amurensis, Sabella spallanzanii, Carcinus maenas, Eriocheir sinensis* and *Potamocorbula amurensis*; Table 9) in eight major ports and Marinas (Whangarei, Waitemata, Tauranga, Wellington, Nelson, Lyttelton, Otago and Bluff).

The introduced portunid crab, *Charybdis japonica*, was captured in Waitemata Harbour during each of the targeted surveillance surveys undertaken between 2002 and 2004. Although it was widely distributed throughout Waitemata Harbour, these data showed a general decline in Catch Per Unit Effort (CPUE) between 2002 and 2005 (Inglis *et al*. 2006v). The cryptogenic parchment tubeworm, *Chaetopterus* sp. was recorded in the Waitemata Harbour on the breakwater off Orakei/Hobson Bay and on pontoons in Bayswater Marina (Morrisey 2007). Few living *Chaetopterus* sp. were captured during the survey of Waitemata Harbour. Samples obtained through epibenthic sledding and intertidal visual searches often consisted of empty tubes (Inglis *et al*. 2006v).

The Asian date mussel, *Musculista senhousia* had been found previously in Waitemata Harbour. *M. senhousia* was first reported from Waitemata Harbour in 1980 (Willan 1987).

Although it had previously been a dominant component of the fauna of intertidal and subtidal sediments in Waitemata Harbour and the nearby Tamaki Estuary (Hayward 1997b), specimens were found in only seven of the >200 sled tows in the targeted surveillance of the harbour by Morrisey *et al* (2007). During the four previous surveys of Waitemata Harbour (2002-2004), *M. senhousia* was found in a total of 4 sled tows (<1% of the total), over muddy subtidal and intertidal sediments between Orakei Basin and Point Chevalier in April 2003 and April 2004. The high fecundity, rapid growth and short life span of this species mean that its distribution and abundance is notoriously patchy in space and time (Crooks 1996; Creese *et al*. 1997).

The small Indo-Pacific bivalve *Limaria orientalis* was recorded from shelly gravel in the upper and middle Waitemata Harbour. It was widespread in the harbour, from the upper harbour, off Hobsonville, to the port area. In October 2003 three specimens were recorded from a single sled tow near the Bledisloe Terminal in the commercial port of Waitemata Harbour (Inglis *et al*. 2006v; Morrisey 2007).

The introduced majid crab *Pyromaia tuberculata* was also recorded during the surveys. A single specimen was collected in a sled sample east of the Harbour Bridge.

RESULTS OF THE FIRST BASELINE SURVEY

An initial baseline survey of the Port of Auckland was completed in April 2003 (Inglis *et al*. 2006d). The report identified a total of 173 species or higher taxa. They consisted of 114 native species, 13 non-indigenous species, 24 cryptogenic taxa (those whose geographic origins are uncertain) and 22 indeterminate taxa (taxa for which there is insufficient taxonomic or systematic information available to allow identification to species level). Two species of marine organisms collected from the Port of Auckland considered to be non-indigenous had not previously been described from New Zealand waters, the bryozoan *Celleporaria* sp. 1 and the ascidian *Cnemidocarpa* sp.

Since the first survey was completed, seven species recorded in it have been reclassified as a result of new information or re-examination of specimens during identification of material from the repeat baseline survey. Specimens identified during the initial survey as the ascidian *Didemnum* sp has been reclassified from an indeterminate to a cryptogenic category 1 taxon, the ascidian *Microcosmus australis* has been reclassified from a native to a cryptogenic category 1 species, the ascidian *Microcosmus squamiger* has been reclassified from a cryptogenic category 2 species to a cryptogentic category 1 species, the crustacean *Pilumnopeus serratifrons* has been reclassified from a cryptogenic category 1 species to a native species, the barnacle *Balanus trigonus* has been reclassified from a cryptogenic category 1 species to a native species, the ascidian *Aplidium phortax* has been reclassified from a cryptogenic category 1 species to a native species and the sponge *Amphilectus fucorum* which was recorded by the name *Esperiopsis* n. sp. 1 has been reclassified from a cryptogenic category 2 species to a non-indigenous species. The revised summary statistics for the Port of Auckland following reclassification were 116 native species, 14 non-indigenous species, 22 cryptogenic taxa and 21 indeterminate taxa. These revisions have been incorporated into the comparison of data from the two surveys below.

The 14 non-indigenous organisms described from the Port of Auckland included representatives of eight phyla. The non-indigenous species detected were: (Annelida) *Hydroides elegans*, (Bryozoa) *Bugula flabellata*, *Bugula neritina*, *Celleporaria sp 1* and *Anguinella palmata*, (Cnidaria) *Obelia longissimi* and *Pennaria disticha*, (Crustacea)

Charybdis japonica, (Mollusca) *Crassostrea gigas* and *Theora lubrica*, (Porifera) *Halisarca dujardini*, (Urochordata) *Cnemidocarpa sp*., and (Vertebrata) *Arenigobius bifrenatus*.

None of the species from the initial survey of the Port of Auckland are listed on the New Zealand register of unwanted organisms. Two species recorded from Auckland, the Pacific oyster *Crassostrea gigas* and the toxic cryptogenic dinoflagellate *Gymnodinium catenatum*, are listed on the Australian ABWMAC list of unwanted marine pests.

Approximately 61.5% (eight of 13 species) of NIS in the Port of Auckland were likely to have been introduced in biofouling assemblages, 15.4% via ballast water and 23.1% could have been introduced by either ballast water or biofouling vectors.

Methods

SURVEY METHOD DEVELOPMENT

The repeat survey of the Port of Auckland was undertaken from 21st March - 23rd April 2006. To allow a direct comparison with the initial baseline survey, the repeat survey used the same methodologies, occurred in the same season, and sampled the same sites used in the initial baseline survey (as requested by MAF Biosecurity NZ) of the port. To improve the description of the biota of the port, some additional survey sites were added during the repeat survey. These are described below.

The sampling methods used in this survey were based on the CSIRO Centre for Research on Introduced Marine Pests (CRIMP) protocols developed for baseline port surveys in Australia (Hewitt and Martin 1996; Hewitt and Martin 2001). CRIMP protocols have been adopted as a standard by the International Maritime Organisation's Global Ballast Water Management Programme (GloBallast). Variations of these protocols are being applied to port surveys in many other nations. A group of New Zealand marine scientists reviewed the CRIMP protocols and conducted a workshop in September 2001 to assess their feasibility for surveys in this country (Gust *et al*. 2001). A number of recommendations for modifications to the protocols ensued from the workshop and were implemented in surveys throughout New Zealand (Table 10). The modifications were intended to ensure cost effective and efficient collection of baseline species data for New Zealand ports and marinas. The modifications made to the CRIMP protocols and reasons for the changes are summarised in Table 9. Further details are provided in Gust *et al*. (2001).

Baseline survey protocols are intended to sample a variety of habitats within ports, including epibenthic fouling communities on hard substrata, soft-sediment communities, mobile invertebrates and fishes, and dinoflagellates. Below, we describe the methods and sampling effort used for the resurvey of the Port of Auckland.

DIVER OBSERVATIONS AND COLLECTIONS ON WHARF PILES

Fouling assemblages were sampled on four pilings at each berth. Selected pilings were separated by 10 – 15 m and comprised two pilings on the outer face of the berth and, where possible, two inner pilings beneath the berth (Gust *et al*. 2001). On each piling, four quadrats (40 cm x 25 cm) were fixed to the outer surface of the pile at water depths of approximately -1.5 m, -1.5 m, -3.0 m and -7 m. A diver descended slowly down the outer surface of each pile and filmed a vertical transect from approximately high water to the base of the pile, using a digital video camera in an underwater housing. On reaching the sea floor, the diver then ascended slowly and captured high-resolution still images of each quadrat using the photo capture mechanism on the video camera. Because of limited visibility, four overlapping still images, each covering approximately ¼ of the area of the quadrat were taken for each quadrat. A second diver then removed fouling organisms from the piling by scraping the organisms inside each quadrat into a 1-mm mesh collection bag, attached to the base of the quadrat (Figure 8). Once scraping was completed, the sample bag was sealed and returned to the laboratory for processing. The second diver also made a visual search of each piling for potential invasive species and collected samples of large conspicuous organisms not represented in quadrats. Additional visual transect searches were made at pre-allocated sites. Ten pilings, or 50 metres of breakwall, were searched by divers for any potential invasive species, with a specific focus on species listed on the New Zealand Register of Unwanted Organisms. Of the eight marine pests on the register, the ones most likely to occur on hard substrata were the macroalga, *Undaria pinnatifida*, the tunicate, *Styela clava* (both known to be present in New Zealand), the polychaete, *Sabella spallanzanii*, the shore crab, *Carcinus maenas*, and the seastar, *Asterias amurensis* (not known from New Zealand) Unusual species that could not be identified reliably in the field were also collected and returned for formal identification. Searches were done to 4-5 m depth on each piling, or breakwall, where possible. Opportunistic visual searches were also made along breakwalls, pontoons, berths and rock facings within the commercial port area. Divers swam vertical profiles of the structures collecting specimens that could not be identified reliably in the field.

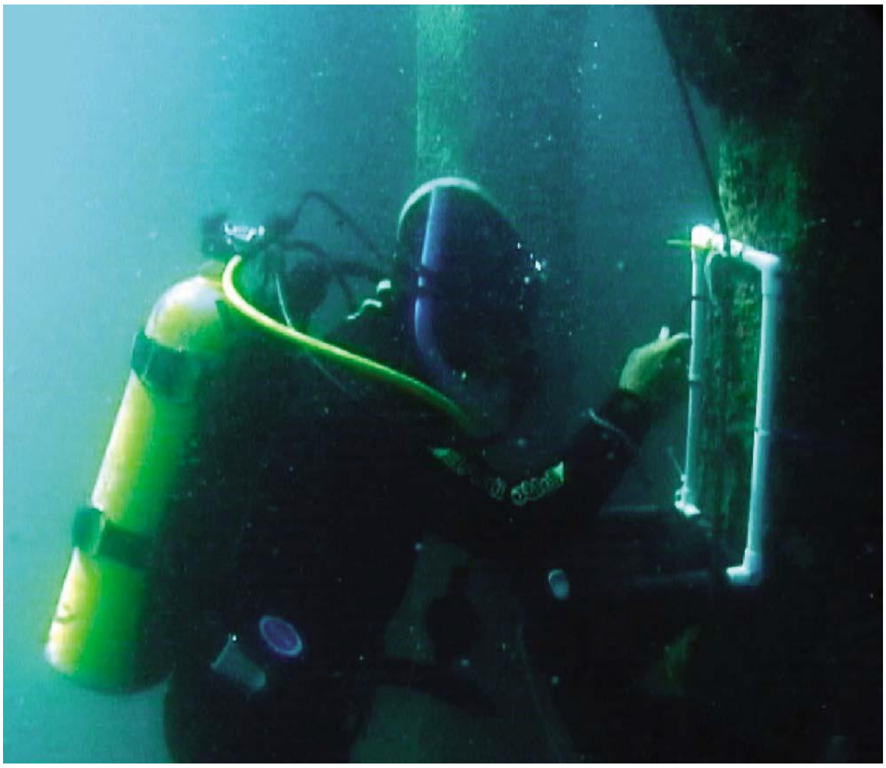

Figure 8: Diver sampling organisms on pier piles.

BENTHIC FAUNA

Benthic infauna was sampled using a Shipek grab sampler deployed from a research vessel moored adjacent to the berth (Figure 9), with samples collected from within 5 m of the edge of the berth. The Shipek grab removes a sediment sample of ~3 *l* and covers an area of approximately 0.04 m^2 on the seafloor to a depth of about 10 cm. It is designed to sample unconsolidated sediments ranging from fine muds and sands to hard-packed clays and small cobbles. Because of the strong torsion springs and single, rotating scoop action, the Shipek grab is generally more efficient at retaining samples intact than conventional VanVeen or Smith McIntyre grabs with double jaws (G. Fenwick *pers obs*). Three grab samples were taken at haphazard locations along each sampled berth. Sediment samples were washed through a 1-mm mesh sieve and animals retained on the sieve were returned to the field laboratory for sorting and preservation.

Figure 9: Shipek grab sampler: releasing benthic sample into bucket

EPIBENTHOS

Larger benthic organisms were sampled using an Ocklemann sled (hereafter referred to as a "sled"). The sled is approximately one meter long with an entrance width of ~0.7 m and height of 0.2 m. A short yoke of heavy chain connects the sled to a tow line (Figure 10). The mouth of the sled partially digs into the sediment and collects organisms in the surface layers to a depth of a few centimetres. Runners on each side of the sled prevent it from sinking completely into the sediment so that shallow burrowing organisms and small, epibenthic fauna pass into the exposed mouth. Sediment and other material that enters the sled is passed through a mesh basket that retains organisms larger than about 2 mm. Sleds were towed for a standard time of two minutes at approximately two knots. During this time, the sled typically traversed between 80 – 100 m of seafloor before being retrieved. Two to three sled tows were completed adjacent to each sampled berth within the port, and the entire contents were sorted.

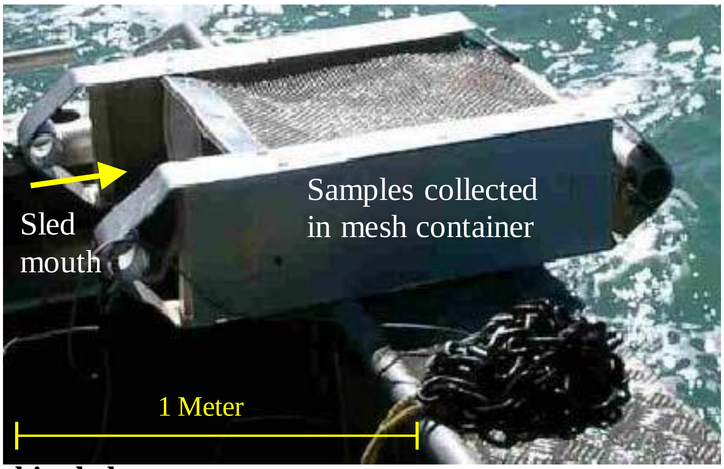

Figure 10: Benthic sled

SEDIMENT SAMPLING FOR CYST-FORMING SPECIES

A TFO gravity corer (hereafter referred to as a “javelin corer”) was used to take small sediment cores for dinoflagellate cysts (Figure 11). The corer consists of a 1.0-m long x 1.5-cm diameter hollow stainless steel shaft with a detachable 0.5-m long head (total length = 1.5 m). Directional fins on the shaft ensure that the javelin travels vertically through the water so that the point of the sampler makes first contact with the seafloor. The detachable tip of the javelin is weighted and tapered to ensure rapid penetration of unconsolidated sediments to a depth of 20 to 30 cm. A thin (1.2 cm diameter) sediment core is retained in a perspex tube within the hollow spearhead. In muddy sediments, the corer preserves the vertical structure of the sediments and fine flocculant material on the sediment surface more effectively than hand-held coring devices (Matsuoka and Fukuyo 2000). The javelin corer is deployed and retrieved from a small research vessel. Cyst sample sites were not constrained to the berths sampled by pile scraping and trapping techniques. Sampling focused on high sedimentation areas within the Port and avoided areas subject to strong tidal flow. On retrieval, the perspex tube was removed from the spearhead and the top 5 cm of sediment retained for analysis. Sediment samples were kept on ice and refrigerated prior to culturing. Culture procedures generally followed those described by Hewitt and Martin (2001).

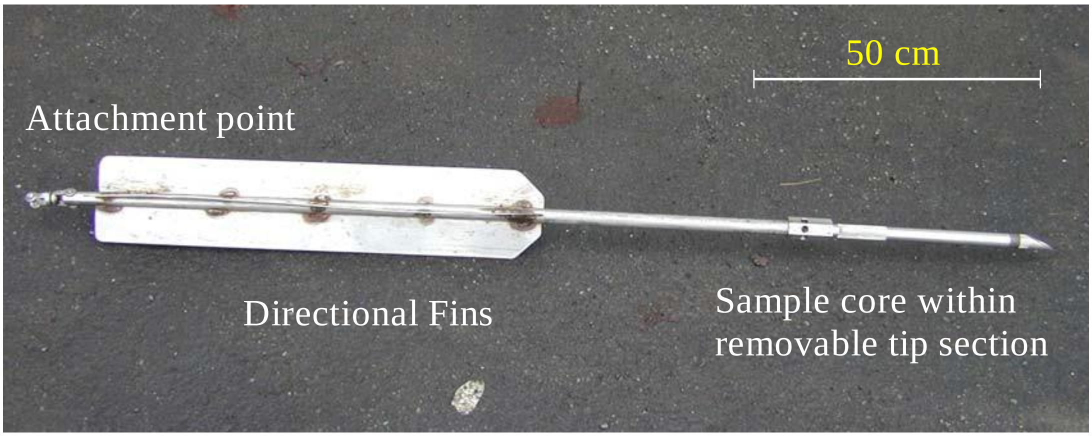

Figure 11: Javelin corer

MOBILE EPIBENTHOS

Benthic scavengers and fishes were sampled using a variety of baited trap designs described below.

Fish (Opera house) traps

Opera house fish traps (1.2 m long x 0.8 m wide x 0.6 m high) were used to sample fishes and other bentho-pelagic scavengers (Figure 12). These traps were covered in 1-cm^2 mesh netting and had entrances on each end consisting of 0.25 m long tunnels that tapered in diameter from 40 to 14 cm. The trap was baited with two dead pilchards (*Sardinops neopilchardus*) held in plastic mesh suspended in the centre of the trap. Two trap lines, each containing two opera house traps were set for a period of 1 hour at each site before retrieval. Previous studies have shown opera house traps to be more effective than other types of fish trap and that consistent catches are achieved with soak times of 20 to 50 minutes (Ferrell *et al*. 1994; Thrush *et al*. 2002).

Crab (Box) traps

Fukui-designed box traps (63 cm x 42 cm x 20 cm) with a 1.3 cm mesh netting were used to sample mobile crabs and other small epibenthic scavengers (Figure 12). A central mesh bait holder containing two dead pilchards was secured inside the trap. Organisms attracted to the bait enter the traps through slits in inward sloping panels at each end. Two trap lines, each containing two box traps, were set on the sea floor at each site and left to soak overnight before retrieval.

Seastar traps

Seastar traps designed by Whayman-Holdsworth were used to catch asteroids and other large benthic scavengers (Figure 12). These are circular hoop traps with a basal diameter of 100 cm and an opening on the top of 60 cm diameter. The sides and bottom of the trap are covered with 26-mm mesh and a plastic, screw-top bait holder is secured in the centre of the trap entrance (Andrews *et al*. 1996). Each trap was baited with two dead pilchards. Two trap lines, each with two seastar traps were set on the sea floor at each site and left to soak overnight before retrieval.

Shrimp traps

Shrimp traps were used to sample small, mobile crustaceans. They consisted of a 15 cm plastic cylinder with a 5-cm diameter screw top lid in which a funnel had been fitted. The funnel had a 20-cm entrance that tapered in diameter to 1 cm. The entrance was covered with 1-cm plastic mesh to prevent larger animals from entering and becoming trapped in the funnel entrance. Each trap was baited with a single dead pilchard. Two trap lines, each containing two scavenger traps, were set on the sea floor at each site and left to soak overnight before retrieval.

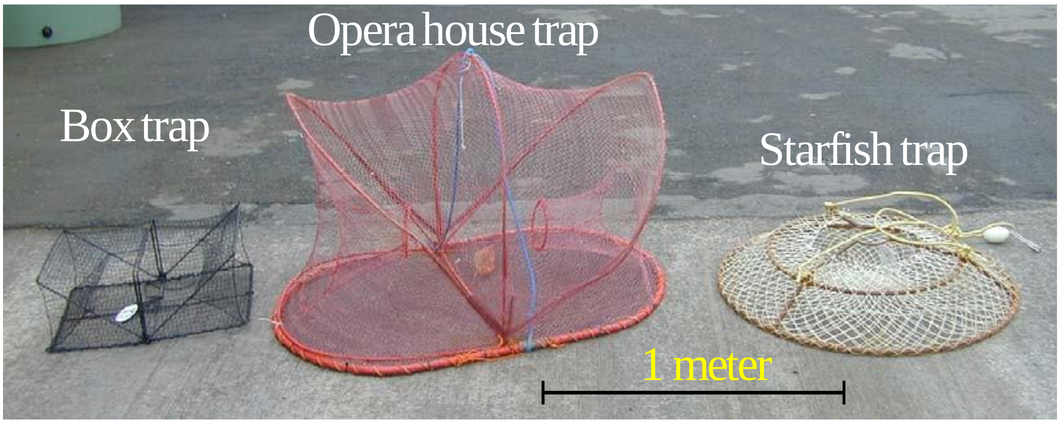

Figure 12: Trap types deployed in the port.

SEDIMENT ANALYSIS

Sediment samples were taken for analysis of grain size and organic content from each site that was sampled for benthic infauna, where possible (some sites had stoney substrates with very little sediment, which prohibited the collection of one or both sediment samples). A ~100 g wet weight sample was collected from each of two replicate anchor box dredge or large hand core samples at each site, and frozen prior to analysis. A ~30 g sub-sample was removed for analysis of organic content, while the remainder was used to determine the particle size distribution of the sample using a laser grain size analyser.

The organic content of the sediments was estimated using the common method of loss on ignition (LOI). For each sample, the wet sample was well mixed and a representative subsample (approximately 30 g) placed into a pre-weighed crucible. The sample was put into a 104 ^{o}C oven until completely dry. It was then transferred to a desiccator to cool before being weighed to the nearest 0.001 g. The sample was then ashed in a muffle furnace at 500 ^{o}C for four hours. When cool enough it was transferred to a desiccator to cool further before being weighed to the nearest 0.001 g. The difference between nett dry and nett ash-free dry weights was then calculated. This difference or weight loss, expressed as a percentage (LOI %), is closely correlated with the organic content (combustible carbon) of the sediment sample (Heiri *et al*. 2001).

The distribution of particle sizes at each port was measured using the standard procedures and equipment of nested sieves to sort the larger particles (down to 0.5 mm) and a laser grain size analyser to sort particles below this size, as follows:

1. Samples were wet sieved using sieves of mesh sizes 8 mm, 5.6 mm, 4 mm, 2.8 mm, 2 mm, 1 mm and 0.5 mm.
2. Sediments retained on each sieve were dried and weighed.
3. The remaining fraction (< 0.5 mm) was prepared for laser analysis: the < 0.5 mm fraction was made up to 1 L in a cylinder fitted with an extraction tap. The sample was homogenised by continuous agitation with a plunger up and down in the cylinder for 20 seconds. With agitation continuing during extraction, approximately 100 ml was

drawn off for drying and weighing and a second 100 ml was drawn off for laser particle analysis.

4. The first 100 ml was measured to obtain a percent of the whole sample, then dried, weighed and scaled up to 100 % to return the < 0.5 mm gross dry weight.
5. The laser analysis returns percent distributions of volume in any chosen size ranges. These percents are then applied to the < 0.5 mm gross dry weight.
6. Laser analysis was conducted using a Galai CIS-100 “time-of-transition” (TOT) stream-scanning laser particle sizer. Particles sized between 2 µm and 600 µm were measured by the laser particle sizer and classified into the standard Wentworth size classes, with some extra divisions included in the pebble and fine silt categories (Table 11). Typically, 250,000 to 500,000 particles were counted per sample.
7. The fraction in each size category calculated by the laser analysis was then calculated as a percent of the total net dry weight.

SAMPLING EFFORT

A summary of sampling effort during the second baseline survey of the Port of Auckland is provided in Table 12, and the exact geographic locations of sample sites are given in Appendix 2. The distribution of effort aimed to maximise spatial coverage and represent the diversity of active berthing sites within the area. Total sampling effort was constrained by the costs of processing and identifying specimens obtained during the survey.

During the initial baseline survey, most sample effort was concentrated around six areas – Auckland Port, Wynyard, Princes, Queens, Marsden and Jellicoe in the main port area. These areas are spread throughout the port and represented a range of active berths and lay-up areas (Figure 2; Figure 3; Table 12). Similar locations were again sampled during the resurvey of the port, wherever possible. It was occasionally necessary to shift sampling sites in order to avoid interference with vessel movements. To improve description of the flora and fauna in the resurvey, we also increased sampling effort for benthic sleds, benthic grabs and all trapping techniques. Sample effort was increased in the repeat survey by sampling an additional three sites with the crab, shrimp, starfish and fish traps, five extra sites with the benthic grab, eight additional sites with the benthic sled, and one extra site with the dinoflagellate cyst core. These additional sampling sites were spread throughout the port (Figure 2; Figure 3; Table 12). The spatial distribution of sampling effort for each of the sample methods is indicated in the following figures: benthic sled (Figure **13**) and benthic grab sampling (Figure **14**), fish, crab, starfish and shrimp trapping (Figure **15**), diver pile scraping and javelin cyst coring (Figure **16**), and sediment sampling (Figure **17**).

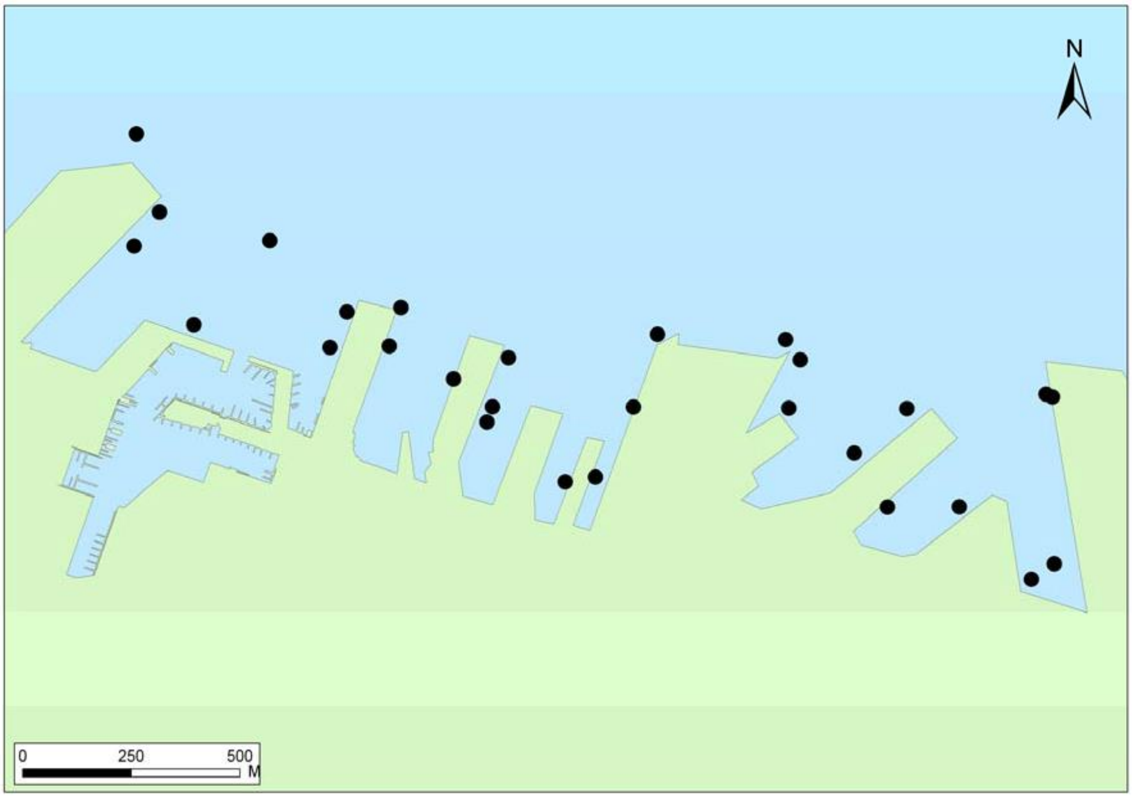

Figure 13: Benthic sled sampling sites

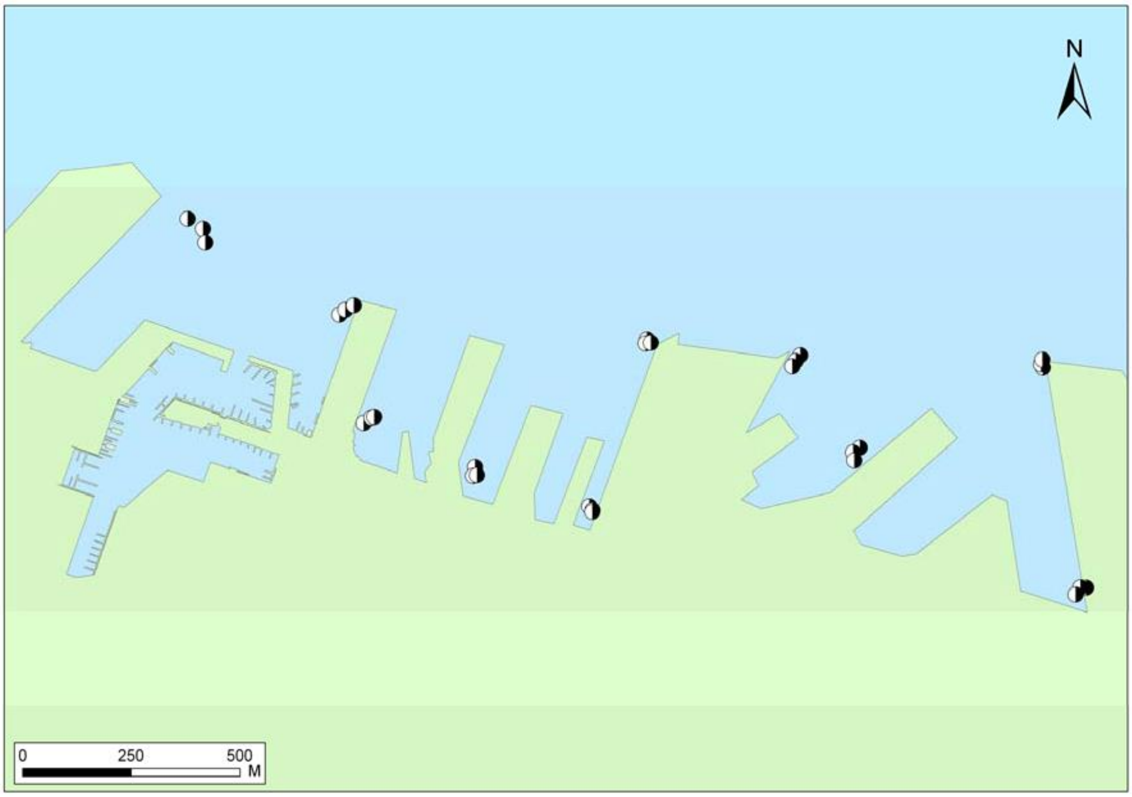

Figure 14: Benthic grab sampling sites.

Figure 15: Sites sampled using fish traps (red triangles), and crab, shrimp and seastar traps (blue circles).

Figure 16: Diver pile scraping (green squares), visual diver transect searches (orange squares) and dinoflagellate cyst core (stars) sampling sites.

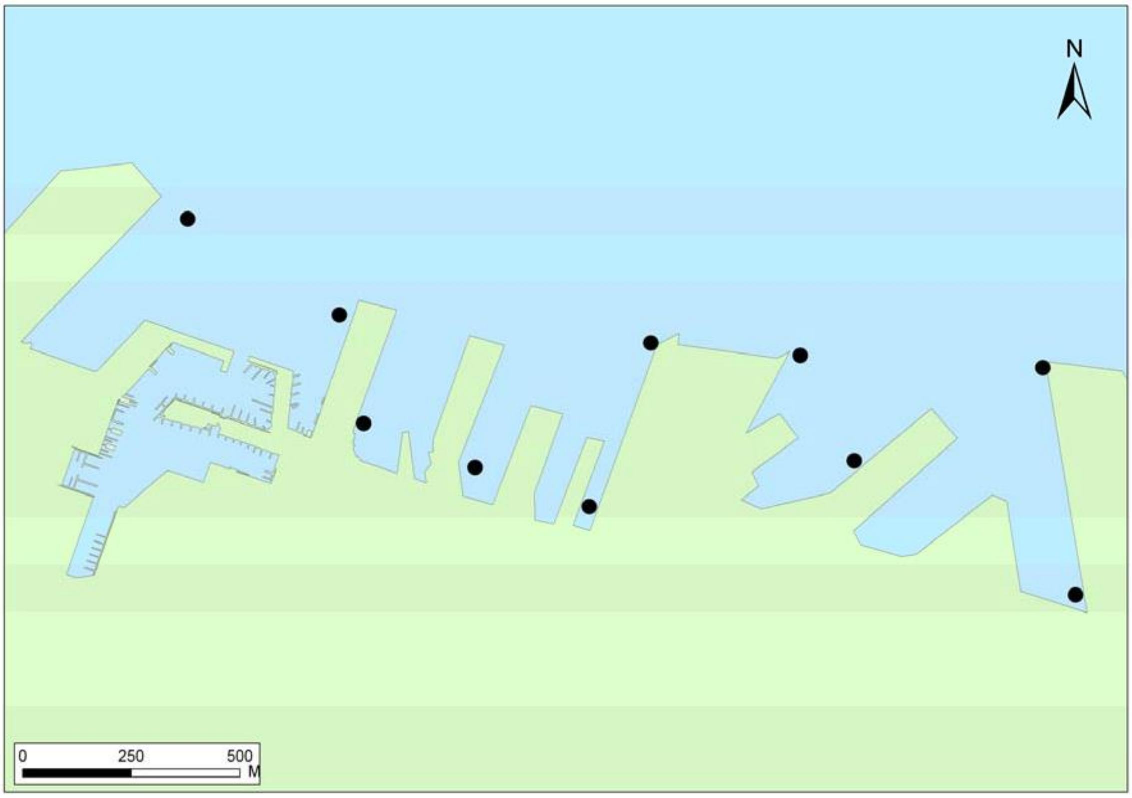

Figure 17: Sediment sampling sites

SORTING AND IDENTIFICATION OF SPECIMENS

Each sample collected in the survey was allocated a unique code on waterproof labels and transported to a nearby field laboratory where it was sorted by a team into broad taxonomic groups (e.g. ascidians, barnacles, sponges etc.). These groups were then preserved and individually labelled. Details of the preservation techniques varied for many of the major taxonomic groups collected, and the protocols adopted and preservative solutions used are indicated in Table 13. Specimens were subsequently sent to a range of taxonomic experts (see "Project Team", above) for identification to species or lowest taxonomic unit (LTU). Experts were not available to examine platyhelminths or sipunculids, so these taxa could only be recorded as "indeterminate taxa" (see "Definitions of species categories", below).

DEFINITIONS OF SPECIES CATEGORIES

Each species recovered during the survey was classified into one of four categories that reflected its known or suspected geographic origin. To do this we used the experience of taxonomic experts and reviewed published literature and unpublished reports to collate information on the species' biogeography.

Patterns of species distribution and diversity in the oceans are complex and still poorly understood (Warwick 1996). Worldwide, many species still remain undescribed or undiscovered and their biogeography is incomplete. These gaps in global marine taxonomy and biogeography make it difficult to determine reliably the true range and origin of many species. The four categories we used reflect this uncertainty. Species that were not demonstrably native or non-indigenous were classified as "cryptogenic" (sensu Carlton 1996). Cryptogenesis can arise because the species was spread globally by humans before scientific descriptions of marine flora and fauna began in earnest (i.e. historical introductions).

Alternatively the species may have been discovered relatively recently and there is insufficient biogeographic information to determine its native range. We have used two categories of cryptogenesis to distinguish these different sources of uncertainty. A fifth category ("indeterminate taxa") was used for specimens that could not be identified to species-level. Formal definitions for each category are given below, a full glossary is provided at the end of the report.

Native species

Native species have occurred within the New Zealand biogeographical region historically and have not been introduced to coastal waters by human mediated transport.

Non-indigenous species (NIS)

Non-indigenous species (NIS) are known or suspected to have been introduced to New Zealand as a result of human activities. They were determined using a series of questions posed as a guide by Chapman and Carlton (1991; 1994); as exemplified by Cranfield *et al*. (1998).

1. Has the species suddenly appeared locally where it has not been found before?
2. Has the species spread subsequently?
3. Is the species' distribution associated with human mechanisms of dispersal?
4. Is the species associated with, or dependent on, other non-indigenous species?
5. Is the species prevalent in, or restricted to, new or artificial environments?
6. Is the species' distribution restricted compared to natives?

The worldwide distribution of the species was tested by a further three criteria:

7. Does the species have a disjunctive worldwide distribution?
8. Are dispersal mechanisms of the species inadequate to reach New Zealand, and is passive dispersal in ocean currents unlikely to bridge ocean gaps to reach New Zealand?
9. Is the species isolated from the genetically and morphologically most similar species elsewhere in the world?

Cryptogenic taxa category 1

Species previously recorded from New Zealand whose identity as either native or non-indigenous is ambiguous. In many cases this status may have resulted from their spread around the world in the era of sailing vessels prior to scientific survey (Chapman and Carlton 1991; Carlton 1992), such that it is no longer possible to determine their original native distribution. Also included in this category are newly described species that exhibited invasive behaviour in New Zealand (Criteria 1 and 2 above), but for which there are no known records outside the New Zealand region.

Cryptogenic taxa category 2

Species that have recently been discovered but for which there is insufficient systematic or biogeographic information to determine whether New Zealand lies within their native range. This category includes previously undescribed species that are new to New Zealand or science.

Indeterminate taxa

Specimens that could not be reliably identified to species. This group includes: (1) organisms that were damaged or juvenile and lacked morphological characteristics necessary for identification, and (2) taxa for which there was not sufficient taxonomic or systematic information available to allow identification to species level.

DATA ANALYSIS

Comparison with the initial baseline survey

Several approaches were used to compare the results of the current survey with the earlier baseline survey of the Port of Auckland, completed in 2003 (Inglis *et al*. 2006d).

Summary statistics were compiled on the total number of species and major taxonomic groups found in each survey and on the numbers of species in each biogeographic category (i.e. native, non-indigenous, etc) recovered by each survey method.

While these summary data give the numbers of species actually observed in each survey they do not, by themselves, provide a robust basis for comparison, since they do not account for differences in sample effort between the surveys, variation in the relative abundance of species at the time of each survey (for a discussion of these issues, see Gotelli and Colwell 2001), or the actual species composition of the recorded assemblages. The latter is important if port surveys are to be used to estimate and monitor the rate of new incursions by non-indigenous species.

In any single survey, the number of species observed will always be less than the actual number present at the site. This is because a proportion of species remain undetected due to bias in the survey methods, local rarity, or insufficient sampling effort. A basic tenet of sampling biological assemblages is that the number of species observed will increase as more samples are taken, but that the rate at which new species are added to the survey tends to decline and gradually approaches an asymptote that represents the total species richness of the assemblage (Colwell and Coddington 1994). In very diverse assemblages, however, where a large proportion of the species are rare, this asymptote is not reached, even when very large numbers of samples are taken. In these circumstances, comparisons between surveys are complicated by the large number of species that remain undetected in each survey. This issue has received considerable attention in recent literature and new statistical methods have been developed to allow better comparisons among surveys (Gotelli and Colwell 2001; Colwell *et al*. 2004; Chao *et al*. 2005). We use several of these new techniques – sample-based rarefaction curves (Colwell *et al*. 2004), non-parametric species richness estimators (Colwell and Coddington 1994), and bias-adjusted similarity indices (Chao *et al*. 2005) - to compare results from the two surveys of the Port of Auckland.

Sample-based rarefaction curves

Sample-based rarefaction curves depict the number of species that would be expected in a given number of samples (n) taken from the survey area, where $n_{(max)}$ is the total number of samples taken in the field survey. The shape of the curves and the number of species expected for a given n can be used as the basis for comparing the surveys and evaluating the benefit of reducing or increasing sample effort in subsequent surveys (Gotelli and Colwell 2001). For each baseline survey we computed separate sample-based rarefaction curves (Gotelli and Colwell 2001) for each survey method. The curves were computed from the presence or absence of each recorded species in each sample unit (i.e. replicated incidence data) using the analytical formula developed by Colwell *et al*. (2004) (the Mau Tau index) and the software EstimateS (Colwell 2005).

Separate curves were computed for each of four methods: pile scraping, benthic sleds, benthic grabs and crab traps. The remaining methods did not usually recover enough taxa to allow meaningful analyses. For pile scrapes, only quadrat samples were used; specimens collected on qualitative visual searches of piles were not included. Since the purpose of the port surveys is primarily inventory of non-indigenous species, we generated separate curves for native species, cryptogenic category 2 taxa, and the combined species pool of non-indigenous and cryptogenic category 1 taxa, where there were sufficient numbers of taxa to produce meaningful curves (arbitrarily set at > 8 taxa per category). This was possible for pile scrapes, benthic sleds and benthic grabs; for the crab traps, all taxa (excluding indeterminate taxa) were pooled in order to have sufficient numbers of taxa. Even after pooling all taxa, there were usually insufficient numbers of taxa recorded by cyst cores, shrimp traps, seastar traps and fish traps, so analyses were not conducted for these methods. Several taxa (Order Tanaidacea (tanaids), Class Scyphozoa (jellyfish), Phylum Platyhelminthes (flatworms), Phylum Sipuncula (peanut worms) and Class Anthozoa (sea anemones)) were specifically excluded from analyses as, at the time the reports were prepared, we had been unable to secure identification of specimens from either the initial survey, the resurvey, or both.

Note that, by generating rarefaction curves we are assuming that the samples can reasonably be considered a random sample from the same universe (Gotelli and Colwell 2001). Strictly, this does not represent the way that sample units were allocated in the survey. For example, quadrat samples were taken from fixed depths on inner and outer pilings at each berth, rather than distributed randomly throughout the 'universe' of pilings in the port. Previously, we showed that there is greater dissimilarity between assemblages in these strata than between replicates taken within each stratum, although the difference is marginal (range of average similarity between strata = 22%-30% and between samples = 25%-35 %, Inglis *et al*. 2003). This stratification is an example of the common tension in biodiversity surveys between optimising the complementarity of samples (i.e. reducing overlap or redundancy in successive samples so that the greatest number of species is included) and adequate description of diversity within a particular stratum (Colwell and Coddington 1994). In practice, no strategy for sampling biodiversity is completely random or unbiased. The effect of the stratification is likely to be an increase in the heterogeneity of the samples, equivalent to increasing the patchiness of species distribution across quadrats. This is likely to mean slower initial rate of accumulation of new species and slower accumulation of rare species (Chazdon *et al*. 1998). Because the same survey strategy was used in both port surveys, this systematic bias should not unduly affect comparisons between the two surveys. Furthermore, preliminary trials, where we pooled quadrat samples to form more homogenous units (e.g. piles or berths as the sample unit) and compared the curves to total randomisation of the smallest unit (quadrats), had little effect on the rate of accumulation (Inglis *et al*. 2003).

Estimates of total species richness

Estimates of total species richness (or more appropriately total "species density") in each survey were calculated using the Chao 2 estimator. This is a non-parametric estimate of the true number of species in an assemblage that is calculated using the numbers of rare species (those that occur in just one or two sample units) in the sample (Colwell and Coddington 1994). That is, it estimates the total number of species present, including the proportion that was present, but not detected by the survey ("unseen" species). As recommended by Chao (in Colwell 2005), we used the bias-corrected Chao 2 formula, except when the coefficient of variation CV > 0.5, in which case the estimates were recalculated using the Chao 2 classic formula, and the higher of the Chao 2 classic and the ICE (Incidence-based Coverage Estimator)was reported.

Plots of the relationship between the species richness estimates and sample size were compared with the sample-based rarefaction curve for each combination of survey, method, and species category. Convergence of the observed (the rarefaction curve) and estimated (Chao 2 or ICE curve) species richness provides evidence of a relatively thorough inventory (Longino *et al*. 2002).

Similarity analyses

A range of indices is available to measure the compositional similarity of samples from biological assemblages using presence-absence data (Koleff *et al*. 2003). Many of these are based on the relative proportions of species that are common to both samples ("shared species") or which occur in only a single sample. The classic indices typically perform poorly for species rich assemblages and are sensitive to sample size, since they do not account for the detection probabilities of rare ("unseen") species. Chao *et al*. (2005) have recently developed new indices based on the classic Jaccard and Sorenson similarity measures that incorporate the effects of unseen species. We used the routines in EstimateS (Colwell 2005) to compare samples from the two surveys using the new Chao estimators, but also report the classic Jaccard and Sorenson measures. Separate comparisons were done for each combination of survey method and species category where there were sufficient taxa (see above). For each similarity index, values range from zero (completely different) to one (identical).

Survey results

PORT ENVIRONMENT

Sampling was carried out at 13 different sites throughout the Port of Auckland. Maximum recorded depths ranged from 18 m at Axis Fergusson 1 Wharf to 7.3 m at Marsden Wharf. During the survey turbidity varied across all sites sampled (1.03 m ± 0.53) with the lowest turbidity being recorded at Princes 1 Wharf (1.8 m secchi depth), whilst it was highest at Axis Fergusson 1 Wharf and Jellicoe Wharf (0.5 m secchi depth). Salinity was variable across sites with an average of 34.5 ppt and ranged from 30 ppt Marsden Wharf and Princes 1 Wharf to 36 ppt at Wynyard Wharf. The average water temperature across all sites was 21 °C ± 0.95 °C. Water temperature was highest at Wynyard Wharf (21.4 °C) and lowest at Princes 1 Wharf (20.8 °C). During sampling, sea states ranged from 2-4 on the Beaufort scale (i.e. approximately 4-16 knots wind speed and 0.2-1.5 m wave height) (Table 14).

The organic content of sediments in the Port of Auckland was moderate, with a mean LOI (loss on ignition) value across the ten analysed samples from ten sites of 6.6 % (Figure 18). Organic content was 1 % at the Axis Bledisole 2 Wharf, which also had the highest proportion of pebble-sized sediment. In comparison, LOI was 11.5 % at the Axis Fergusson 1 Wharf where sediment samples did not contain any particles larger than 2 mm (Table 15).

Sediments at the sampling sites at the Port of Auckland were dominated by sand-sized particles (55-94 %), with silt and clay-sized particles also found in every sample (Table 15). Gravel and pebble-sized particles were found in four of the sites sampled. Pebble-sized particles made up 33 % of the sample collected at Axis Bledisloe 2 Wharf (Table 15).

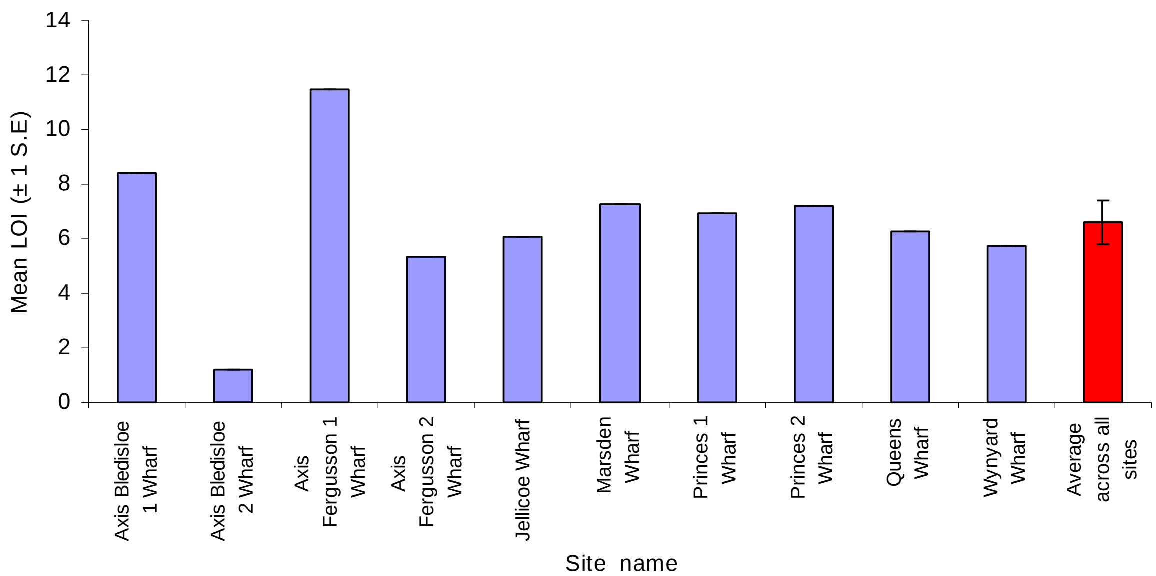

Figure 18: Organic content as determined by loss on ignition analyses of sediments from ten sites at and around Port of Auckland.

SPECIES RECORDED

A total of 238 species or higher taxa were identified from the resurvey of the Port of Auckland. This collection consisted of 145 native (Table 16), 34 cryptogenic (Table 17), and 14 non-indigenous species (Table 18), with the remaining 45 taxa being made up of indeterminate taxa (Table 19, Figure 19). In comparison, (after revision; see "Results of the first baseline survey" above) 173 taxa were recorded from the initial survey of the port in April 2003, comprising 116 native species (Table 16), 22 cryptogenic taxa (Table 17), 14 non-indigenous species (Table18), and 21 indeterminate taxa (Table 19).

The biota in the resurvey included a diverse array of organisms from 16 phyla, and one unidentified alga (Figure 20). For general descriptions of phyla encountered during this study refer to Appendix 3, and for detailed species lists collected using each method refer to Appendix 4.

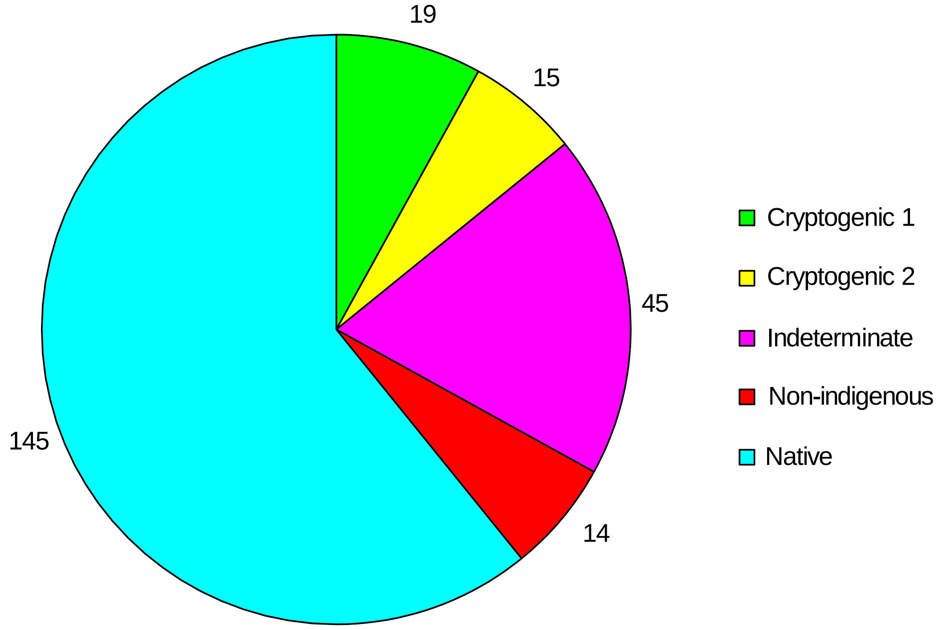

Figure 19: Diversity of marine species sampled in the Port of Auckland. Values indicate the number of taxa in each category.

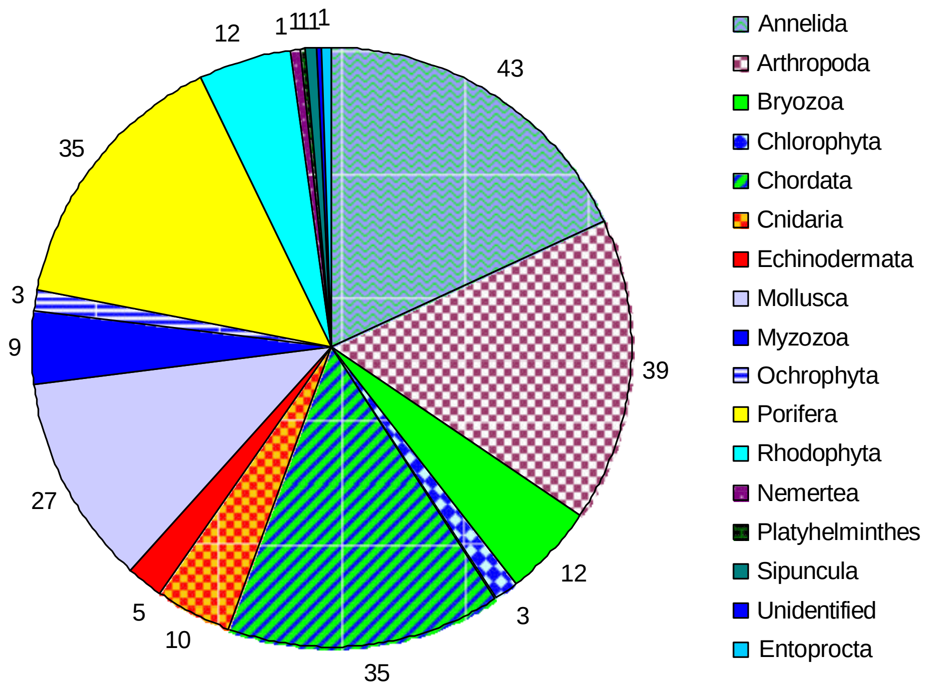

Figure 20: Phyla recorded in the Port of Auckland. Values indicate the number of taxa in each of the major taxonomic groups.

Native species

The 145 native species recorded during the resurvey of the Port of Auckland represented 61 % of all species identified from this location (Figure 19) and included diverse assemblages of annelids (33 species), crustaceans (27 species), molluscs (21 species), fish (13 species), sponges (11 species), ascidians (10 species), red alga (7 species) and bryozoans (6 species). A number of other less diverse major taxonomic groups including echinoderms, cnidarians, brown algae, dinoflagellates and green alga were also recorded from the Port (Figure 20).

Cryptogenic taxa

Cryptogenic taxa (n = 34) represented 14 % of all species or higher taxa identified from the Port. The cryptogenic organisms identified included 19 Category 1 and 15 Category 2 species as defined in "Definitions of species categories" above. These organisms included 21 sponges, six ascidians, five annelids, 1 cnidarian and one dinoflagellate (Table 17). Eight of the cryptogenic category 1 taxa were not recorded in the initial baseline survey of the port (the annelids *Neodexiospira pseudocorrugata*, *Heteromastus filiformis*, *Chaetopterus chaetopterus* and the sponges *Ciocalypta pencillus*, *Ciocalypta polymastia*, *Halichondria panicea*, *Lissodendoryx isodictyalis* and *Pseudosuberites sulcatus*). Only three of the 14 Category 1 species recorded in the initial baseline survey of the Port of Auckland were not found during the resurvey (the ascidian *Asterocarpa humilis* and the Cnidarians *Clytia hemisphaerica* and *Obelia bidentata*). Several of the Category 1 cryptogenic taxa (e.g the ascidians *Asterocarpa humilis*, *Heteromastus filiformis* and *Corella eumyota*) have been present in New Zealand for more than 100 years but have distributions outside New Zealand that suggest non-native origins (Cranfield *et al*. 1998). The Chapman and Carlton (1994) criteria applicable to each C1 taxon are indicated in Appendix 5.

Eight of the cryptogenic category 2 taxa recorded in the resurvey of the Port of Auckland were not recorded in the initial survey of the port (the annelids *Perinereis Perinereis*-A and *Spirobranchus S. polytrema* complex and the sponges *Halichondria* cf. *rugosa*, *Scopalina* new sp. 1, *Haliclona* new sp. 3, *Haliclona* new sp. 9, *Paraesperella* new sp. 1 and *Mycale (Carnia)* new. sp. 4). Only three of the 14 Category 2 species recorded in the initial baseline survey of the Port of Auckland were not found during the resurvey (the annelids *Typosyllis Typosyllis*-B and *Pseudopotamilla Pseudopotamilla*-A and the amphipod *Acontiostoma* new sp.)

The *Didemnum* species group, which we have included in cryptogenic category 1, warrants further discussion. This genus includes at least two species that have recently been reported from within New Zealand (*D. vexillum* and *D. incanum*) and two related, but distinct species from Europe (*D. lahillei*) and the north Atlantic (*D. vestum* sp. nov.) that have displayed invasive characteristics (i.e. sudden appearance and rapid spread, Kott 2004a; Kott 2004b). All can be dominant habitat modifiers. The taxonomy of the Didemnidae is complex and it is difficult to identify specimens to species level. The colonies do not display many distinguishing characters at either species or genus level and are comprised of very small, simplified zooids with few distinguishing characters (Kott 2004a). Six species have been described in New Zealand (Kott 2002) and 241 in Australia (Kott 2004a). Most are recent descriptions and, as a result, there are few experts who can distinguish the species reliably.

Specimens of *Didemnum* obtained during the initial port baseline surveys were examined by the world authority on this group, Dr Patricia Kott (Queensland Museum). She identified *D. vexillum* among specimens taken from the initial baseline surveys of Nelson and Tauranga, and *D. incanum* from the ports of Tauranga, Picton and Bluff. A third species, *D. tuberatum*, which Dr Kott described as native to New Zealand, was also recorded from Bluff. At the time that this report was prepared, we had been unable to secure Dr Kott's services to examine specimens from the repeat baseline surveys, and all *Didemnum* specimens were identified only to genus level. We have reported these species collectively, as a species group (*Didemnum* sp., Table 17).

Non-indigenous species

The 14 non-indigenous species (NIS) recorded in the resurvey of the Port of Auckland represented 6 % of all species or higher taxa identified from the Port and included three molluscs, two each of annelid worms, crustaceans, bryozoans and sponges, and one ascidian, one cnidarian and one entoproct (Table 18). Seven species found in the resurvey were not recorded during the initial baseline survey in April 2003. These were: the annelid *Paralepidonotus ampulliferus*, the amphipod *Apocorophium acutum*, the bryozoan *Watersipora subtorquata,* the ascidian *Styela clava,* the molluscs *Limaria orientalis* and *Callyspongia robusta* and the entoproct *Barentsia matsushimana.* None of the NIS are new records for New Zealand.

Six NIS recorded in the initial survey were not recorded in the resurvey (the bryozoans *Bugula neritina, Celleporaria* sp. 1 and *Anguinella palmate*, the fish *Arenigobius bifrenatus*, the cnidarian *Obelia longissima* and the sponge *Halisarca dujardini*). Each of these species was present in just a single sample in the initial baseline survey.

Below we summarise available information on the biology of each of these species, providing images where available, and indicate what is known about their distribution, habitat preferences and impacts. This information was sourced from published literature, the taxonomists in the Project Team and from regional databases on non-indigenous marine species in Australia (National Introduced Marine Pest Information System, Hewitt *et al.* 2002) and the USA (National Exotic Marine and Estuarine Species Information System, Fofonoff *et al*. 2003). Distribution maps for each NIS in the port are composites of multiple replicate samples and display presence/absence data only for the sampling techniques that could have been expected to collect the particular species. Where overlayed presence and absence symbols occur on the map, this indicates the NIS was found in at least one, but not all replicates at that GPS location. NIS are presented below by major taxonomic groups in the same order as. The Chapman and Carlton (1994) criteria applicable to each NIS are indicated in Appendix 4 (Chapman and Carlton 1994).

Hydroides elegans (Haswell, 1883)

Image and information: NIMPIS (2002c)

Hydroides elegans is a small, tube dwelling polychaete worm that grows to up to 20mm in length. It constructs hard, sinuous, calcareous tubes. The worm has 65-80 body segments, and an opercular crown with 14-17 spines. *Hydroides elegans* is a fouling species on both natural and artificial structures. It is found subtidally and is highly tolerant of contaminated waters. Although the type specimen for this species was described from Sydney Harbour, Australia, the native range of *H. elegans* is unknown, as it is possible it was introduced to Australia prior to 1883 (Australian Faunal Directory 2005). *H. elegans* is present in the Caribbean Sea, Brazil, Argentina, northwest Europe, Japan, the Mediterranean, north-west and south-east Africa, and New Zealand (Figure 21). This species is able to grow in high densities, particularly in tropical and sub-tropical ports, sometimes heavily fouling any newly immersed structure. It creates microhabitat for some species and competes with others for food and space. *H. elegans* has been present in New Zealand since at least 1952 and has been recorded from Waitemata and Lyttelton Harbours (Cranfield *et al*. 1998).

During the initial port baseline surveys, *H. elegans* was recorded in Gulf Harbour marina and the Port of Auckland (Figure 22; (Inglis *et al*. 2006b, d)). During the second baseline surveys it was recorded from the Port of Nelson, Viaduct Harbour, Westhaven Marina (Inglis *et al*. 2006u), Inglis *et al.* in press) and in this survey of the Port of Auckland (Figure 23; Table 20).

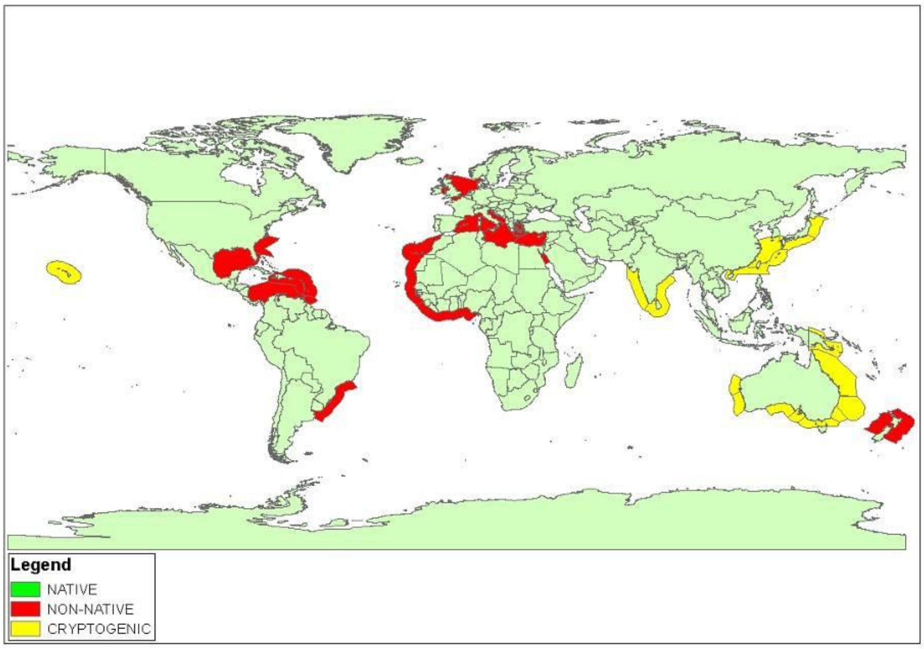

Figure 21: Global distribution of *Hydroides elegans*

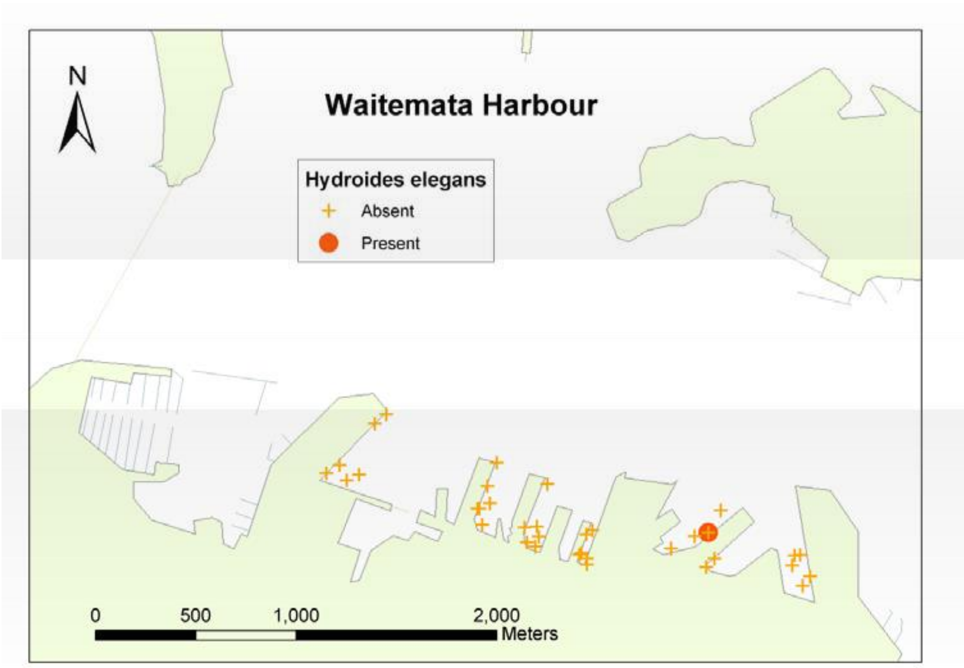

Figure 22: Distribution of *Hydroides elegans* in the initial survey of the Port of Auckland

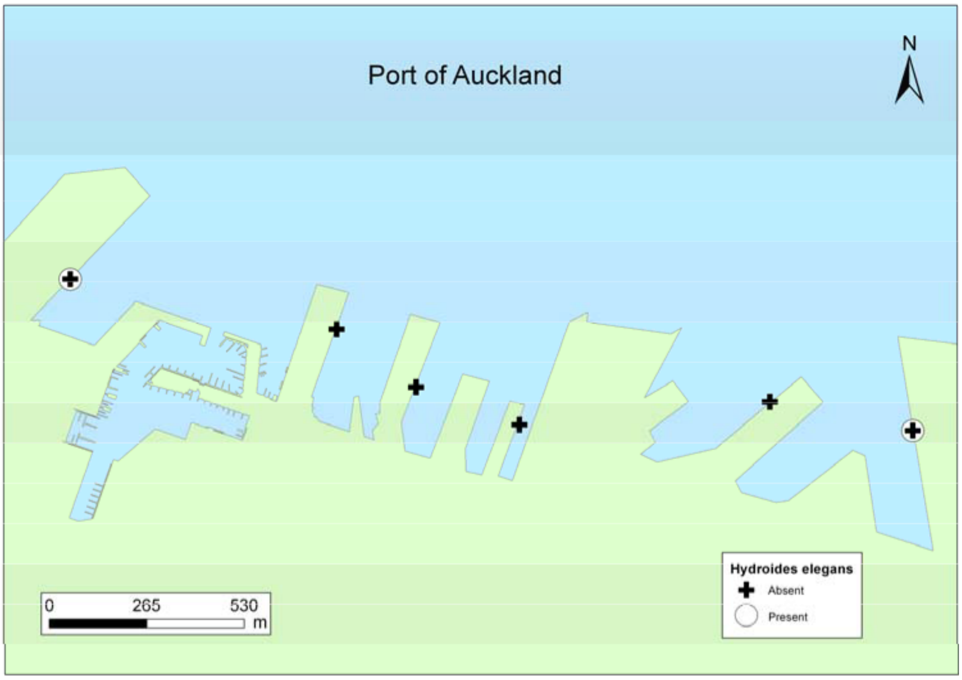

Figure 23: Distribution of *Hydroides elegans* in the resurvey of the Port of Auckland

***Paralepidonotus ampulliferus* (Horst, 1915)**

No Image Available.

Paralepidonotus ampulliferus is a soft-shore polynoid (scale-worm) which has a broad body and can grow to have up to 40 segments. *P. ampulliferus* is widely distributed across the Indian Ocean and the western Pacific Ocean, and is present around much of the Australian coast (Figure 24). The scale worm most likely arrived in New Zealand via ship ballast water, vessel hull fouling, or shipments of live shellfish. *Paralepidonotus ampulliferus* appears to be habitat-flexible and has been found as epifauna in environments other than soft sediment. No restrictive associations with other species have yet been detected (Read 2006).

P. ampulliferus has been found subtidally in Whangarei Harbour, and is widespread around the soft-shores of Waitemata Harbour (Auckland) and nearby Hauraki Gulf inlets, with the earliest record dating from late 1998 and seems to have a restricted but expanding national distribution (Read 2006). *P. ampulliferus* was recorded in the initial survey of Viaduct Harbour and the Westhaven Marina (Inglis *et al*. in press), and in the second baseline surveys of the ports of Whangarei (Inglis *et al*. in press), and in this survey of the Port of Auckland (Figure 25; Table 18; Table 20).

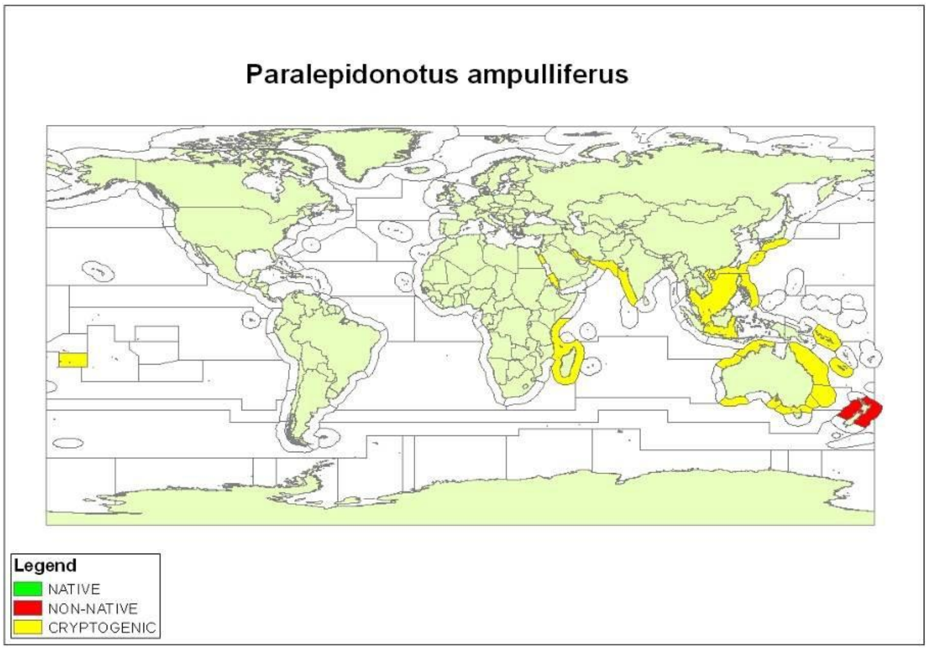

Figure 24: Global distribution of *Paralepidonotus ampulliferus*

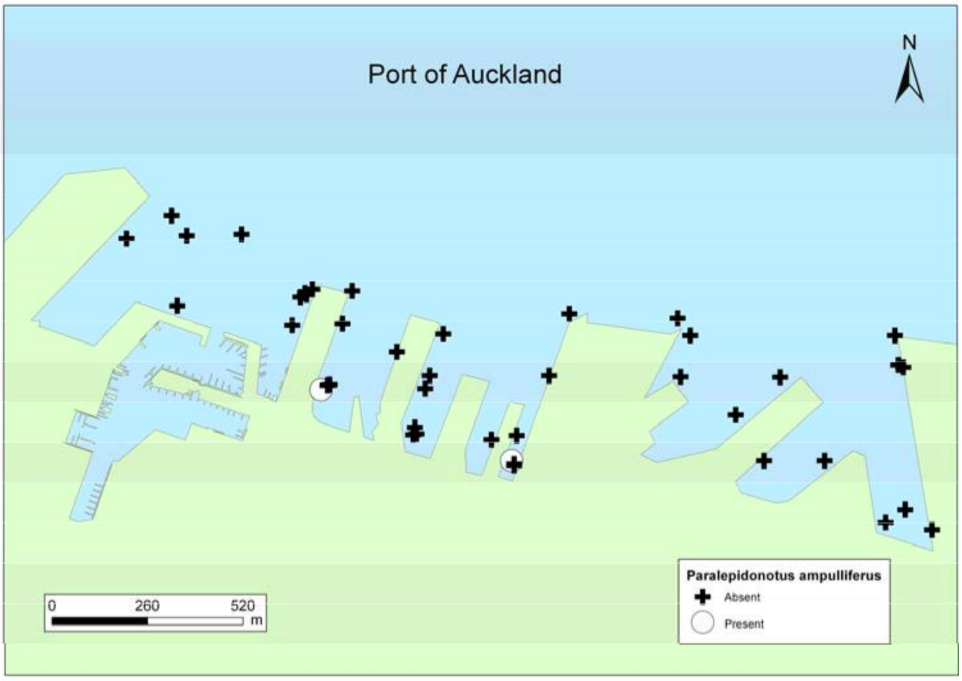

Figure 25: ***Paralepidonotus ampulliferus*** **distribution in the resurvey of the Port of Auckland**

Apocorophium acutum (Chevreux, 1908)

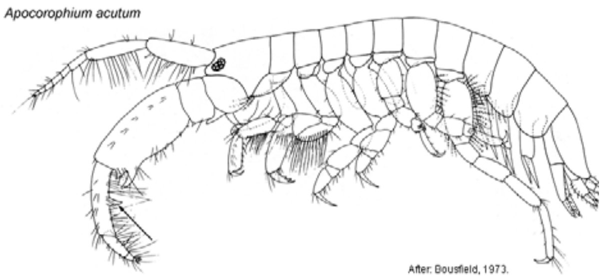

Image and information: Myers *et al*. (2006)

Apocorophium acutum is a corophiid amphipod, known from the Atlantic Ocean (England, France, and North America) and the Pacific Ocean (New Zealand) (Figure 26). The native range of this species is not known. *Apocorophium acutum* inhabits marine sediments in estuarine mudflats and brackish water and fouling assemblages where it builds muddy tubes. It has no known documented impacts.

During the initial port baseline surveys *A. acutum* was recorded from the ports of Tauranga, Lyttelton, Timaru and Dunedin, and from Gulf Harbour and Opua marinas (Inglis *et al*. 2006a, b, c; Inglis *et al*. 2006e; Inglis *et al*. 2006j, k, l)). During the second baseline surveys it was recorded from the ports of Lyttelton, Timaru, Bluff, Dunedin, Gisborne, Napier, Whangarei and the Opua, Gulf Harbour, Westhaven and Whangarei Marinas (Inglis *et al*. 2006k; Inglis *et al*. 2006o, s; Inglis *et al.* in press) and this resurvey of the Port of Auckland (Figure 27; Table 18; Table 20).

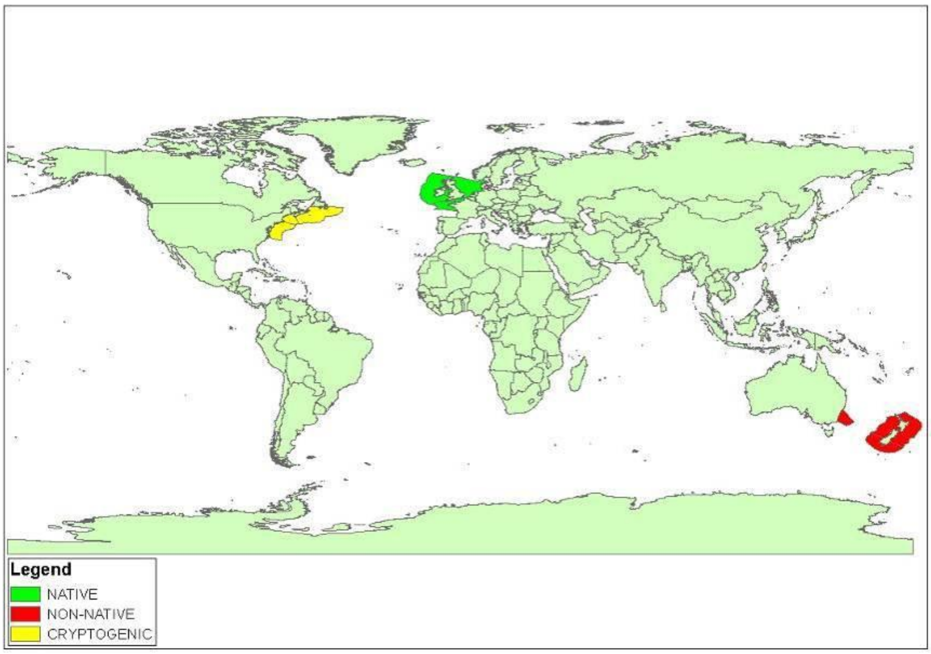

Figure 26: Global distribution of *Apocorophium acutum*

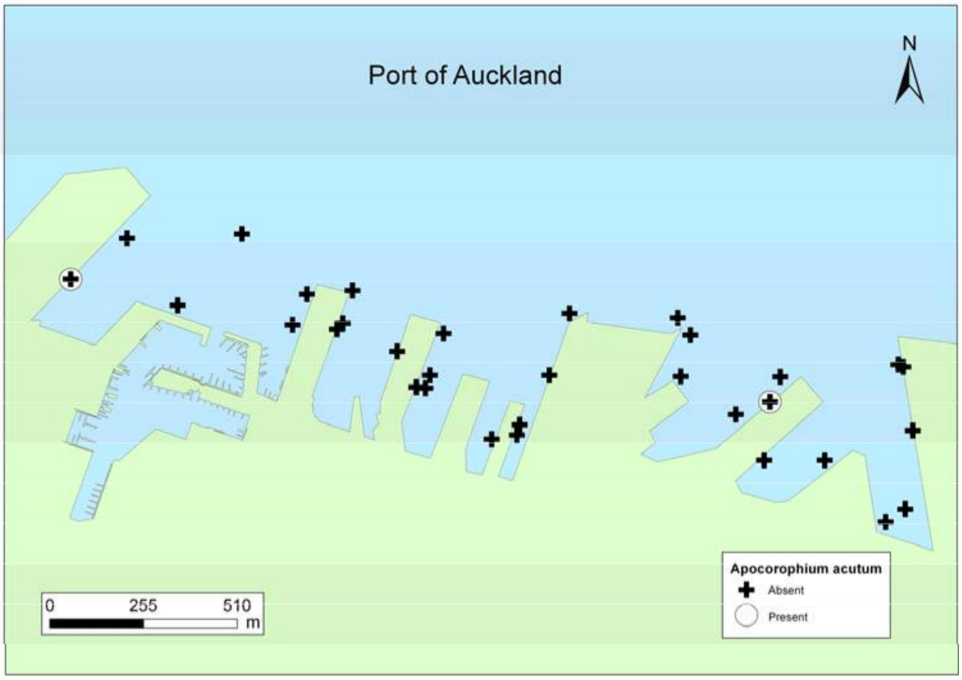

Figure 27: ***Apocorophium acutum*** **distribution in the resurvey of the Port of Auckland**

Charybdis japonica (A. Milne-Edwards, 1861)

Image and information:
Gust and Inglis (2006)

Charybdis japonica is a large (max. carapace width ~ 10 cm) portunid (paddle) crab that was first discovered in New Zealand, in Waitemata Harbour in September 2000. It is native to the north-west Pacific, including coastal regions of China, Malaysia, Korea, Taiwan and Japan (Figure 28). Carapace colouration is variable, but can include a yellow-brown marbled shell or a dark shell with blue and red flashes on the ventral surfaces and legs. Adult crabs occupy a range of habitats in sub-tidal coastal areas and estuaries. In its native range, juvenile *C. japonica* are commonly found in tide pools in the rocky intertidal zone. Trapping surveys of the Waitemata population showed that *C. japonica* had spread widely throughout a range of habitats in the Harbour (Gust *et al.* 2006). Delimitation surveys undertaken in late 2002 showed that it was abundant in the Waitemata Harbour and two nearby estuaries (the Tamaki and Weiti), but there was no evidence of its spread to other shipping ports nationwide. As a key estuarine predator, *C. japonica* is likely to have significant impacts on native estuarine benthic assemblages, particularly small bivalves.

C. japonica was recorded in the initial survey of the Port of Auckland (Figure 29; (Inglis *et al.* 2005), and in this survey of the Port of Auckland (Figure 30; Table 18; Table 20).

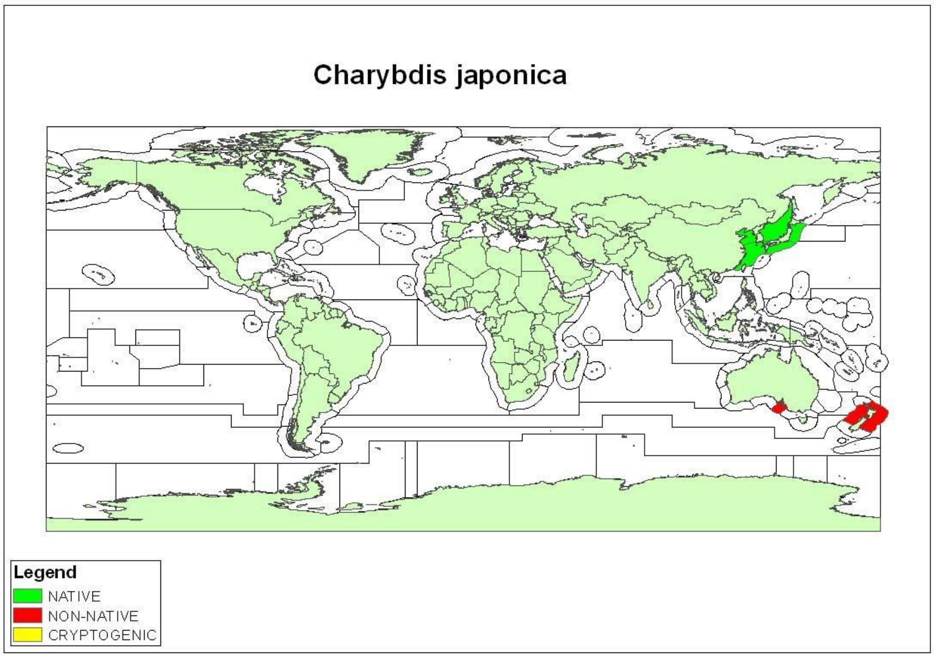

Figure 28: Global distribution of *Charybdis japonica*

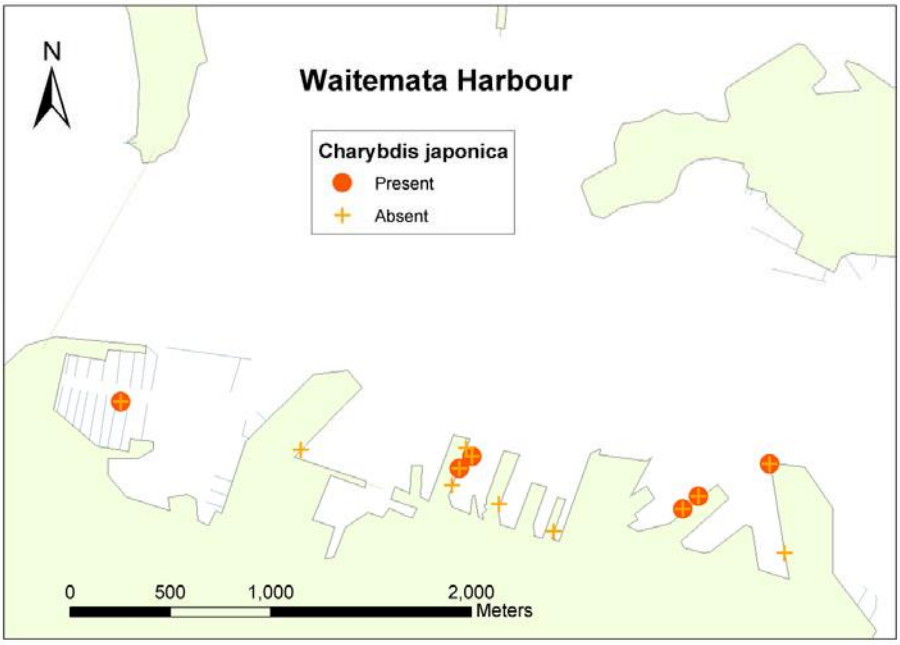

Figure 29: *Charybdis japonica* **distribution in the initial survey of the Port of Auckland**

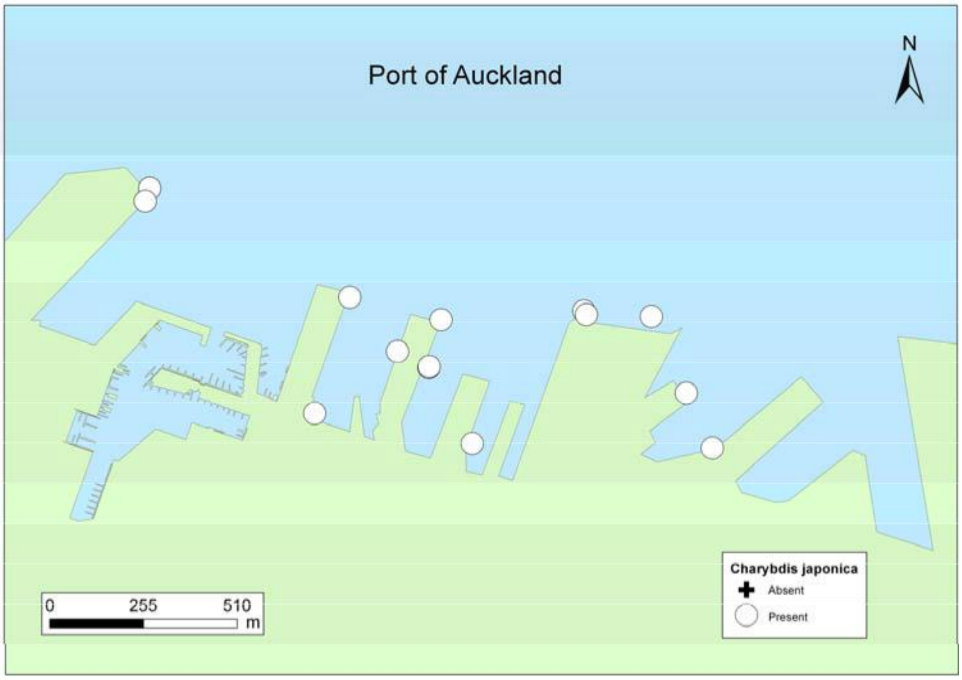

Figure 30: *Charybdis japonica* **distribution in the resurvey of the Port of Auckland**

***Bugula flabellata* (Thompson in Gray, 1848)**

Image and information: NIMPIS (2002a)

Bugula flabellata is an erect bryozoan with broad, flat branches. It is a colonial organism and consists of numerous 'zooids' connected to one another. It is pale pink and can grow to about 4 cm high and attaches to hard surfaces such as rocks, pilings and pontoons or the shells of other marine organisms. It is often found growing with other erect bryozoan species such as *B. neritina* (see below) or growing on encrusting bryozoans. Vertical, shaded, sub-littoral rock surfaces also form substrata for this species. It has been recorded down to 35 m. *Bugula flabellata* is native to the British Isles and North Sea and has been introduced to Chile, Florida and the Caribbean and the northern east and west coasts of the USA, as well as Australia and New Zealand. It is cryptogenic on the Atlantic coasts of Spain, Portugal and France (Figure 31). *Bugula flabellata* is a major fouling bryozoan in ports and harbours, particularly on vessel hulls, pilings and pontoons and has also been reported from offshore oil platforms. *Bugula flabellata* has been present in New Zealand since at least 1949 and is present in most New Zealand ports. There have been no recorded impacts from *B. flabellata.*

During the initial port baseline surveys *B. flabellata* was recorded from Opua and Westhaven Marina, Whangarei, Tauranga, Napier, Taranaki, Wellington, Picton, Nelson, Lyttelton, Timaru, Dunedin, Bluff and the Port of Auckland (Figure 32). During the second baseline surveys of *B. flabellata* was recorded from the ports of Opua, Whangarei, Tauranga, Gisborne, Taranaki, Wellington, Picton, Nelson, Lyttelton, Timaru, Dunedin, Bluff (Inglis *et al*. 2006o, p, q, r, s; Inglis *et al*. 2006t; Inglis *et al*. 2006u) and in this resurvey of Port of Auckland (Figure 33; Table 18; Table 20).

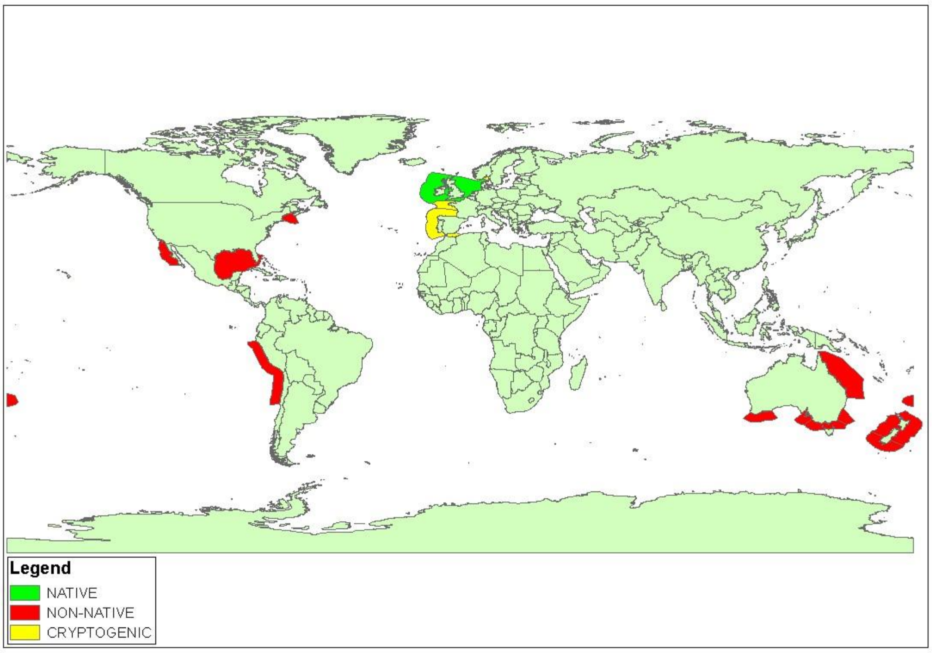

Figure 31: Global distribution of *Bugula flabellata*

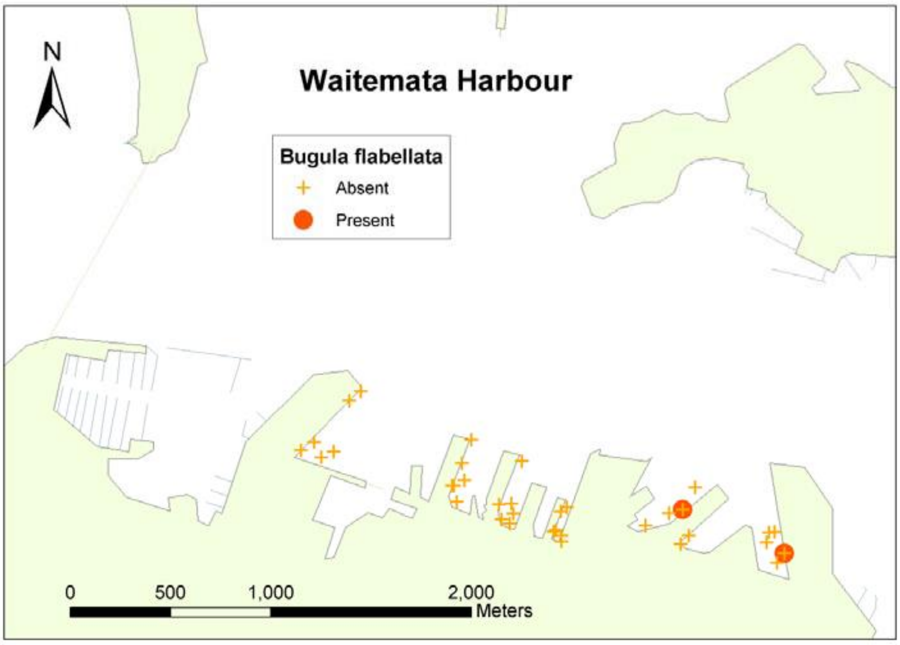

Figure 32: *Bugula flabellata* distribution in the initial survey of the Port of Auckland

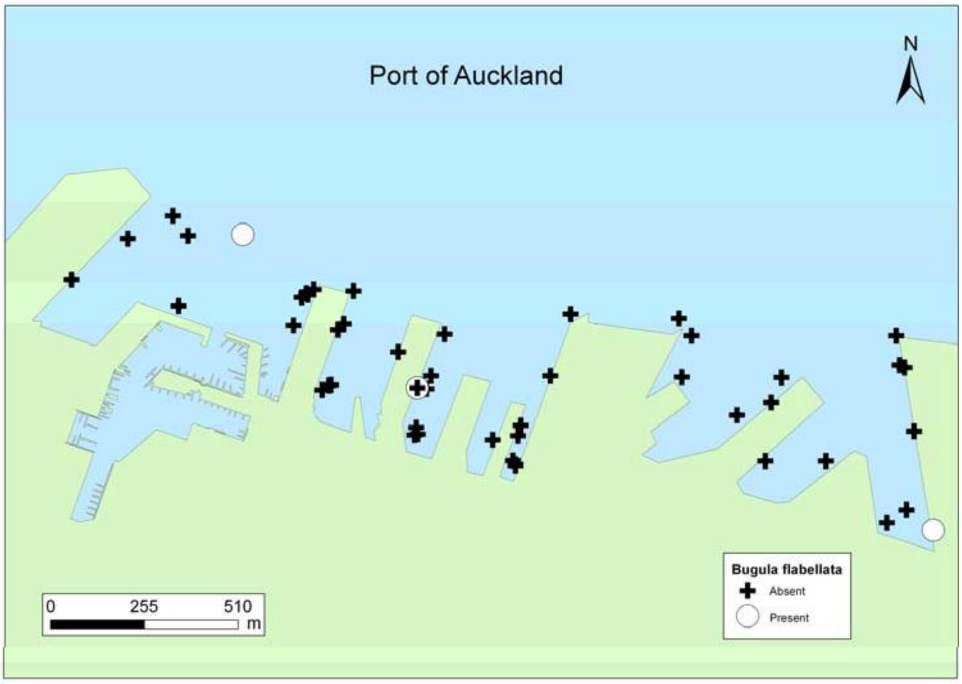

Figure 33: *Bugula flabellata* distribution in the resurvey of the Port of Auckland

***Watersipora subtorquata* (d'Orbigny, 1852)**

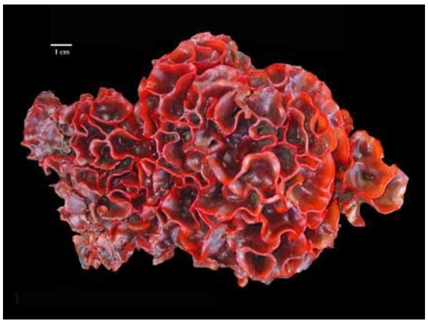

Image: Cohen (2005)
Information: Gordon and Matawari (1992)

Watersipora subtorquata is a loosely encrusting bryozoan capable of forming single or multiple layer colonies. The colonies are usually dark red-brown, with a black centre and a thin, bright red margin. The operculum is dark, with a darker mushroom shaped area centrally. *W. subtorquata* has no spines, avicularia or ovicells. The native range of the species is unknown, but is thought to include the wider Caribbean and South Atlantic. The type specimen was described from Rio de Janeiro, Brazil (Gordon and Mawatari 1992). It also occurs in the northwest Pacific, Torres Strait and northeastern Australia (Figure 34).

Watersipora subtorquata is a common marine fouling species in ports and harbours. It occurs on vessel hulls, pilings and pontoons. This species can also be found attached to rocks and seaweeds. They form substantial colonies on these surfaces, typically around the low water mark. *W. subtorquata* is also an abundant fouling organism and is resistant to a range of antifouling toxins. It can therefore spread rapidly on vessel hulls and provide an area for other species to settle onto which can adversely impact on vessel maintenance and speed, as fouling assemblages can build up on the hull.

Watersipora subtorquata has been present in New Zealand since at least 1982 and is now present in most ports from Opua to Bluff (Gordon and Matawari 1992). During the initial port baseline surveys, it was recorded from the Opua, Westhaven and Gulf Harbour marinas, Whangarei Harbour (Marsden Point and Whangarei Port) and the ports of Tauranga, Gisborne, Napier, Taranaki, Wellington, Picton, Nelson, Lyttelton, Timaru, Dunedin and Bluff (Inglis *et al*. 2006b, c; Inglis *et al*. 2006e, g; Inglis *et al*. 2006h, i, j, k, l, m). During the repeat baseline surveys *W. subtorquata* was recorded from the ports of Opua, Whangarei, Tauranga, Gulf Harbour Marina, Taranaki, Wellington, Picton, Nelson, Lyttelton, Timaru Gisborne, Otago, Bluff (Inglis *et al*. 2006o, p, q, r, s; Inglis *et al*. 2006t; Inglis *et al*. 2006u) and in this resurvey of the Port of Auckland (Figure 35; Table 18; Table 20).

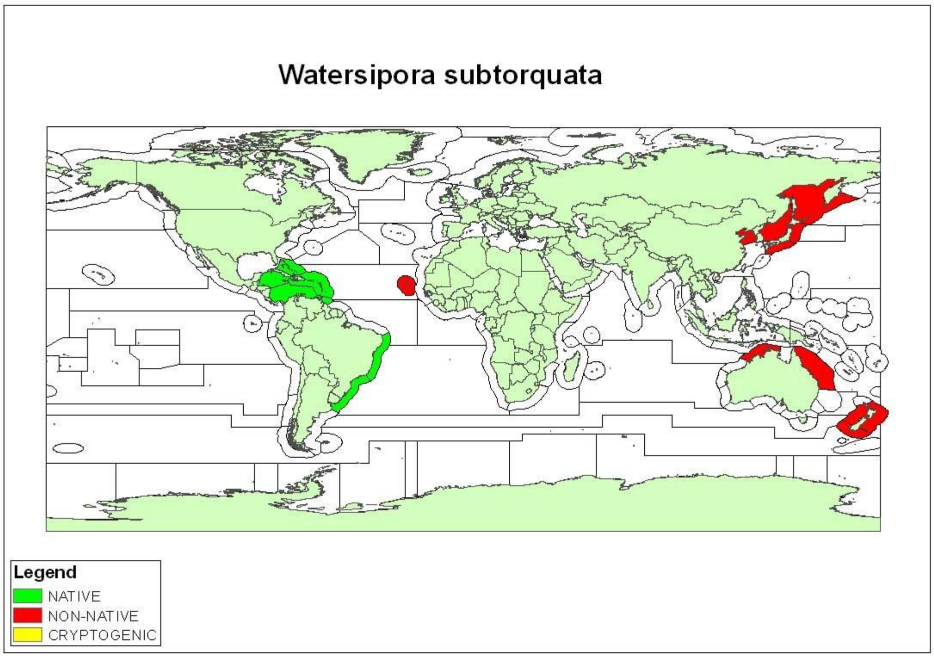

Figure 34: Global distribution of *Watersipora subtorquata*

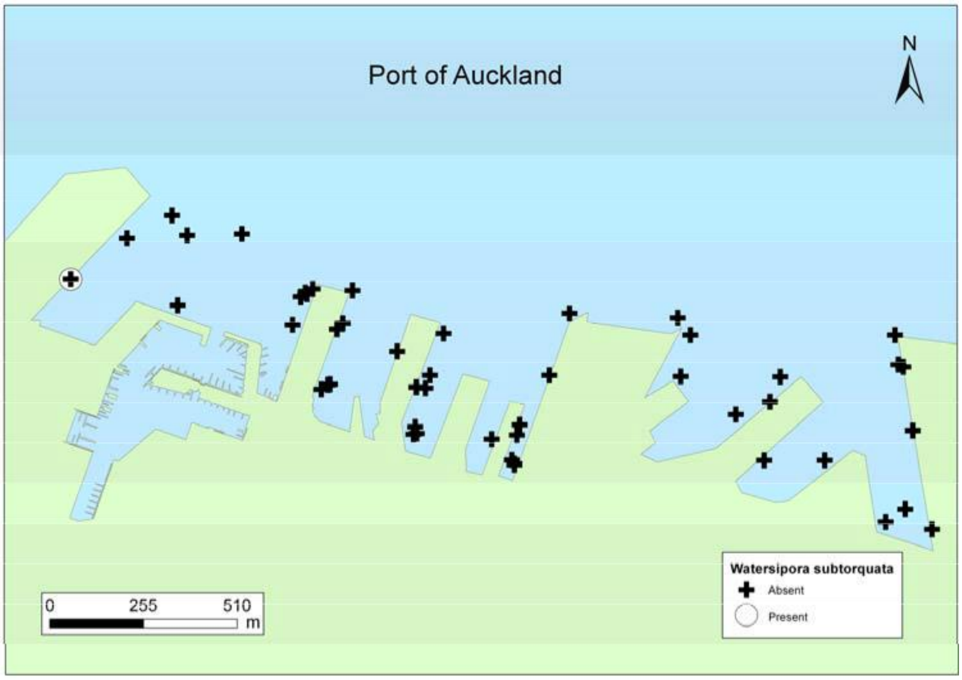

Figure 35: *Watersipora subtorquata* distribution in the resurvey of the Port of Auckland

Styela clava **(Herdman, 1881)**

Image and information: NIWA (2006)

Styela clava is a club-shaped, solitary ascidian with a leathery cylindrical body. It has two short siphons and tapers to a basal stalk, although juveniles may not be stalked. The stalk is shorter than the stalk of the similar native species *Pyura pachydermatina* (Biosecurity New Zealand 2005). Individuals of *S. clava* can grow up to 160 mm long, and are whitish-yellow, yellow-brown or reddish-brown. *S. clava* is native to the northwest Pacific (Japan, Korea, northern China and Siberia; Figure 36). It has been introduced to the eastern and western coasts of North America, Europe, and southern Australia (northern Tasmania, southern New South Wales and Victoria). *S. clava* can tolerate a wide range of salinity and temperature, and can breed in water temperatures above 15°C and salinities above 25-26 ppt (NIMPIS 2002d). It is found from low tide to at least 25 m depth and prefers sheltered waters. It settles on rocks, seaweed, shellfish and man-made structures including wharves, docks, boat hulls, mooring lines, buoys and aquaculture structures. *S. clava* is capable of rapid proliferation and can achieve very large densities of 500 to 1,500 individuals per square metre. In Canada, it has had a significant impact on mussel aquaculture through fouling of equipment, overgrowth of mussel lines and competition with mussels for nutrients.

Styela clava was not recorded during the initial baseline surveys of ports. It was first identified in New Zealand in September 2005 from specimens collected in Viaduct Harbour by a visiting scientist. Soon after (October 2005), a specimen was identified in samples of ascidians collected during the repeat baseline survey of the Port of Lyttelton in November 2004. Subsequent delimitation surveys commissioned by MAF Biosecurity New Zealand have shown that *S. clava* is widely distributed in the Hauraki Gulf and is present in Tutukaka marina (Northland) and Magazine Bay Marina in Lyttelton Harbour (Gust *et al*. 2006). Re-examination of stored ascidian specimens collected by other researchers prior to this survey confirm that it has been present in Lyttelton since at least 2002 and may have been present in the Hauraki Gulf for ten years or more. *S. clava* was recorded in the initial surveys of Viaduct Harbour and Westhaven Marina (Inglis *et al.* in press) undertaken in 2006 and the repeat surveys of Gulf Harbour Marina, Lyttelton (Inglis *et al*. 2006o) (Inglis *et al.* in press) and in this survey of Auckland (Figure 37; Table 18; Table 20).

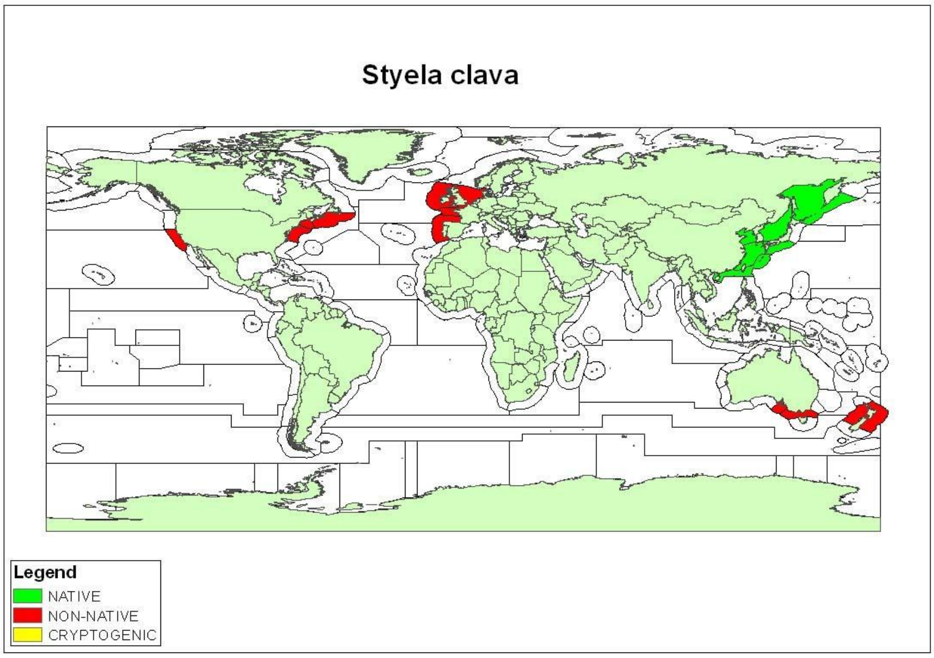

Figure 36: Global distribution of *Styela clava*

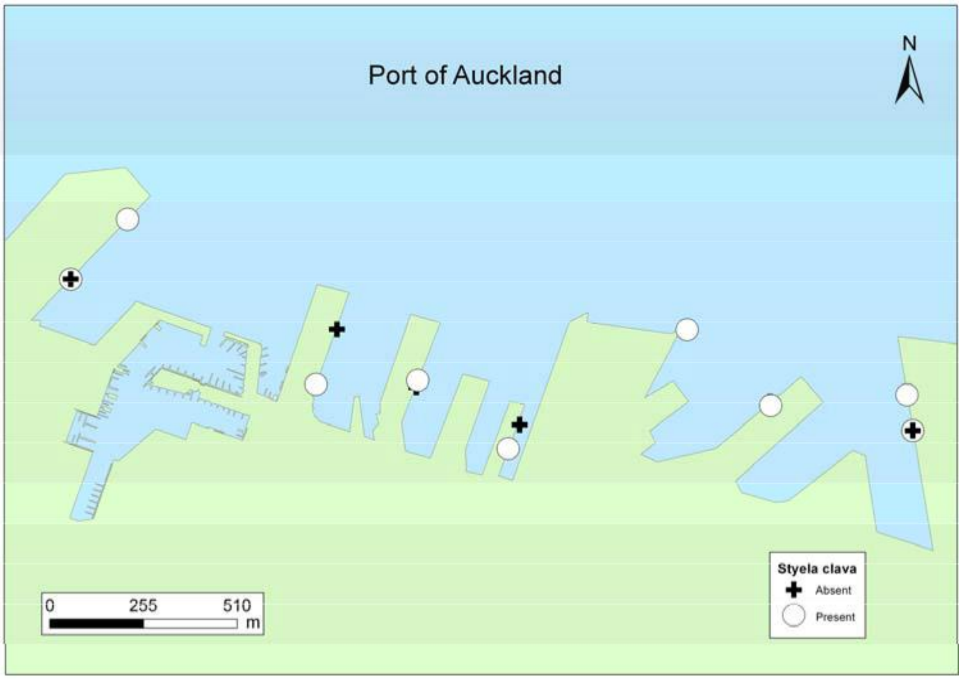

Figure 37: *Styela clava* distribution in the resurvey of the Port of Auckland

***Pennaria disticha* (Goldfuss, 1820)**

Image and information: Eldredge and Smith (2001)

Pennaria disticha is a hydroid that forms large colonies as tall as 30 cm, with dark brown to black stems and branches. The branches are usually overgrown with diatoms and algae, making them appear muddy brown. The branching is alternate. The polyps at the tip of the branches are white with a reddish tinge. *Pennaria disticha* lives attached to artificial and natural hard substrates where there is some water movement. It is a very common fouling organism in harbours and commonly found on reefs usually in more protected areas or in cracks and crevices. The native range of *P. disticha* is thought to be the north east Atlantic, but it now occurs in tropical and subtropical seas around the world (Cranfield *et al*. 1998) (Figure 38). Its impacts on native organisms are unknown.

It has been present in New Zealand since at least 1928 (Cranfield *et al*. 1998). During the initial port baseline surveys it was recorded in the Port of Auckland (Figure 39; (Inglis *et al*. 2005) and Westhaven Marina (Inglis *et al.* in press). In the second baseline surveys it was reported in Dunedin, Viaduct Harbour Marina, Bluff, the Kaikoura area and in this survey of the Port of Auckland (Inglis *et al*. in press; Figure 40; Table 18; Table 20).

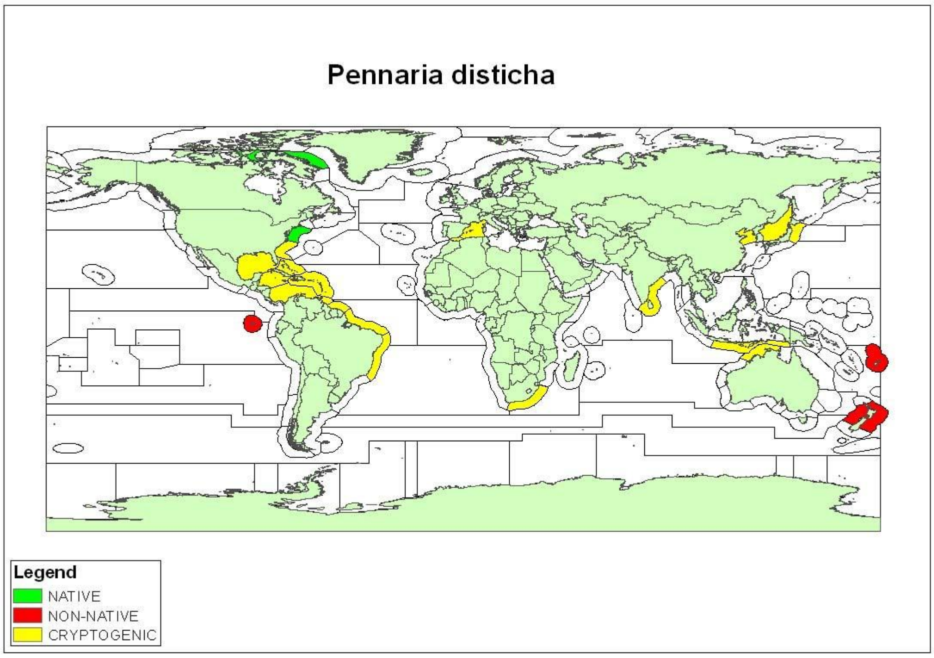

Figure 38: Global distribution of *Pennaria disticha*

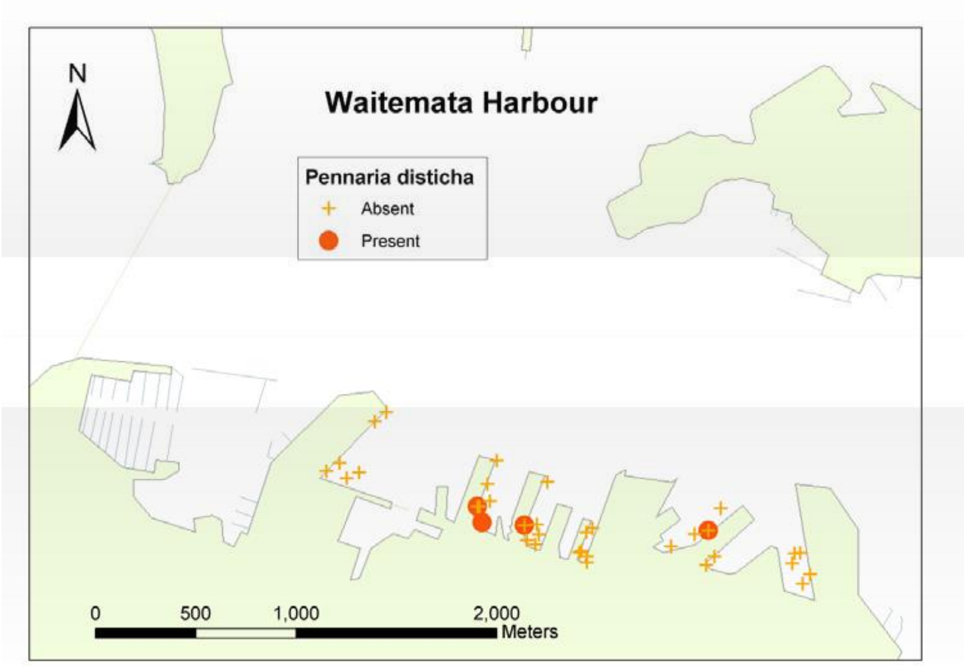

Figure 39: ***Pennaria disticha*** **distribution in the initial survey of the Port of Auckland**

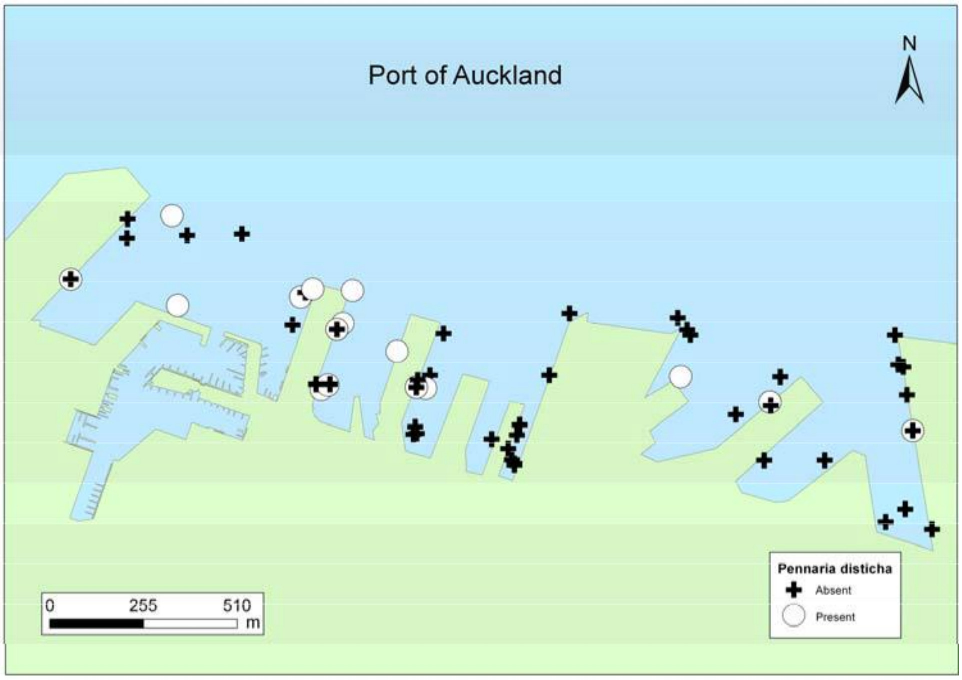

Figure 40: ***Pennaria disticha*** **distribution in the resurvey of the Port of Auckland**

Limaria orientalis (Adams & Reeve, 1850)

Image: www.femorale.com.

Limaria orientalis (file shell) is a bivalve in the family Limidae. It is known from Australia and the tropical Indo-Pacific (Figure 41). It was first recorded in New Zealand in 1972 from the Hauraki Gulf and Waitemata Harbour. It has since been recorded from the Bay of Islands and Coromandel (Cranfield *et al*. 1998), and is common in the Marlborough Sounds (Don Morrisey, NIWA, *pers. comm*.). *L. orientalis* was recorded in Gulf Harbour, Viaduct Harbour and Opua Marinas in the initial baseline surveys (Inglis *et al*. 2006b, c). It was detected in the repeat survey of Whangarei Port and this resurvey of Auckland (Figure 42, Table 18; Inglis *et al*. in press). *L. orientalis* can be a dominant member of benthic assemblages in muddy shell gravels (Hayward 1997). Its impacts in its introduced range are unknown.

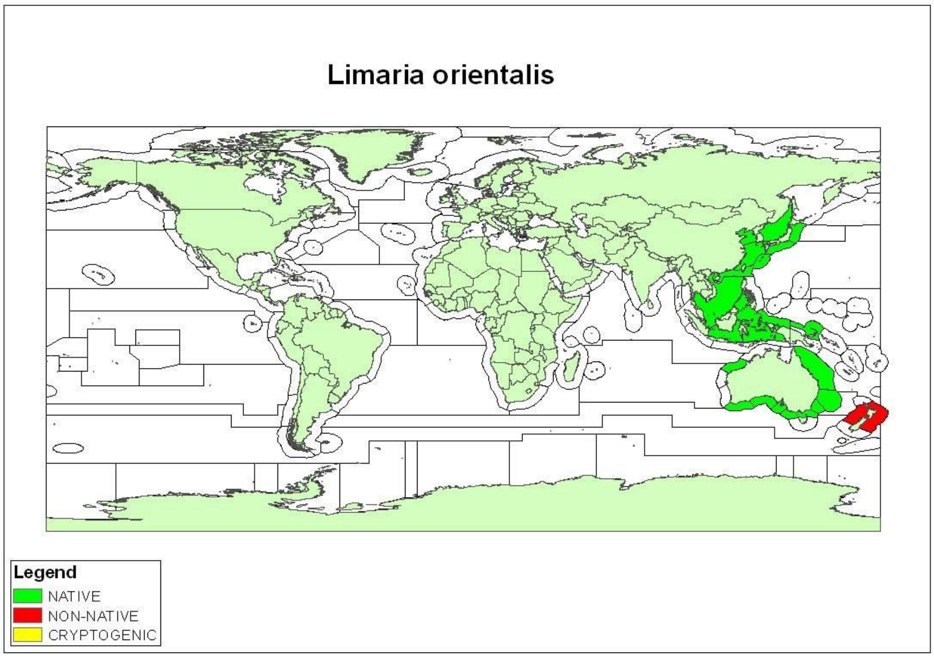

Figure 41: Global distribution of *Limaria orientalis*

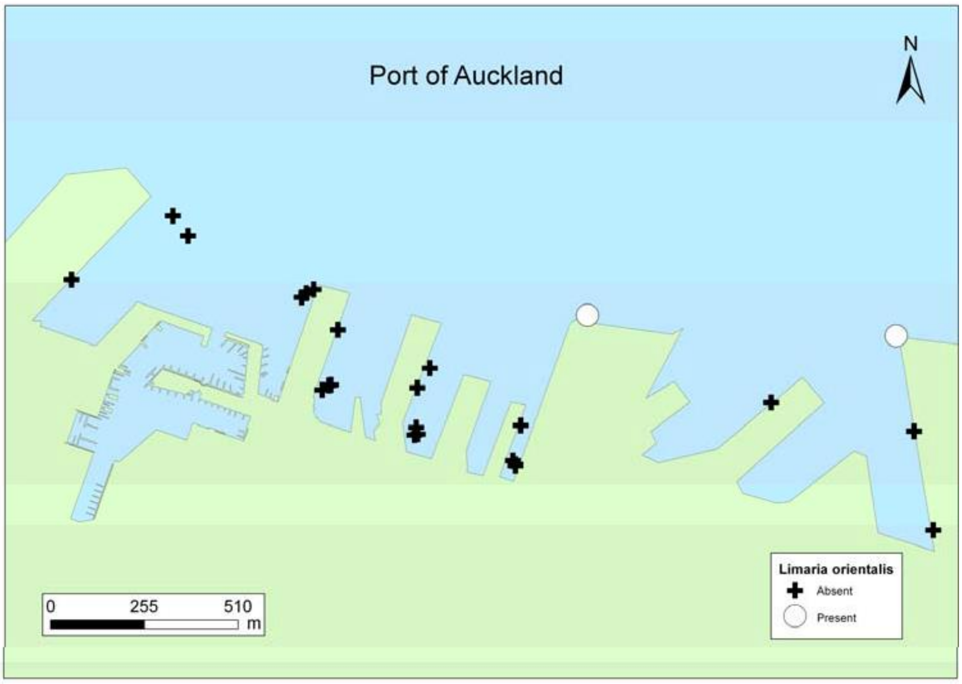

Figure 42: ***Limaria orientalis*** **distribution in the resurvey of the Port of Auckland**

***Crassostrea gigas* (Thunberg, 1793)**

Image and information: NIMPIS (2002b)

The Pacific oyster, *Crassostrea gigas*, is an important aquaculture species throughout the world, including New Zealand. It has a white elongated shell, with an average size of 150-200 mm. The two valves are solid, but unequal in size and shape. The left valve is slightly convex and the right valve is quite deep and cup shaped. One valve is usually entirely cemented to the substratum. The shells are sculpted with large, irregular, rounded, radial folds.

C. gigas is native to the Japan and China Seas and the northwest Pacific (Figure 43). It has been introduced to the west coast of both North and South America, the West African coast, the northeast Atlantic, the Mediterranean, Australia, New Zealand, Polynesia and Micronesia. It is cryptogenic in Alaska (Figure 43). *C. gigas* will attach to almost any hard surface in sheltered waters. Whilst they usually attach to rocks, the oysters can also be found in muddy or sandy areas. Oysters will also settle on adult oysters of the same or other species. They prefer sheltered waters in estuaries where they are found in the intertidal and shallow subtidal zones, to a depth of about 3 m. *C. gigas* settles in dense aggregations in the intertidal zone, resulting in the limitation of food and space available for other intertidal species.

C. gigas has been present in New Zealand since the early 1960s. Little is known about the impacts of this species in New Zealand, but it is now a dominant structural component of fouling assemblages and intertidal shorelines in northern harbours of New Zealand and the upper South Island. *C. gigas* is now the basis of New Zealand's oyster aquaculture industry, having displaced the native rock oyster, *Saccostrea glomerata*. During the initial port baseline surveys

C. gigas was recorded from the Opua and Gulf Harbour marinas, Whangarei Harbour (Whangarei Port and Town Basin marina), and the ports of Auckland, Taranaki, Nelson and Dunedin (Inglis *et al*. 2006a, d; Inglis *et al*. 2006g; Inglis *et al*. 2006i); (Inglis *et al*. 2006d). During the second baseline surveys *C. gigas* was recorded from the ports of Taranaki Nelson and Whangarei (Whangarei Port and Town Basin Marina), Opua, and Gulf Harbour Marinas (Inglis *et al*. 2006q; Inglis *et al*. 2006u), Westhaven Marina (Inglis *et al*. in press) and in this survey of the Port of Auckland (Figure 45; Table 18; Table 20).

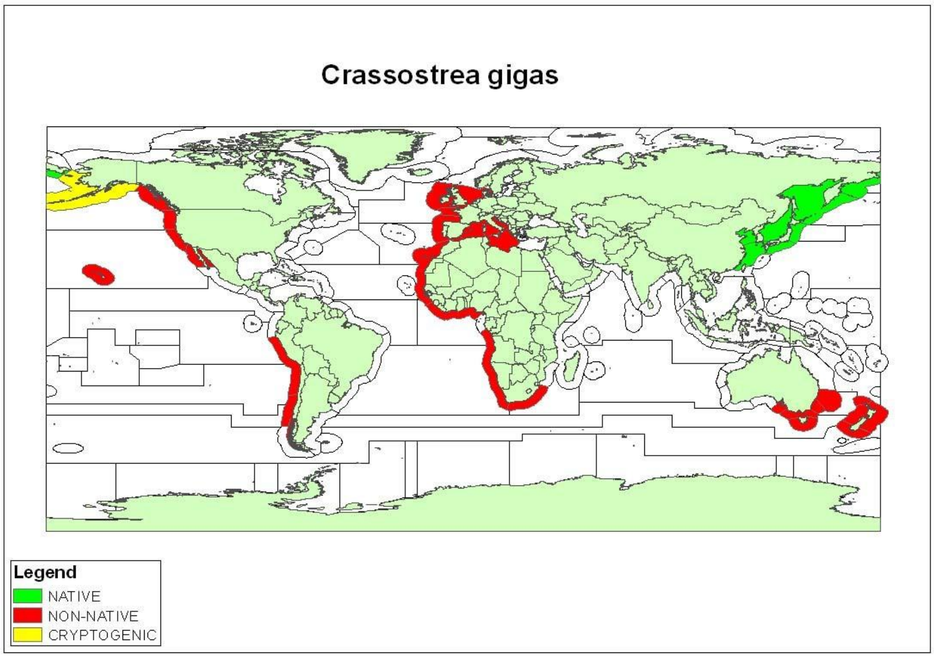

Figure 43: Global distribution of *Crassostrea gigas*

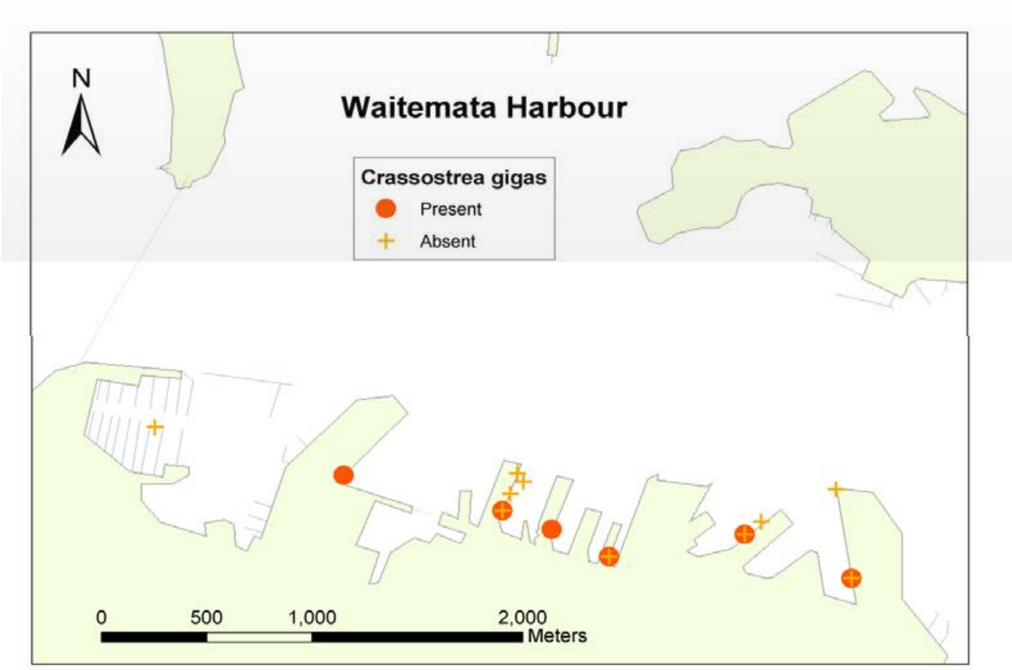

Figure 44: *Crassostrea gigas* distribution in the initial survey of the Port of Auckland

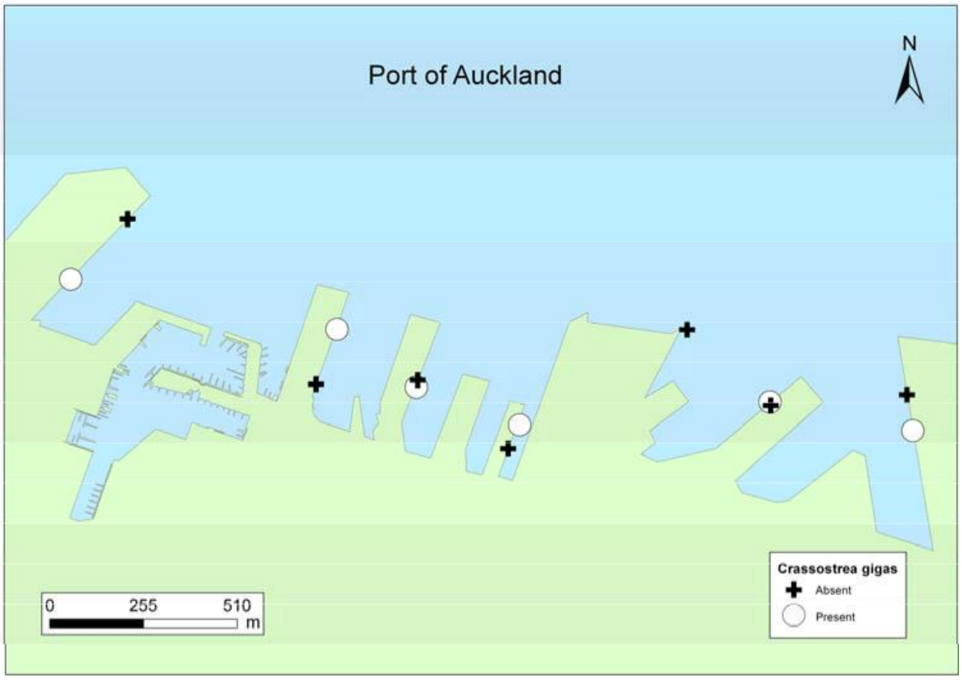

Figure 45: ***Crassostrea gigas*** **distribution in the resurvey of the Port of Auckland**

***Theora lubrica* (Gould, 1861)**

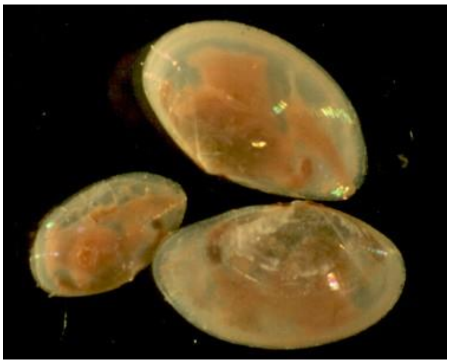

Image and information: NIMPIS (2002e)

Theora lubrica is a small bivalve with an almost transparent shell. The shell is very thin, elongated and has fine concentric ridges. *T. lubrica* grows to about 15 mm in size, and is characterised by a fine elongate rib extending obliquely across the internal surface of the shell. *T. lubrica* is native to the Japanese and China Seas. It has been introduced to the west coast of the USA, Australia and New Zealand (Figure 46). *T. lubrica* typically lives in muddy sediments from the low tide mark to 50 m, however it has been found at 100 m. In many localities, *T. lubrica* is an indicator species for eutrophic and anoxic areas. *T. lubrica* has been present in New Zealand since at least 1971 (Cranfield *et al*. 1998) (Table 18). It occurs in estuaries of the northeast coast of the North Island, including the Bay of Islands, Whangarei Harbour, Waitemata Harbour, Wellington and Pelorus Sound (Table 20).

During the initial port baseline surveys, *T. lubrica* was recorded from Whangarei port and marina, Opua, Gulf Harbour and Westhaven Marinas, and the ports of, Napier, Taranaki, Wellington, Nelson, Lyttelton and Auckland ((Inglis *et al*. 2006b, c, d; Inglis *et al*. 2006e; Inglis *et al*. 2006f; Inglis *et al*. 2006g; Inglis *et al*. 2006i, l, m, n) Figure 47, Table 20). During the second baseline surveys, *T. lubrica* was recorded from Opua Marina, Whangarei Port and Marina, Gisborne, Kaipara, Westhaven Marina, Gulf Harbour Marina, Port Underwood, Taranaki, Napier, Wellington, Picton, Nelson, Lyttelton, and in this resurvey of the Port of Auckland (Inglis *et al*. 2006o, p, q; Inglis *et al*. 2006t; Inglis *et al*. 2006u)(Inglis *et al*, in press) (Figure 48; Table 18; Table 20).

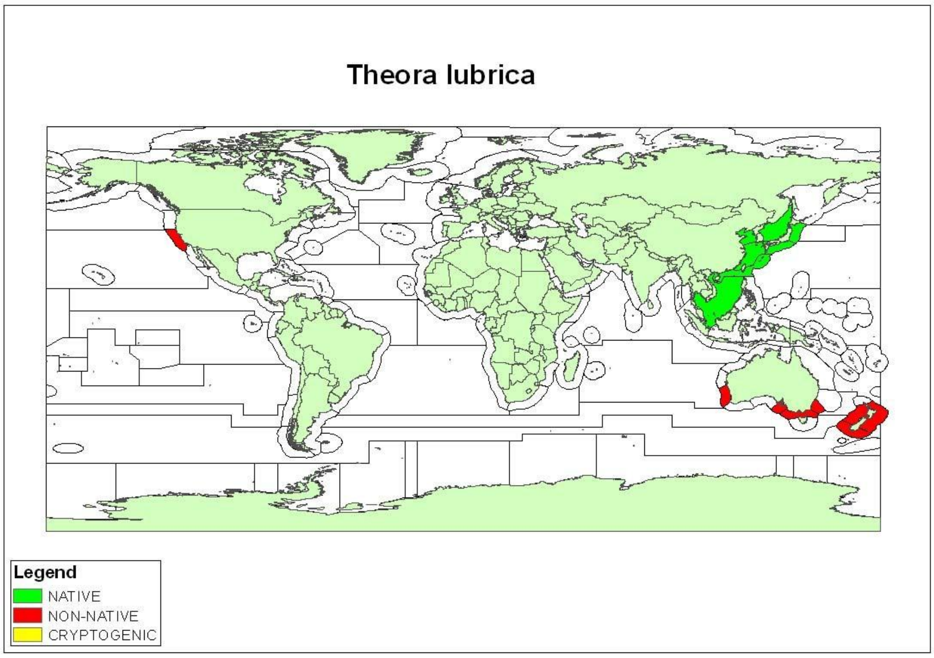

Figure 46: Global distribution of *Theora lubrica*

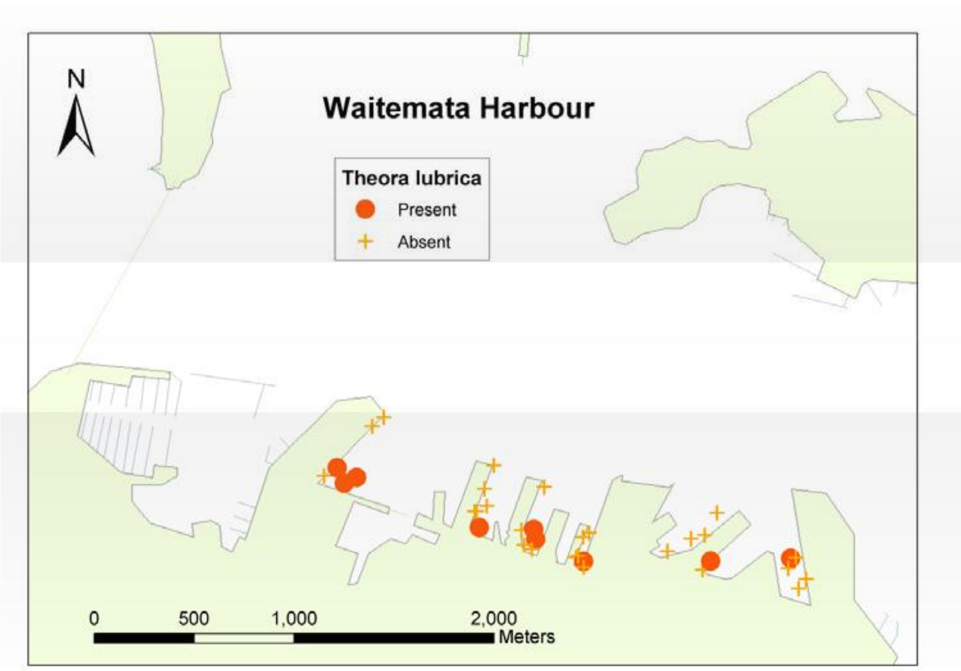

Figure 47: *Theora lubrica* distribution in the initial survey of the Port of Auckland

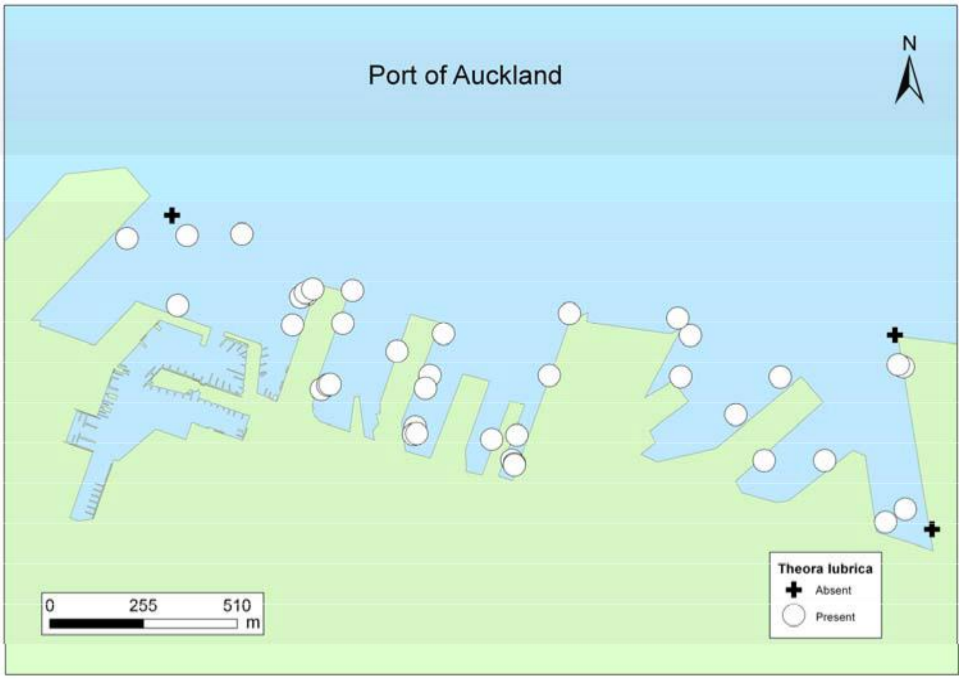

Figure 48: ***Theora lubrica*** **distribution in the resurvey of the Port of Auckland**

***Amphilectus fucorum* (Esper, 1794)**

Image: (Picton 2005)

Amphilectus fucorum is a soft textured sponge which is extremely polymorphic and fast growing and can change shape in just a few weeks. It may be encrusting as thin sheets or cushions, massive lobose, with or without tassels, or branched (Picton 2005). It is usually between 2 and 15 cm thick. The colour is often vivid yellow or orange. In deeper locations, with limited light exposure the colour is usually pale yellow or even grey (Telnes 2009). *A. fucorum* is common on the low shore and shallow sublittoral, it is seldom found in the circalittoral zone. It occurs in a wide range of habitats from extremely sheltered to extremely exposed and also under a wide range of current regimes (Picton 2005).

A common and widespread species, *A. fucorum* has been recorded from the Northeast Atlantic, Cape Verde, the Faroe Islands, Sweden, the United Kingdom, West Africa and the West Mediterranean (Van Soest 2009b).

A. fucorum was recorded as the cryptogenic category 2 taxon *Esperiopsis* new sp. 1 in the initial baseline surveys of Auckland (Figure 49), Picton, Tauranga, Taranaki and Westhaven Marina (Inglis *et al*. 2006d, Inglis *et al*. in press; 2006h, i, j). In the resurveys it was recorded as *Esperiopsis* new sp. 1 in Picton, Taranaki, Tauranga, Opua and Whangarei, and as the non-indigenous species *A. fucorum* in this resurvey of the Port of Auckland (Inglis *et al*. 2006p, q, r) (Figure 50; Table 18; Table 20).

Bioregion information for *Amphilectus fucorum* was not available at the time the report was prepared.

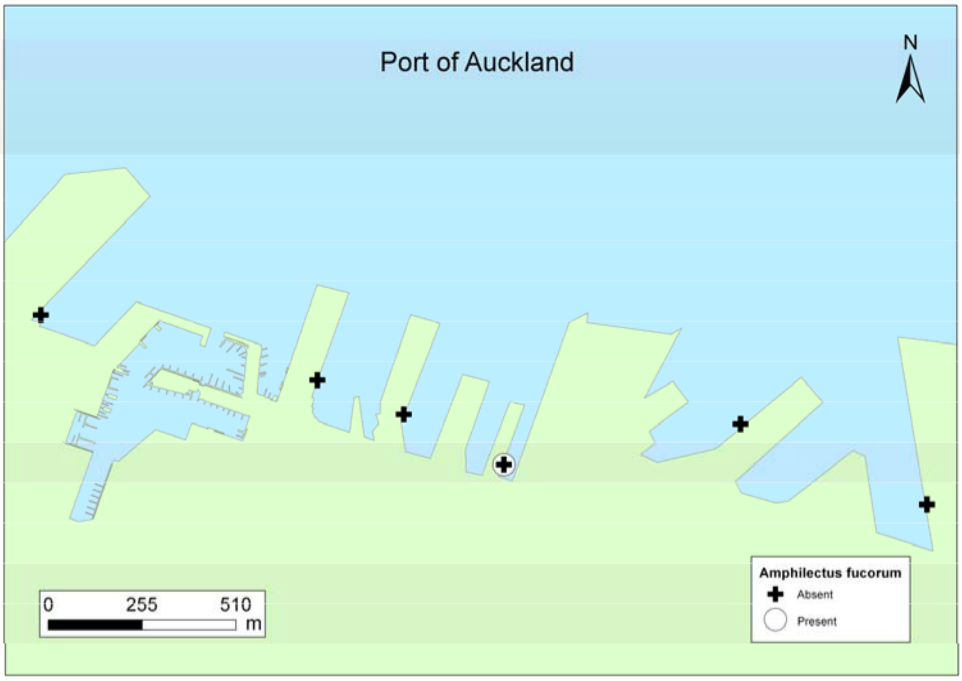

Figure 49: ***Amphilectus fucorum*** **distribution in the initial survey of the Port of Auckland**

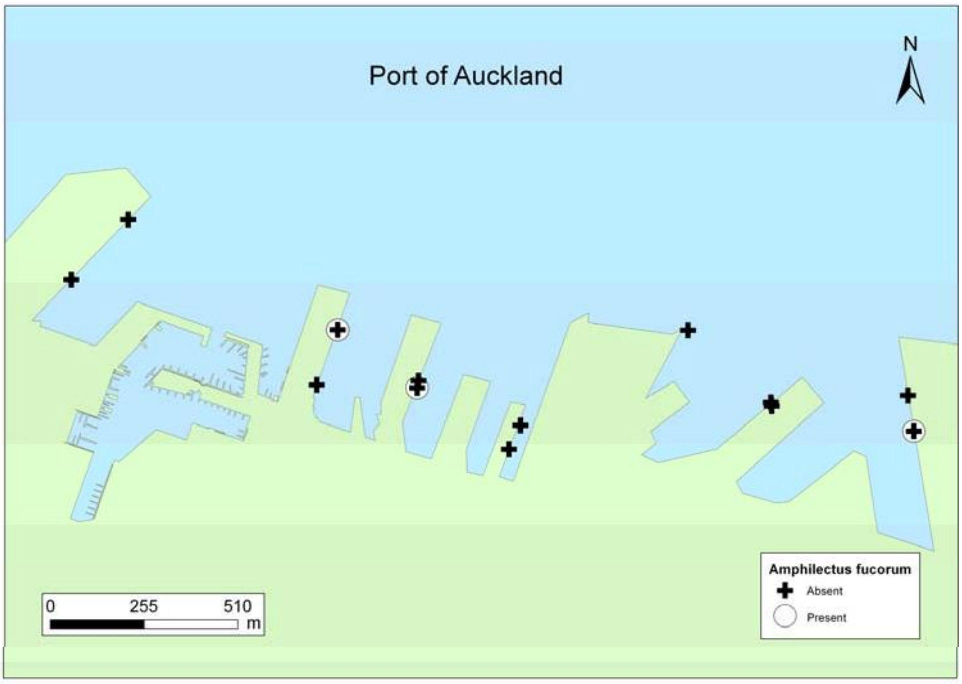

Figure 50: ***Amphilectus fucorum*** **distribution in the resurvey of the Port of Auckland**

Callyspongia robusta* (Ridley, 1884*)

No Image Available.

Callyspongia robusta is an erect, ramose sponge with thick, slightly rounded to palmate, branches (Bergquist and Warne 1980). It is fawn-to-mustard in colour and has a hard, only slightly compressible, texture. This sponge is hard to tear due to the toughness of the fibres and the surface of *C. robusta* is rough to touch due to the foreign material in the dermal membrane (Bergquist and Warne 1980).

An unusual characteristic of *C. robusta* is that the toxas are embedded in the sponge at the interstices (M. Kelly, *pers com*). This feature distinguishes it from the morphologically similar species *C. ramose* (Bergquist and Warne 1980). *C. robusta* has been recorded in water from 0-40 m below sea level: (Australian *et al.* 2008)

The type locality of *C. robusta* is Port Jackson, Australia (Ridely 1884 *cited in* (Bergquist and Warne 1980). It has also been recorded in New South Wales, Australia; Brazil and in New Zealand (Van Soest 2009a); (Australian *et al*. 2008) and Bahia (Bergquist and Warne 1980) (Figure 52). In New Zealand *C. robusta* has been previously recorded in Port Chalmers (Bergquist and Warne 1980). It is unknown how long the species has been present in New Zealand. This is the first record of *C. robusta* in the Port of Auckland and in the baseline port surveys (Table 18; Table 20).

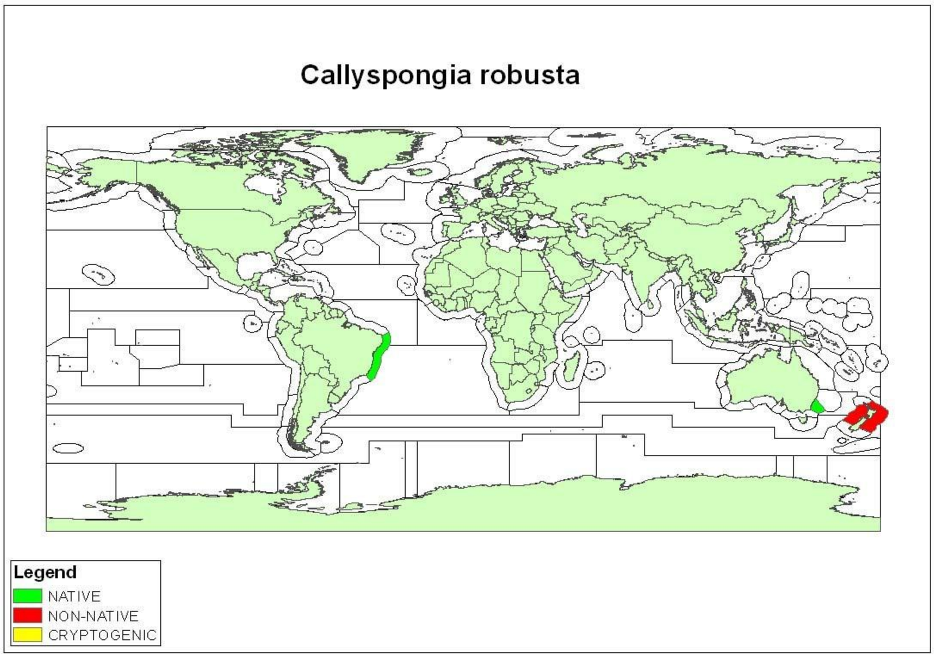

Figure 51: Global distribution of *Callyspongia robusta*

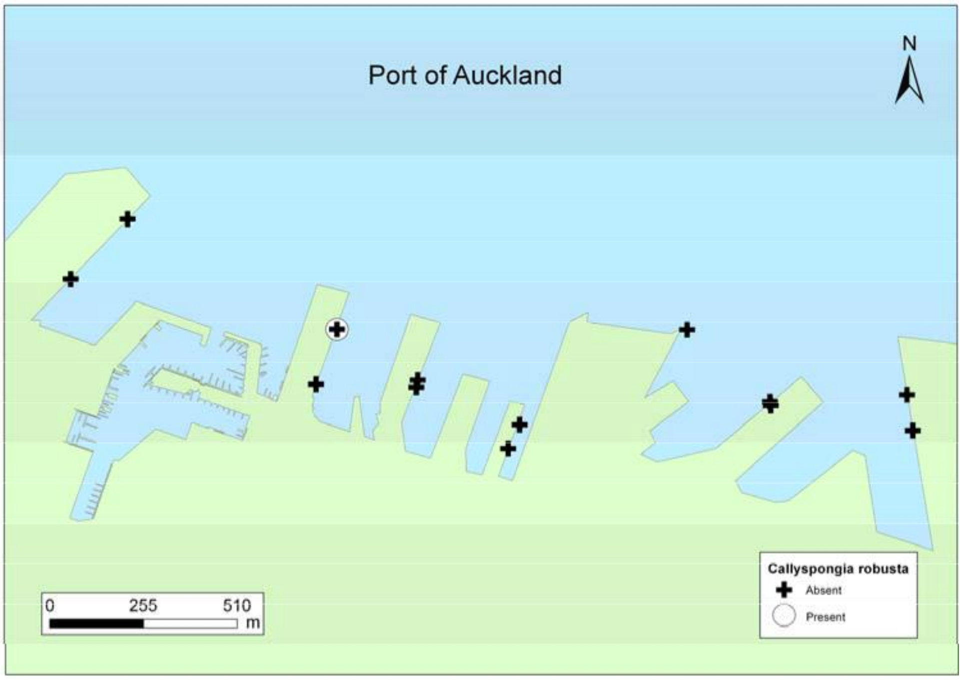

Figure 52: ***Callyspongia robusta*** **distribution in the resurvey of the Port of Auckland**

Barentsia matsushimana (Toriumi, 1951)

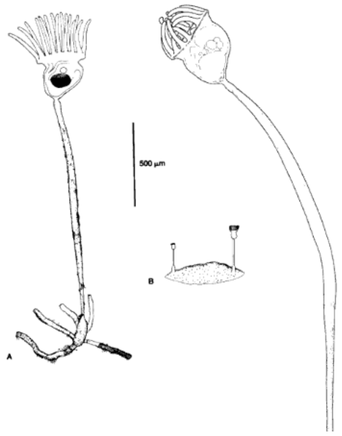

Image: (Nielsen 1989)

Barentsia matsushimana is a small, sessile, colonial entoproct which can grow to have a body of about 400 µm long and a stalk of about 4 mm. The body is about as thick as it is long and is slightly laterally compressed. The abfrontal side is strongly convex while the frontal side is almost straight. The lower part of the body tapers evenly towards the stalk. The star-cell complex comprises 11-13 cells and the cuticle is only very slightly thickened in the uppermost part of the stalk (Nielsen 1989).

Specimens of *B. matsushimana* from shallow water and harbours tend to be quite robust, while those from red algae from deeper water (10-20 m) are much more delicate. Larvae are produced in April in Japan and in June in Denmark (Nielsen 1989), but there is no imformation on the reproduction of *B. matsushimana* in New Zealand.

Colonies of *B. matsushimana* grow on various substrata including stones, shells, algae and hydroids. In shallow water they are often found between colonies of *Pedicellina,* small hydroids, and tubes of polychaetes (*Fabricia*) and amphipods (*Corophium*).

B. matsushimana has been recorded from Skagerrak, Kattegat, North Oresund, the West Baltic and Irish (Isle of Man) Seas, the west coast of the United States and Japan (Nielsen 1989) (Figure 53). *B. matsushimana* is thought to have arrived in New Zealand prior to 1995 and is established in Otago Harbour (Cranfield *et al.* 1998). It has been recorded in the resurveys of Whangarei Harbour and the Port of Auckland (Figure 54; Table 18; Inglis *et al.* in press.).

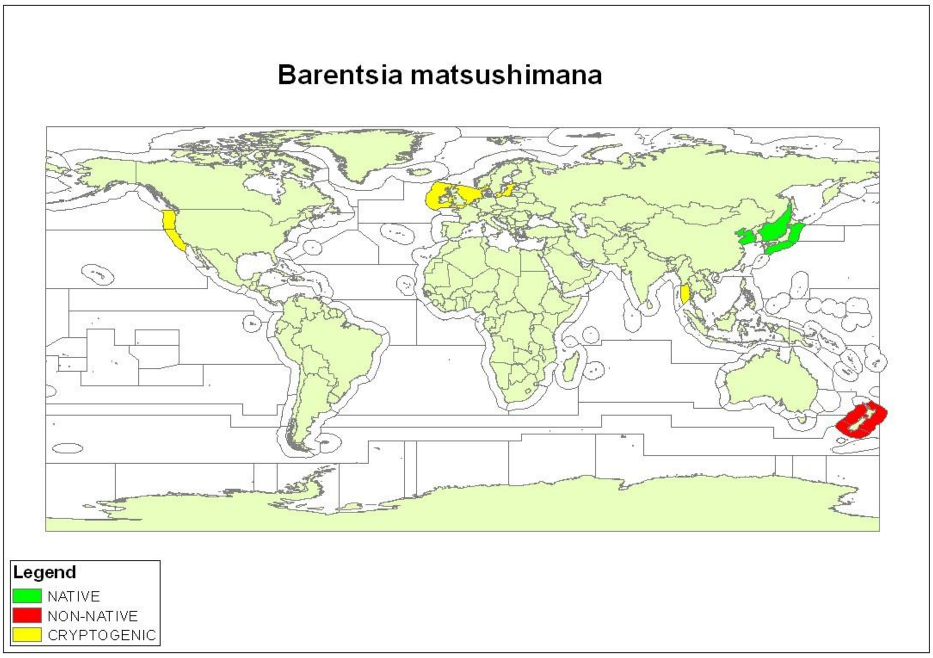

Figure 53: Global distribution of *Barentsia matsushimana*

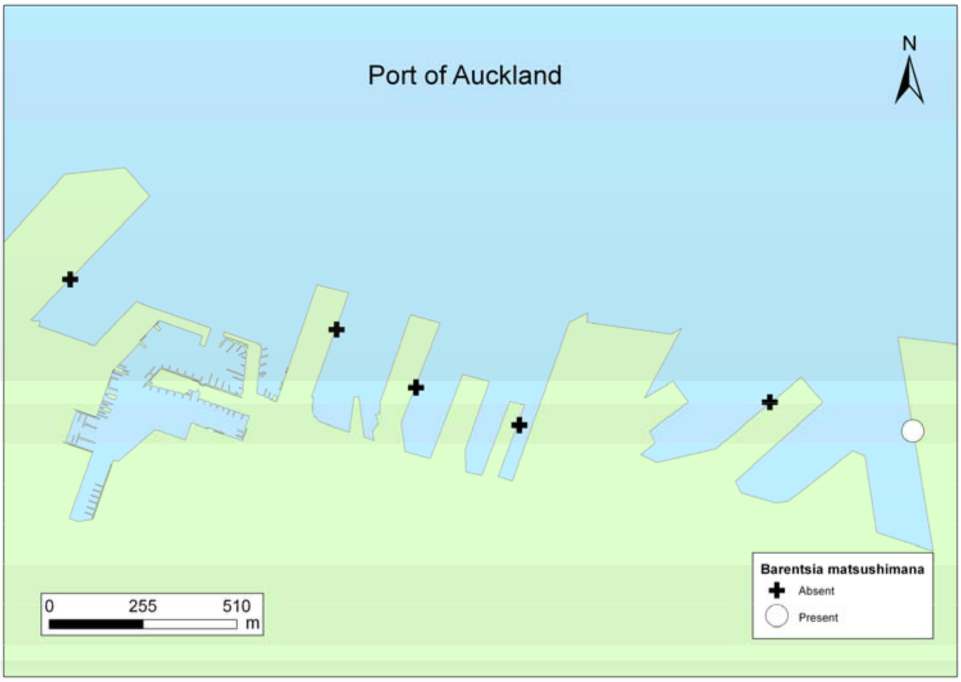

Figure 54: *Barentsia matsushimana* distribution in the resurvey of the Port of Auckland

Indeterminate taxa

There were 45 organisms from the resurvey of the Port of Auckland classified as indeterminate taxa. If each of these organisms is considered a species of unresolved identity, then together they represent 19% of all species collected from this survey (Figure 19). Indeterminate taxa from the Port of Auckland included 10 crustaceans, five red algae, four bryozoans, four fish, four cnidarians, three annelids, three molluscs, three dinoflagellates, two green alage and one ascidan, echinoderm, sponge, alga, nemertean, Platyhelminthes and Sipuncula(Table 19).

Notifiable and unwanted species

One species recorded from the Port of Auckland, the club-shaped ascidian *Styela clava*, is currently listed on the New Zealand Register of Unwanted Organisms (Table 9). Although not recorded in this survey, the Asian kelp, *Undaria pinnatifida* is also known to be present in the port and has been recorded from nearby Viaduct Harbour and Westhaven Marina (Stuart and McClary 2004).

The Australian Consultative Committee on Introduced Marine Pest Emergencies (CCIMPE) has recently endorsed a Trigger List (Table 21) of marine pest species (CCIMPE 2006). Three taxa on this list have been recorded from the Port of Auckland: the Asian paddle crab *Charybdis japonica*, *Undaria pinnatifida* and exotic invasive strains of the colonial ascidian *Didemnum* sp. *Charybdis japonica* and exotic strains of *Didemnum*, such as *Didemnum vexillum*, are not known to be present in Australia.

Australia has recently prepared an expanded list of priority marine pests that includes 53 non-indigenous species that have already established in Australia and 37 potential pests that have not yet reached its shores (Hayes *et al*. 2005a). A similar watch list for New Zealand is currently being prepared by MAF Biosecurity NZ. Eight of the 53 Australian priority domestic pests (ie. those already present in Australia) are present in the Port of Auckland. These are listed in descending order of the impact potential ranking attributed to them by Hayes *et al*. (2005a): *Gymnodinium catenatum, Crassostrea gigas, Bugula flabellata, Watersipora subtorquata, Styela clava, Theora lubrica, Bougainvillia muscus* and *Apocorophium acutum.*

One of the 37 priority international pests (i.e. those not yet in Australia) identified by Hayes *et al*. (2005a), the Asian paddle crab *Charybdis japonica* was present in the survey of Port of Auckland.

Species not previously recorded in New Zealand

No species recorded from the resurvey of the Port of Auckland are new records from New Zealand waters.

Range extensions

The occurrence of 11 species in samples from the resurvey of the Port of Auckland was highlighted by taxonomists to represent extensions to the known range of these species in New Zealand. These species are the sponges *Halichondria panicea* (C1: previously known from the Bay of Islands, Hauraki Gulf, Manukau Harbour, Mayor Island, New Plymouth, Foveaux Strait (M. Kelly, pers. comm.), Tauranga, Wellington, Lyttelton, Whangarei, Napier and Dunedin), *Lissodendoryx isodictyalis* (C1: previously known from Whangarei, Tauranga, Gisborne Clifton Beach and Waitemata Harbour), *Scopalina* new sp. 1 (C2: previously known from Whangarei), *Adocia* new sp. 2 (C2: previously known from Wellington, Picton, Nelson and Lyttelton), *Adocia* new sp. 4 (C2: previously known from Whangarei, Timaru and Bluff), *Haliclona* new sp. 3 (C2: previously known from Wellington, Tauranga, Whangarei, Opua, Timaru, Dunedin and Bluff), *Haliclona* new sp. 9 (C2: previously known from Opua Marina), *Mycale (Carnia)* new. sp. 4 (C2: previously known from Whangarei), *Paraesperella* new sp. 1 (C2: previously known from New Plymouth, Napier, Picton, Lyttelton, Dunedin and Whangarei), *Callyspongia robusta* (NIS: previously known from Port Chalmers) and the entoproct *Barentsia matsushimana* (NIS: previously known from Otago and Whangarei).

Cyst-forming species

Cysts of nine species of dinoflagellate were collected during this survey. Five of these are considered native species (Table 16), three are indeterminate (Table 19) and one is a cryptogenic category 1 taxon (Table 17). One of them - the C1 taxon *Gymnodinium catenatum*- is known to produce toxins, as described below.

Gymnodinium catenatum is the only gymnodinioid that is capable of producing PSP. Toxin profiles of different populations of *G. catenatum* show quite different toxin components. The Spanish strains tend to produce a high proportion of the low potency sulfocarbamoyl toxins, while strains in warmer waters from Singapore tend to produce highly potent carbamate gonyautoxin as dominant (GTX1 and 4), with lesser amount of GTX2, GTX3, neosaxitoxin (neoSTX) and saxitoxin (STX).

Depth stratification trends

The greatest proportion of NIS and C1 taxa occurred in samples from zero to three metres depth, despite only 23 % of samples having been collected from that depth class (Figure 55). A much larger proportion of native taxa were also recorded from this depth class compared to the sampling effort there. This was due to the large proportion of taxa – both NIS and C1 (74 %) and native (67 %) - that were recorded in pile scrapings, which were conducted mostly in the 0-5 m depth class. Only 21 % of the pile scrape samples were conducted in deeper water (at 7 m depth), yet they yielded 57 % of the NIS and C1 taxa and 45 % of the native taxa that were recorded by this method – demonstrating that the pile scraping method is an effective method for sampling many organisms.

The relative proportions of taxa recorded decreased with depth, especially beyond the depth classes where pile scrapings were conducted (Figure 55). Samples taken from the lower depth classes (>5-10 m, >10-15 m and >15-20) were mostly taken using benthic sleds, benthic grabs, and crab, fish and starfish traps. This decrease in abundance with lower depths reflects the high proportion of NIS and C1 taxa recorded during the survey that were fouling organisms and which were sampled from pile scrapes of wharf structures at ≤ 7 m depth.

Of the 31 NIS and C1 taxa for which depths were recorded, 23 (70 %) were collected at 0-5 m depth (Figure 55). Eight of these 23 taxa were not recorded from deeper samples; these were the annelids *Hydroides elegans* and *Neodexiospira pseudocorrugata*, the ascidians *Microcosmus australis* and *Styela clava* the bryozoan *Watersipora subtorquata*, the sponges *Plakina monolopha* and *Pseudosuberites sulcatus* and the entoproct *Barentsia matsushimana*. These were all collected in pile scrape samples (* Species on Interim CCIMPE Trigger List; Table 21). Eight taxa were not collected in samples from 0-5 m depth, these were the annelids *Heteromastus filiformis* and *Paralepidonotus ampulliferus,* the ascidian *Diplosoma listerianum*, the molluscs *Theora lubrica* and *Limaria orientalis* and the sponges *Ciocalypta pencillus*, *Ciocalypta polymastia* and *Halichondria panacea*. These were collected in benthic sled, benthic grab, pile scrape and starfish trap samples.

Native taxa were recorded from each depth class, ranging from eight native taxa at >15-20 m depth, to 96 taxa at >0-5 m depth (Table 23). A large proportion of the native taxa were recorded in each of the top three depth classes (67 % in 0-5 m, 44 % in >5-10 m and 38 % in >10-15 m depth), but the range of taxa varied between depth classes. Of the 143 native taxa for which depths were recorded, 47 (33 %) were recorded from only the 0-5 m depth class, 10 (7 %) were recorded only from the >5-10 m depth class, 25 (17 %) were recorded only from the >10-15 m depth class and one (0.7 %) was recorded only from the >15-20 m depth. The variation of taxa recorded from different depth classes highlights the importance of sampling a range of depths in order to gain as complete an inventory of organisms as possible.

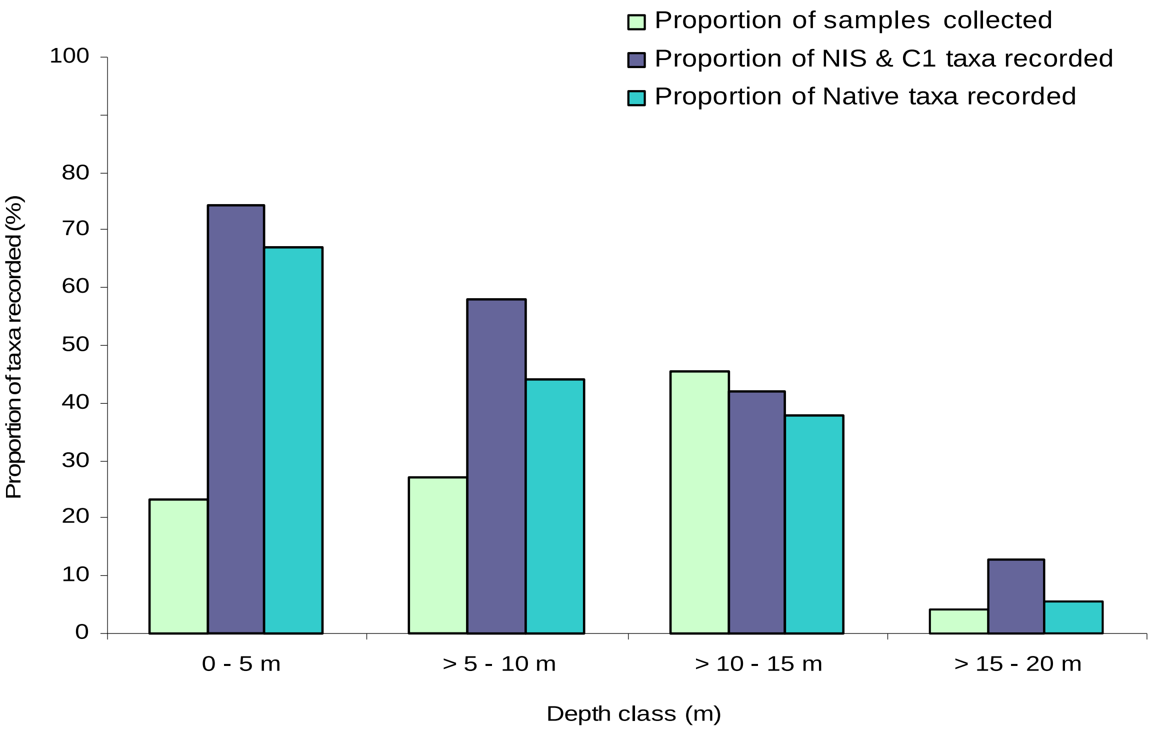

Figure 55: Proportion of taxa recorded from four depth classes during the second survey of the Port of Auckland. The proportion of taxa sums to a total of >100% across depth classes, as some taxa were recorded from more than one depth class.

COMPARISON OF RESULTS FROM THE INITIAL AND REPEAT BASELINE SURVEYS OF THE PORT OF AUCKLAND

Pile scrape samples

Native species

Rarefaction curves and estimates of total species richness in pile scrape samples taken from the two baseline surveys of the Port of Auckland are presented in Figure 56.

A greater number of species were recorded in the second survey (96) compared to the first survey (88), even though slightly fewer samples taken (Table 24). Curves for the native species assemblage were concordant in each survey, with very similar rates of species accumulation relative to sampling effort. In each case, the observed richness increased steadily as more samples were taken and did not approach an asymptote (Figure 56).

Estimates of total species richness in each survey also continued to increase with sample size and did not plateau or converge with observed richness (Figure 56), indicating a high proportion of unsampled species in the assemblages. Indeed, as sample size increased, more unique species (i.e. those that occurred in only one sample) were added to the survey. These 'rare' species comprised large proportions of the sampled assemblage. Thirty-nine percent and 33 % of the native species observed in each survey, respectively, occurred in just a single sample (Table 24). The large number of uniques had a strong influence on the estimated number of unsampled species in the assemblage, which varied between 60 % in the first survey (i.e. 53 unsampled species out of 88 observed) and 53 % in the resurvey (i.e. 51 unsampled species of 96 observed; Figure 56).

Despite the correspondence between the observed rarefaction curves for the two surveys, the species composition of the assemblages in each survey was quite different. Only 54 species (42 % of the total number) were recorded in both surveys (Table 24). Again, this reflects the large number of comparatively rare species in the assemblage, with non-detection of many of these probably accounting for much of the difference observed between the two surveys. For example, the classic Jaccard and Sorenson measures of compositional similarity indicate low similarity between the assemblages recorded in the initial and repeat baseline surveys of Auckland (0.415 and 0.587, respectively). In contrast, the new Chao similarity indices, which adjust for the effects of non-detection of rare species, suggest much closer resemblance of the two samples (Chao bias-adjusted Jaccard = 0.766; Chao bias-adjusted Sorenson = 0.868; (Table 24).

Cryptogenic category 2 taxa

A greater number of cryptogenic category 2 taxa were recorded in the resurvey of the Port of Auckland (14 taxa) than the initial baseline survey (ten taxa; Table 24). The observed species density in the initial survey appeared to have plateaued above 60 samples and, by 90 quadrat samples, was at the estimated total richness of 10 taxa (Chao 2 Bias-corrected formula; Figure 56This suggested a relatively complete inventory of this group with a small proportion of uniques (20 %) and, therefore, few undetected taxa (Table 24).

Similarly the estimated taxa density in the second survey appeared to have plateaued above 45 quadrat samples. By 86 samples the observed richness was approaching was approaching the estimated richness of 15 taxa (Figure 56). The modest difference between the observed and estimated richness (one species) suggested a relatively complete inventory of this group with again a small proportion of uniques (29 %; Table 24) and therefore few undetected taxa.

Seven taxa (forty-one percent of the total number) were shared between the two surveys (Table 24). The similarity indices show a moderately close resemblance between the two assemblages, once adjustment has been made for undetected taxa (Chao bias-adjusted Jaccard = 0.764; Chao bias-adjusted Sorenson = 0.866; Table 24).

Non-indigenous and cryptogenic category 1 species

Curves for the non-indigenous and cryptogenic category 1 species assemblage were concordant in each survey (Figure 56). Both surveys recorded a total of 23 species and showed low rates of species accumulation relative to sampling effort (Figure 56). In comparison, the estimated species richness, in both surveys, was high and, failed to converge with the observed richness, suggesting an incomplete inventory of these groups. The estimated richness (Chao-2 Classic formula) in the initial survey varied around 43 species for the last 20 quadrat samples, but did not stabilized and reach an asymptote (Figure 56). Estimated richness in the repeat survey reached a plateau after 55 quadrat samples at ~40 species (Table 24). The large difference between observed and estimated richness suggests that both the initial and second survey assemblages comprised of a high proportion of unsampled species and a number of 'rare' species. Indeed, as sample size increased, more unique species (i.e. those that occurred in only one sample) were added to the survey. Thirty-eight percent and 39 % of the native species observed in each survey, respectively, occurred in just a single sample (Table 24).

Forty-eight percent of species recorded were common to both resurveys (Table 24). Once adjustment for the effects of non detection of rare species had been made the similarity indices suggest a close resemblance between surveys (Chao bias-adjusted Jaccard = 0.854; Chao bias-adjusted Sorenson = 0.921; Table 24).

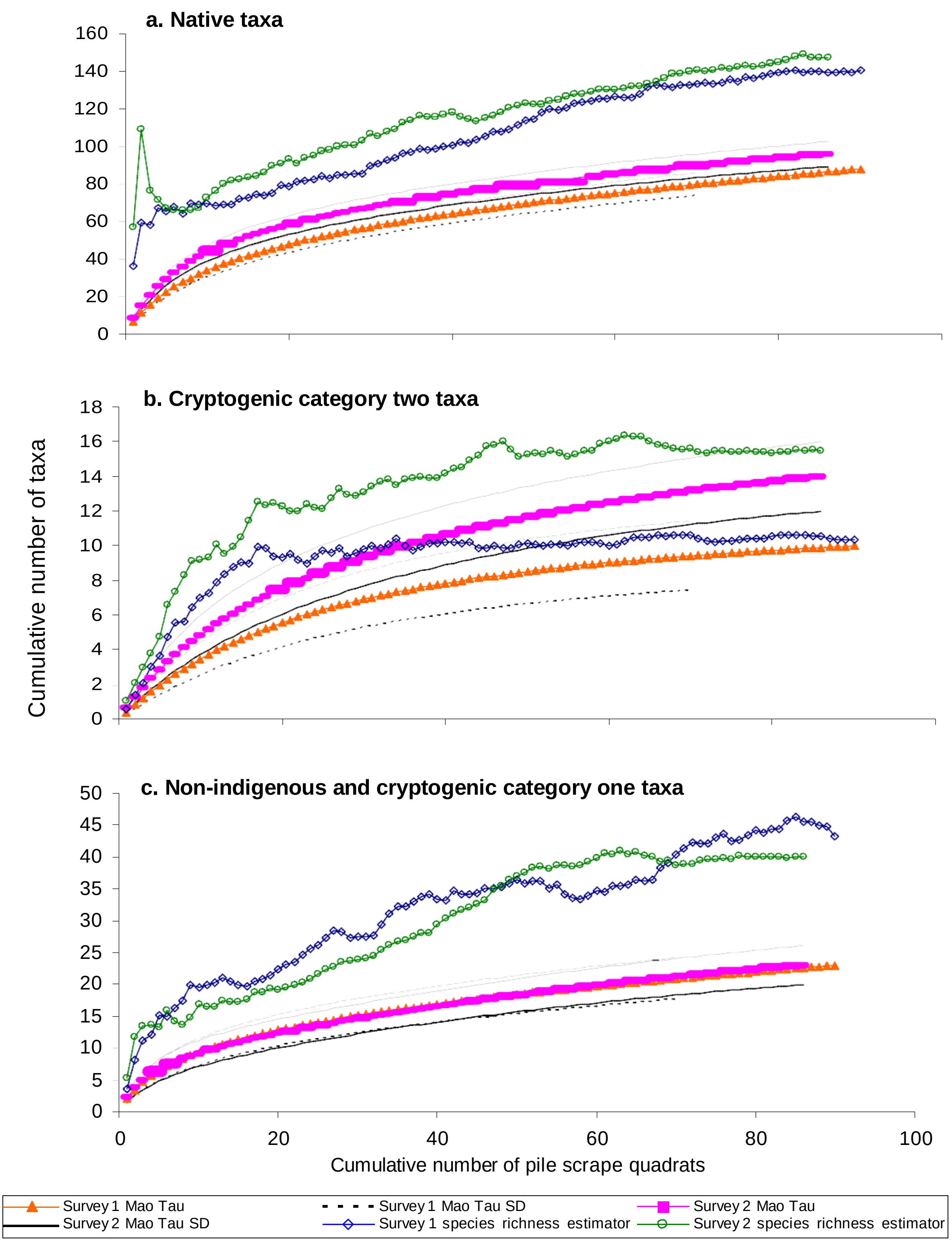

Figure 56: Mean (± 1 standard deviation (SD)) rarefaction curves (Mao Tau) for native (a), cryptogenic category two (b) and non-indigenous and cryptogenic category one (c) taxa collected from pile scrape quadrats for the first survey (full triangles, ± SD (dashed lines)) and second survey (full squares, ± SD (solid lines)). Species richness estimators are also shown for the first survey (empty diamonds) and second survey (empty circles); the ICE formula was used for NIS and C1 taxa in the second survey, the Chao 2 bias-corrected formula was used for cryptogenic category 2 taxa in both the first and second surveys and the Chao 2 Classic formula was used in all other instances.

Benthic sled samples

Native species

Survey effort for the benthic sled samples was increased by 60 % in the repeat baseline survey in an attempt to improve description of the epibenthic fauna of the port (Table 24). The observed total richness of native species was less in the initial baseline survey (18 species) than in the repeat survey (37 species; Figure 57).

In the initial survey, samples taken using this method were dominated by uniques (67 % of species; Table 24), resulting in a comparatively large and unstable estimate of total species richness (Figure 57). The observed and estimated richness curves failed to converge, suggesting an incomplete inventory of this group.

Despite the increased sample effort in the second survey the trajectory of the rarefaction curve was relatively flat (Figure 57), indicating slow accumulation of species with additional samples. The estimated curve also failed to converge with observed richness curve (Figure 57). The estimated richness in the second survey appeared to have stabilised at 70 species and, at the rate indicated in Figure 57, a further 27 samples would be needed to capture the estimated species richness of the assemblage (ICE estimate = 70 species). Again, a high proportion of species recorded in the second survey were uniques (51 %; Table 24). Only 11 of the 44 species (25 %) were recorded in both surveys, with moderate similarity between the two samples (Chao bias-adjusted Jaccard = 0.667; Chao bias-adjusted Sorenson = 0.801; Table 24).

Cryptogenic category 2 taxa

Too few taxa were recorded in this category for quantitative comparison of the two baseline surveys. Each survey only recovered one cryptogenic category 2 taxa from the benthic sled samples (Table 24).

Non-indigenous and cryptogenic category 1 species

Too few species were recorded in this category during the initial survey to allow quantitative comparison of the two baseline surveys and meaningful species accumulation curves to be calculated. Only seven non-indigenous and cryptogenic category 1 species were recorded in the initial survey (Table 24).

Eight NIS and Cryptogenic category 1 species were recorded in the second survey. The observed richness curve for this group was flat compared to the steep, high and unstable estimated richness curve (Figure 57). The two curves failed to converge (Figure 57) suggesting an incomplete inventory of this group and that a number of undetected species were present in the assemblage. This is probably due to the high proportion of uniques. Seventy-five percent of all species recorded were uniques (Table 24), it is therefore likely that as more samples were taken, a greater number of uniques would be recorded.

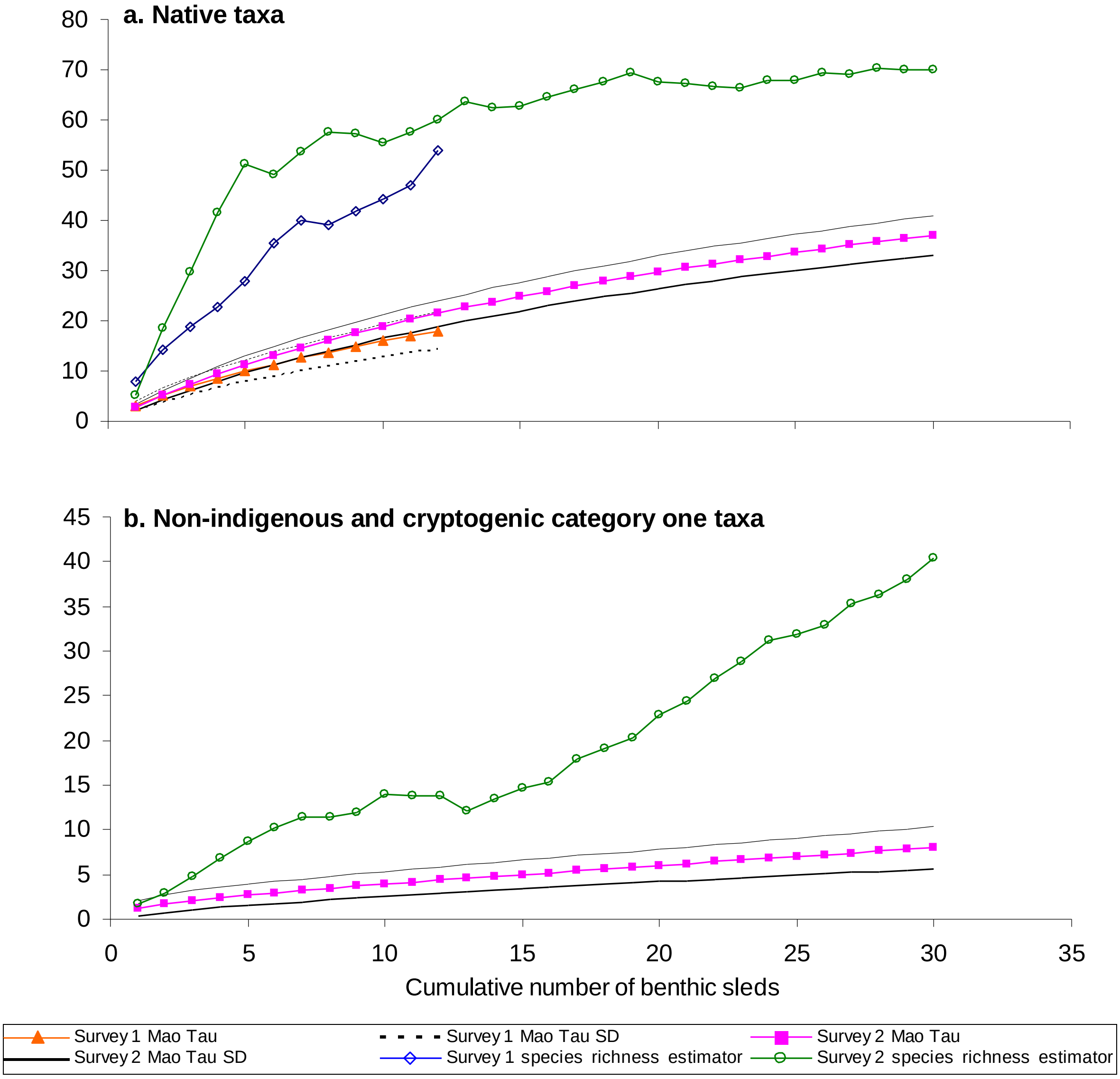

Figure 57: Mean (± 1 standard deviation (SD)) rarefaction curves (Mao Tau) for native (a) and non-indigenous (NIS) and cryptogenic category one (b) taxa combined collected in benthic sled tows for the first survey (full triangles, ± SD (dashed lines)) and second survey (full squares, ± SD (solid lines)). There were too few NIS and cryptogenic category 1 taxa recorded in the initial survey, and cryptogenic category two taxa encountered in both surveys, for a meaningful analysis of this group. Species richness estimators are also shown for the first survey (empty diamonds) and second survey (empty circles); the Chao 2 classic formula was used for cryptogenic category 2 taxa in the first survey. The ICE formula was used in both other instances.

Benthic grab samples

Native species

Sampling effort was increased from 18 benthic grabs, in the initial survey, to 30 benthic grabs in the second survey, in an attempt to improve the description of the epibenthic fauna of the port (Table 24). A larger number of species was recorded in the second survey (15) compared to the initial survey (8, Table 24). The trajectory of the observed richness curves for both the initial and second surveys were relatively flat (Figure 58). The estimated richness for the initial survey plateaued and began to converge with the observed richness by 18 benthic grabs samples. This small difference (two species), suggests a relatively complete inventory of this group. The estimated richness curve in the second survey, however, increased steeply and, although it plateaued after 10 benthic grabs, was much higher at 26 species (ICE estimate) than the observed richness (Figure 58). The large difference suggests an incomplete inventory in the second survey. At the rate indicated in Figure 58, a further 22 benthic grabs would need to be taken to reach the estimated richness. Both assemblages contained a high proportion of uniques (initial survey = 63 %, second survey = 47 %; Table 24), suggesting many patchily distributed, 'rare' species, a typical feature of many marine communities.

The species overlap between the two surveys was low; only four of the 19 species recorded were recorded in both the initial and second survey (Table 24). This is reiterated by the low similarity indices (Chao bias-adjusted Jaccard = 0.251; Chao bias-adjusted Sorenson = 0.402; Table 24).

Cryptogenic category 2 taxa

Samples taken with the benthic grab did not contain any cryptogenic category 2 species in either survey (Figure 58).

Non-indigenous and cryptogenic category 1 species

Only one non-indigenous species was recorded in benthic grabs samples taken in the initial survey of the Port of Auckland (Table 24). Therefore, rarefaction curves and similarity indices could not be calculated for this group.

The second survey recorded eight NIS and cryptogenic category 1 species (Table 24). The observed richness curve increased throughout all samples and the estimated richness, although began to plateau after 23 benthic grabs, remained higher than the observed richness at 11 species (Chao-2 Bias corrected mean; Figure 58). The estimated and observed curves failed to converge (Figure 58) suggesting an incomplete inventory of this group and a number of unsampled species present in the assemblage. Indeed, 50 % of species recorded were uniques (Table 24).

At the rate indicated in Figure 58, a further 10 benthic grabs would be needed to reach the estimated richness.

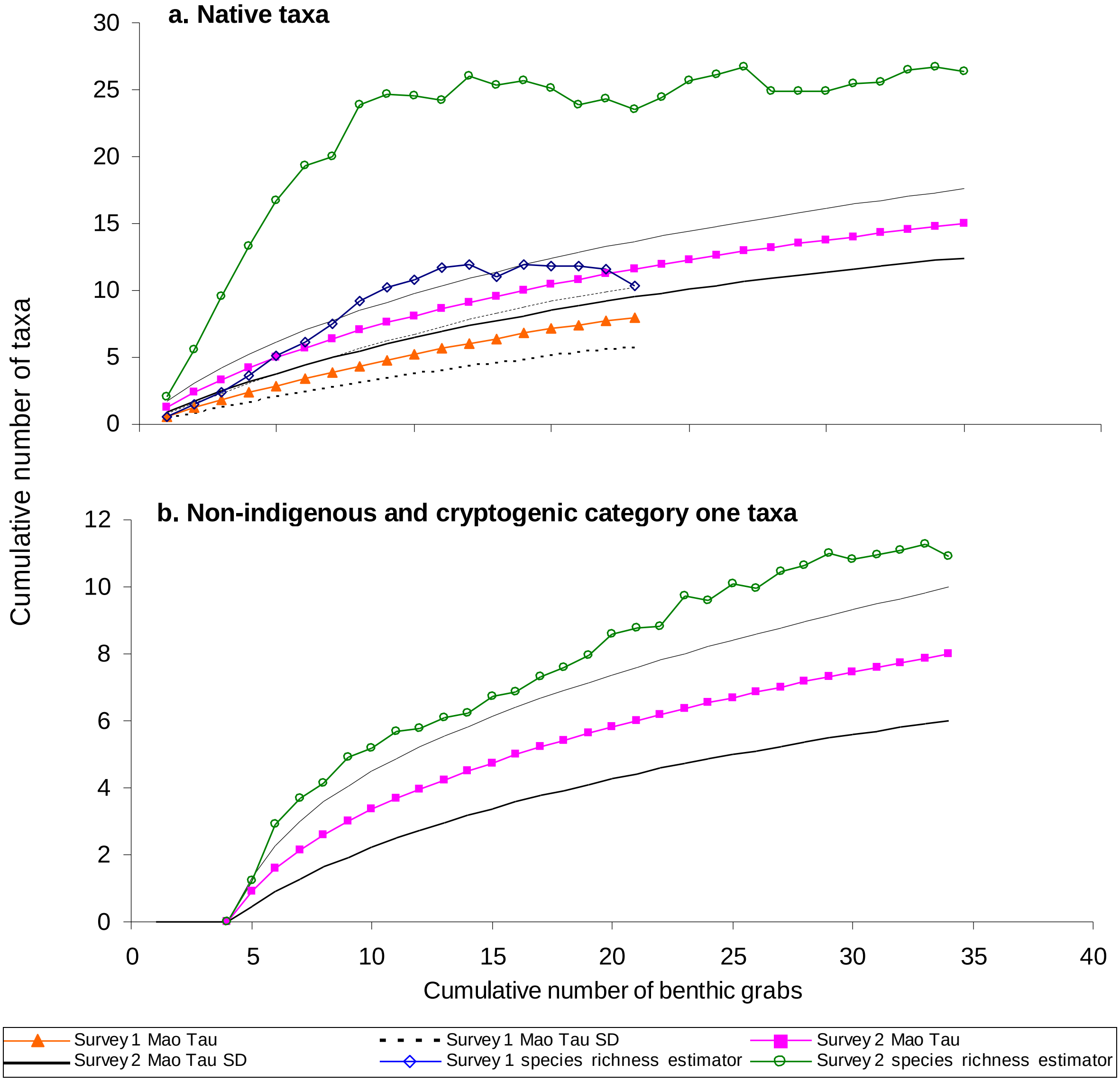

Figure 58: Mean (± 1 standard deviation (SD)) rarefaction curves (Mao Tau) for native (a) and non-indigenous and cryptogenic category one (b) taxa combined collected in benthic grabs for the first survey (full triangles, ± SD (dashed lines)) and second survey (full squares, ± SD (solid lines)). There were too few cryptogenic category two taxa in both surveys and NIS, and C1 taxa encountered in the first survey, for a meaningful analysis of these groups. Species richness estimators are also shown for the first survey (empty diamonds, (second survey only)) and second survey (empty circles); the ICE formula was used for native taxa in the second survey. The Chao-2 biased-corrected formula was used in all other instances.

Crab trap samples

Samples obtained using baited crab traps were characterised by relatively few species. This was a feature of all of the passive trapping techniques (see below). In total, 11 species were sampled using the crab traps, over both surveys (Table 24). Most of these were recorded in the second survey (10 of 11 species). The initial survey only recovered five taxa in total and therefore similarity curves and indices were not calculated for this group.

The slope of the observed richness curve was relatively flat, and did not converge with estimated richness (Figure 59), suggesting an incomplete inventory of this group. The estimated richness curve reached an asymptote around 13 taxa (ICE estimate; Figure 59). At the rate indicated in Figure 59 another seven crab traps would be needed to reach the estimated richness of 13 taxa (ICE estimate). One third of species collected were uniques (Table 24).

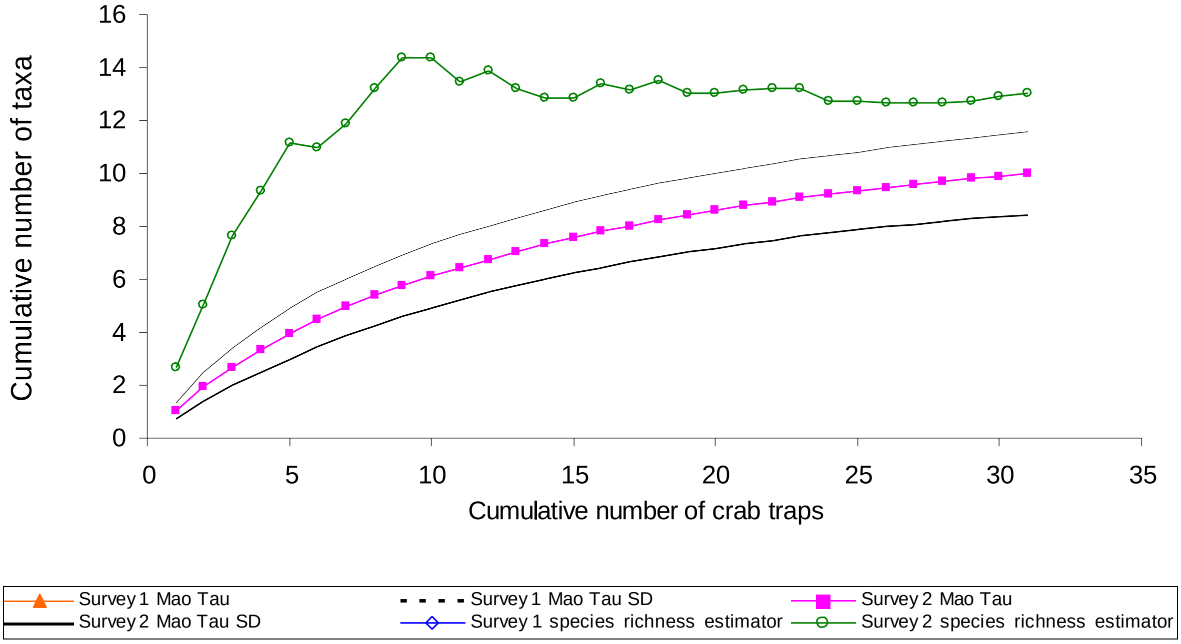

Figure 59: Mean (± 1 standard deviation (SD)) rarefaction curves (Mao Tau) for native, cryptogenic and non-indigenous taxa combined collected in crab traps for the second survey (full squares, ± SD (solid lines)). Too few taxa were encountered in the first survey for a meaningful analysis of this group. Species richness estimators are also shown for the second survey (empty circles, ICE formula).

POSSIBLE VECTORS FOR THE INTRODUCTION OF NON-INDIGENOUS SPECIES TO THE PORT

The non-indigenous species located in the Port of Auckland are thought to have arrived in New Zealand mostly via international shipping. They may have reached the Port of Auckland directly from overseas or through domestic spread (natural and/or anthropogenic) from other New Zealand ports. Table 18 indicates the possible vectors for the introduction of each NIS recorded from the Port of Auckland during the baseline port surveys. Likely vectors of introduction are largely derived from Cranfield *et al*. (1998) and expert opinion. They suggest that only two of the 19 NIS (10 %) probably arrived via ballast water, nine species (47 %) were most likely to be associated with biofouling, seven species (36 %) could have arrived via either ballast water or biofouling and the vectors of introduction for two species (10 %) are currently unknown.

Assessment of the risk of new introductions to the port

Many non-indigenous species introduced to New Zealand ports by shipping do not survive to establish self-sustaining local populations. Those that do, often come from coastlines that have similar marine environments to New Zealand. For example, approximately 80 % of the marine NIS known to be present within New Zealand are native to temperate coastlines of Europe, the northwest Pacific, and southern Australia (Cranfield *et al*. 1998).

Between 2002 and 2005, there were 4026 vessel arrivals from overseas to the Port of Auckland. The greatest number of these came from Australia (1375) (predominantly Queensland, Victoria and New South Wales; Table 5), Pacific Islands (1258), Japan (437) and the East Asian Seas (314) (Table 4). Many of these are tropical locations with coastal environments dissimilar to those of New Zealand. However, southern Australian locations, such as southern New South Wales and Victoria, are in temperate regions that have coastal environments similar to New Zealand's. Due to the environmental similarities and relatively short transit times, vessels arriving from Sydney and southern Australia present perhaps the greatest risk of introducing new non-indigenous species to the Port of Auckland. Furthermore, six of the eight marine pests on the New Zealand Register of Unwanted Organisms are already present in southern Australia (*Carcinus maenas*, *Asterias amurensis*, *Undaria pinnatifida*, *Sabella spallanzanii*, *Caulerpa taxifolia*, and *Styela clava*).

Bulk carriers and tankers that arrive in port empty carry the largest volumes of ballast water. In the Port of Auckland these vessel types came predominantly from Australia (86 visits) the Pacific Islands (17 visits), northwest Pacific (14 visits) and the East Asian seas (10 visits; Table 4). Smaller, slower moving vessels, such as barges and fishing boats, tend to carry a greater density of fouling organisms than faster cargo vessels. The majority of barges and fishing boats visiting the Port of Auckland from overseas between 2002 and 2005 (the period covered by the LMIU database) came from the Pacific Islands (36 visits), Japan (27 visits) and Australia (13 visits; Table 4).

Based on the shipping patterns above, shipping from southern Australia, Japan and the northwest Pacific (predominantly China, Korea, Russia and Taiwan) present the greatest risk of introducing new non-indigenous species to the Port of Auckland. Because of the relatively short transit time and similarity of the marine environment, shipping originating in southern Australia (particularly Victoria and Tasmania) carries, perhaps, the greatest overall risk.

Assessment of translocation risk for introduced species found in the port

Between 2002 and 2005, vessels departing from the Port of Auckland travelled to 18 ports throughout New Zealand. Tauranga, Wellington, Lyttelton and Napier were the next ports of call for the most domestic vessel movements from Auckland (Table 8). Although many of the non-indigenous species found in the resurvey of the Port of Auckland have been recorded in other locations throughout New Zealand (Table 20), they were not detected in all of the other ports surveyed. There is, therefore, a risk that species established in the Port of Auckland could be spread to other New Zealand locations.

Of particular note are species present in Auckland that are on the New Zealand Register of Unwanted Species: the club-shaped ascidian, *Styela clava*, and the Asian kelp, *Undaria pinnatifida*. *Styela clava* is found throughout the Hauraki Gulf and is known from Lyttelton Harbour and Tutukaka Marina (Gust *et al.* 2006). This species is considered a significant pest of aquaculture (particularly long-line mussel culture) and there is concern about further spread to important mussel growing areas in the Marlborough Sounds and Coromandel. Although there are relatively few vessel movements between the Ports of Auckland and Picton (in the Marlborough Sounds), there is regular traffic from Auckland to nearby Nelson and Wellington by a range of vessel types (Table 8). Because they are fouling organisms, the risk of translocating *S. clava* is highest for slow-moving vessels, such as yachts and barges, and vessels that have long residence times in port. In the Port of Auckland, cargo and bulk (including fuel) carriers, recreational craft, and seasonal fishing vessels that are laid up for significant periods of time pose a particular risk for the spread of these species.

Several other species recorded during the baseline resurvey have only been recorded from the Port of Auckland or have relatively restricted distributions nationwide and could, therefore, be spread from Auckland to other locations. These include the annelids *Hydroides elegans,* and *Paralepidonotus ampuliferus*, the crab *Charybdis japonica*, the entoproct *Barensia matsushimana*, the mollusc *Limaria orientalis* and the sponge *Callyspongia robusta* (Table 20). Information on the ecology of most of these species is limited, but only *C. japonica* is thought to have potential for significant impacts.

Management of existing non-indigenous species in the port

Many of the NIS detected in this survey appear to be well established in the port. Three NIS were recorded from only one site in this survey (Table 20). They included two species that were not recorded during the initial baseline survey of Auckland (the bryozoan *Watersipora subtorquata* and the entoproct *Barentsia matsushimana*), and one that was present in only one sample in the initial baseline survey (the annelid *Hydroides elegans*). Furthermore, two of the three species (*W. subtorquata* and *B. matsushimana*) were recorded from only a single sample, while *H. elegans* was found in only two samples. Nevertheless, both *Hydroides elegans* and *W. subtorquata* are known to have been present in Waitemata Harbour for over two decades and occur in a range of other New Zealand ports (Cranfield *et al*. 1998).

Management activities could be directed toward mitigating the spread of species established in the port to locations where they do not presently occur. This is particularly important for the unwanted species *Styela clava* and *Undaria pinnatifida* and for potentially damaging species like *Charybdis japonica*. MAF Biosecurity NZ led an initial response to the incursion by *Styela clava* into New Zealand. In December 2005, however, a technical advisory group of marine experts from New Zealand, Australia and North America determined that, because it was so widespread in the Hauraki Gulf, eradication was not technically feasible. The group recommended measures to slow the spread of *Styela*. MAF Biosecurity NZ has since moved towards pathway management measures to target vessels or equipment that might spread pests like *S. clava.*

Prevention of new introductions

Interception of unwanted species transported by shipping is best achieved offshore, through control and treatment of ships destined for Auckland from high-risk locations elsewhere in New Zealand or overseas. Under the Biosecurity Act (1993), the New Zealand Government has developed an Import Health Standard for ballast water that requires large ships to exchange foreign coastal ballast water with oceanic water prior to entering New Zealand, unless exempted on safety grounds. This procedure (“ballast exchange”) does not remove all risk, but does reduce the abundance and diversity of coastal species that may be discharged with ballast. Ballast exchange requirements do not currently apply to ballast water that is taken on board domestically, within New Zealand. Globally, shipping nations are moving toward implementing the *International Convention for the Control and Management of Ships Ballast Water & Sediments* that was adopted by the International Maritime Organisation (IMO) in 2004. When the convention comes into force, all merchant vessels will be required to meet discharge standards for ballast water stipulated within the agreement by 2016.

Options are currently lacking, however, for effective in-situ treatment of biofouling and sea-chests. MAF Biosecurity NZ has recently completed a national survey of biofouling on vessels entering New Zealand from overseas and is currently developing specific border requirements regarding biofouling, based on the outcomes of the study. Shipping companies and vessel owners can reduce the risk of transporting NIS in hull fouling or sea chests through regular maintenance and antifouling of their vessels. Until effective risk mitigation options are developed, it is recommended that local authorities and port companies assess the risk of activities such as in-water cleaning of vessel hulls and sea-chests and discharge of waste material from shore-based cleaning facilities. These activities can increase the likelihood of non-indigenous fouling species being released and potentially becoming established within the port. They should be discouraged where the risk is considered unacceptable. Slow moving barges or vessels that are laid up in overseas ports for long periods before travelling to New Zealand can carry large densities of non-indigenous marine organisms with them. Cleaning and maintenance of these vessels should be encouraged by port authorities and shipping companies prior to their departure for New Zealand waters.

Studies of historical patterns of invasion have suggested that changes in trade routes can herald an influx of new NIS from regions that have not traditionally had major shipping links with the country or port (Carlton 1985; Hayden *et al*. 2009). The growing number of baseline port surveys internationally and an associated increase in published literature on marine NIS means that information is becoming available to allow more robust risk assessments to be carried out for new shipping routes. We recommend that port companies consider undertaking such assessments for their ports when new import or export markets are forecast to develop. The assessment would allow potential problem species to be identified and appropriate management and monitoring requirements to be put in place

Conclusions and recommendations

The national biological baseline surveys have significantly increased our understanding of the identity, prevalence and distribution of introduced and native species in New Zealand's shipping ports. They represent a first step towards a comprehensive assessment of the risks posed to native coastal marine ecosystems from non-indigenous marine species. Although measures are being taken by the New Zealand government to reduce the rate of new incursions, foreign species are likely to continue to be introduced to New Zealand waters by shipping. There is a need for continued monitoring of non-indigenous marine species in port environments to allow for (1) early detection and control of harmful or potentially harmful non-indigenous species, (2) to provide on-going evaluation of the efficacy of management activities, and (3) to allow trading partners to be notified of species that may be potentially harmful.

The repeat survey of the Port of Auckland recorded 238 species or higher taxa, including 14 non-indigenous species. Although many species also occurred in the initial, April 2003 baseline survey of the port, the degree of overlap was not high. Around 49 % of the native species, 50 % of non-indigenous species, and 47 % of cryptogenic taxa recorded during the repeat survey were not found in the earlier survey. This is not simply attributable to the greater sampling effort in the second survey. The species assemblage in each survey was characterised by high diversity, a comparatively large proportion of uncommon species, and patchy local distributions that are typical of marine biota. As a consequence, the estimated numbers of undetected species were comparatively high. In the initial baseline survey, for example, six of the 13 non-indigenous species (46 %) were each found in just a single sample. The increased sampling effort in the second survey improved the rate of recovery of two of these species (*Amphilectus fucorum* and *Hydroides elegans*), but the other four species went undetected in the second survey. Furthermore, of the seven non-indigenous species that were detected only in the second survey, three (43 %) were present in just a single sample. This makes it difficult to determine if the new records in the second survey represent incursions that occurred after the first survey or, rather, are species that were present, but undetected during the first survey due to their sparse densities or distribution. Similarly, the absence of the six non-indigenous species recorded in the initial survey but not in the resurvey (the bryozoans *Bugula flabellata, Bugula neritina, Celleporaria sp. 1*, *Anguinella palmata* and *Arenigobius bifrenatus*; the cnidarian *Obelia longissima* and the sponge *Halisarca dujardini*) could be explained either by (most likely) sampling error or local extinction since the initial baseline survey.

In each case, additional information can be used to address this problem. Three of the non-indigenous species recorded only in the second survey – *Apocorophium acutum, Watersipora subtorquata* and *Limaria orientalis* – have been present in New Zealand for more than 25 years and have all been recorded previously from Auckland Harbour. Each of these species was present in fewer than four samples. It seems likely, therefore, that they were present in Auckland during the first survey, albeit at small densities, and were not detected by the survey because of their rarity. Of the remaining four species *Barentsia matsushimana* has been known in New Zealand prior to 1995 and the date of first occurrence for *Callyspongia robusta* is unknown. However, *Paralepidonotus ampulliferus* and *Styela clava* have been described only recently from New Zealand and have relatively limited national distributions. Although the evidence is only circumstantial, these two species are the most likely to represent new incursions. Similarly, three of the six non-indigenous species that were not recorded in the second survey of Auckland – *Bugula neritina, Obelia longissima* and *Halisarca dujardini*– have been recorded in New Zealand for at least 35 years (Gordon and Mawatari 1992;

Cranfield *et al*. 1998) and are likely to have been present, but undetected during the repeat survey. The remaining two, *Celleporaria* sp. 1 and *Arenigobius bifrenatus* have been known in New Zealand since 2002 and 1998, respectively.

As several recent analyses have shown, the large area of habitat available for marine organisms within shipping ports and the logistical difficulties of sampling in these environments mean that detection probabilities are likely to be comparatively low for species with low prevalence, even when species-specific survey methods are used (Inglis 2003; Inglis *et al*. 2003; Hayes *et al*. 2005b; Gust *et al*. 2006). In generalised pest surveys, such as the baseline port surveys, this problem is compounded by the high cost of identifying all specimens (native and non-indigenous) which constrains the total number of samples that can be taken (Inglis 2003). A consequence is that a high proportion of comparatively rare species will remain undetected by any single survey. This problem is not limited to non-indigenous species, as up to 31% of native species recorded in the surveys also occurred in just a single sample. Nor is it unique to marine assemblages. These results reflect the spatial and temporal variability that are features of marine biological assemblages (Morrisey *et al*. 1992a, b) and the difficulties that are involved in characterising diversity within hyper-diverse assemblages (Gray 2000; Gotelli and Colwell 2001; Longino *et al*. 2002).

Nevertheless, the baseline surveys continue to reveal new records of non-indigenous species in New Zealand ports and, with repetition, the cumulative number of undetected species should decline over time. This type of sequential analysis of occupancy and detection probability requires a series of three (or more) surveys, which should allow more accurate estimates of the rate of new incursions and extinctions (MacKenzie *et al*. 2004). Hewitt and Martin (2001) recommend repeating the baseline surveys on a regular basis to ensure they remain current. It may also be prudent to repeat at least components of a survey over a shorter time frame to achieve better estimates of occupancy without the confounding effects of temporal variation and new incursions.

This survey, alone, cannot determine the threat to New Zealand's native ecosystems that is presented by the non-indigenous species encountered in this port. It does, however, provide a starting point for further investigations of the distribution, abundance and ecology of the species described within it. Non-indigenous marine species can have a range of adverse impacts through interactions with native organisms. These include competition with native species, predator-prey interactions, hybridisation, parasitism or toxicity and modification of the physical environment (Ruiz *et al*. 1999; Ricciardi 2001). Assessing the impact of a NIS in a given location ideally requires information on a range of factors, including the mechanism of their impact and their local abundance and distribution (Parker *et al*. 1999). To predict or quantify their impacts over larger areas or longer time scales requires additional information on the species' seasonality, population size and mechanisms of dispersal (Mack *et al*. 2000).

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Glossary

Term	Definition	Terms with the same or similar meaning
Biosecurity	The *Biosecurity Strategy for New Zealand* defines Biosecurity as the exclusion, eradication or effective management of risks posed by pests and diseases to the economy, environment and human health.	
Biosecurity status	A determination of the known or suspected geographic origin of a species or higher taxon. Categories of biosecurity status used in this report are *native, non-indigenous, cryptogenic* (category 1 or category 2), and *indeterminate*.	
Chief Technical Officer†	A person appointed as a Chief Technical Officer under section 101 of the Biosecurity Act 1993	
Cryptogenic Taxa	Species that are neither clearly indigenous nor non-indigenous.	
Endemic	An organism restricted to a specified region or locality.	
Environment†	(a) Ecosystems and their constituent parts, including people and their communities; and (b) All natural and physical resources; and (c) Amenity values; and (d) The aesthetic, cultural, economic, and social conditions that affect or are affected by any matter referred to in paragraphs (a) to (c) of this definition	
Established	A non-indigenous organism that has formed self-sustaining populations within the new area of introduction, but is not necessarily an invasive species.	Naturalised
Generalised pest survey	A survey to identify and inventory the range of non-indigenous species present in an area	Blitz survey
Introduction	Direct or indirect movement by a human agency of an organism across a major geographical barrier to a region or locality that is beyond its natural distribution potential.	Translocation (*usually applied to secondary movement of the organism within a new region*)
Indeterminate taxa	Specimens that could not be identified to species level reliably because they were damaged, incomplete or immature, or because there was insufficient taxonomic or systematic information to allow identification to species level.	*(referred to as "Species indeterminata" in previous NZ port survey reports)*
Harmful organism	Organisms considered harmful to the environment, where "*environment*" has the broad definition described above.	Noxious, Pest
Invasive species	A *non-indigenous species* that has established in a new area and is expanding its range	
Indigenous species	An organism occurring within its natural past or present range and dispersal potential (organisms whose dispersal potential is independent of human intervention).	Native
Non-indigenous species	Any organism (including its seeds, eggs, spores, or other biological material capable of propagating that species) occurring outside its natural past or present range and dispersal potential (organisms whose dispersal is caused by human action).	Adventive Alien, Allochthonous, Exotic, Introduced, Non-native
Pathway	Used interchangeably with *vector*, but can also include the purpose (the reason why a species is moved), and route (the geographic corridor) by which a species is moved from one point to another (Carlton 2001).	Vector
Pest†	(1) A non-indigenous organism that is considered harmful to the environment, where "*environment*" has the broad definition described above. (2) An organism specified as a pest in a pest management strategy that has been approved under Part V of Biosecurity Act 1993.	
Prevalence	The ratio of the number of recorded occurrences of a species relative to the total number of observations.	

Term	Definition	Terms with the same or similar meaning
Species richness	The number of species present in an area.	
Species composition	The types or identities of species present in a sample, site, or region.	
Species density	The number of species per unit area.	
Targeted pest survey	A survey to determine characteristics of a particular pest population	
Unwanted organism†	Any organism that a *Chief Technical Officer* believes is capable or potentially capable of causing unwanted harm to any natural resources	
Vector	The physical means by which a species is transported	Pathway

†Terms defined by the New Zealand *Biosecurity Act 1993*

Sources for definitions of commonly used biosecurity terms include: Biosecurity Council (2003), Carlton (2001), Cohen and Carlton (1998), Colautii and MacIsaac (2004), Falk-Petersen *et al*. (2006), Gotelli and Colwell (2001), Gray (2000) and Occhipinti-Ambrogi and Galil (2004).

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Tables

Table 1: Berthage facilities in the Port of Auckland

Wharf	No of Berths	Purpose	Construction	Total Length of Berths (m)	Depth (m below chart datum)
Axis Fergusson	4	Containers	Concrete deck/concrete piling with wooden fendering	610	13.5
Axis Bledisloe	2	Containers, including refrigerated containers (reefers)	Concrete deck/concrete piling with wooden fendering	430 (170m on B2 and 260m on B3)	8-12
Freyberg Wharf	2	Containers, general cargo, fruit & vegetables, steel, dry bulk cargo, imported vehicles	Concrete deck/concrete piling with wooden fendering, some steel sheet piling on south end	426	12
Jellicoe Wharf	4	Containers, general cargo, fruit & vegetables, steel, dry bulk cargo, imported vehicles	Concrete deck/concrete piling with wooden fendering	670	12
Marsden Wharf	2	Imported vehicles	Concrete deck/concrete piling with wooden fendering	398	2-10
Captain Cook Wharf	2	Imported vehicles	Concrete deck/concrete piling with wooden fendering	478	10
Queens Wharf	2	Imported vehicles, fruit & vegetables, timber, back-up cruise ship berth	Concrete deck/concrete piling with wooden fendering	516	12
Wynyard Wharf	2	Chemicals, mineral, vegetable oils, fish, general cargo, bulk sand, petroleum based products	Concrete deck/concrete piling with wooden fendering	486	13
Princes Wharf		Local and international passenger vessels, water taxis, accommodation	Concrete deck/concrete piling with wooden fendering	516	13

Table 2: Weight and value of overseas cargo unloaded at the Port of Auckland between the 2001-2002 and 2004-2005 financial years (data from Statistics New Zealand (2006b))

Year ended June	Gross weight (tonnes)	% weight change from previous year	Value (CIF) ($million)	% value change from previous year	% by weight of all NZ Seaports	% by value of all NZ Seaports
2002	3,345,664		13,965		21.8	57.4
2003	3,632,981	8.6	14,318	2.5	22.6	58.0
2004	3,846,103	5.9	14,558	1.7	21.8	57.5
2005	3,783,654	-1.6	14,776	1.5	19.9	53.2
Change from 2002 to 2005	437,990	13.1	811	5.8		

[1] CIF: Cost including insurance and freight

Table 3: Weight and value of overseas cargo loaded at the Port of Auckland between the 2001-2002 and 2004-2005 financial years (data from Statistics New Zealand (2006b))

Year ended June	Gross weight (tonnes)	% weight change from previous year	Value (FOB) ($million)	% value change from previous year	% by weight of all NZ Seaports	% by value of all NZ Seaports
2002	1,996,782		6,499		8.1	23.1
2003	2,008,910	0.6	5,677	-12.6	8.0	22.3
2004	2,016,792	0.4	5,646	-0.5	9.0	22.0
2005	1,987,714	-1.4	5,700	1.0	9.1	21.8
Change from 2002 to 2005	-9,068	-0.5	-799	-12.3		

[1] FOB: Free on board

Table 4: Number of vessel arrivals from overseas to the Port of Auckland by each general vessel type and previous geographical area, between 2002 and 2005 inclusive (data from LMIU “SeaSearcher.com” database)

Geographical area of previous port of call	Bulk/ cement carrier	Bulk/ oil carrier	Dredge	Fishing	General cargo	LPG/ LNG	Passenger/ vehicle/ livestock	Other (inc pontoons, barges, mining & supply ships, etc)	Passenger ro/ro	Research	Tanker (inc chemical/ oil and asphalt)	Container/ unitised carrier and ro/ro	Tug	Total
Australia	86			2	159		189	11		5	100	813	10	**1375**
Pacific Islands	17			23	755	1	145	13		3	3	298		**1258**
Japan	3			25	209		182	2			6	10		**437**
East Asian seas	10			2	81			1			5	215		**314**
West coast North America inc USA, Canada & Alaska	2			1	26						1	173		**203**
Northwest Pacific	14			2	23			1			11	152		**203**
Central America inc Mexico to Panama					3		37			1		39		**80**
South America Pacific coast					52					1	1	17		**71**
U.S, Atlantic coast including part of Canada					3		24	1				5		**33**
South America Atlantic coast					1						21	1		**23**
Gulf of Mexico											8	1		**9**
Central Indian Ocean				1	1									**2**
Africa Atlantic coast											2			**2**
Gulf States					1									**1**
Scandinavia inc Baltic, Greenland, Iceland etc					1									**1**
South & East African coasts			1											**1**
Caribbean Islands												1		**1**
Eastern Mediterranean inc Cyprus, Turkey								1						**1**
Not stated in database				3				6				2		**11**
Total	**132**		**1**	**59**	**1315**	**1**	**577**	**36**		**10**	**158**	**1727**	**10**	**4026**

Table 5: Number of vessel arrivals to the Port of Auckland from Australia by each general vessel type and Australian state, between 2002 and 2005 inclusive (data from LMIU "SeaSearcher.com" database)

Australian state of previous port of call	Bulk/ cement carrier	Bulk/ oil carrier	Dredge	Fishing	General cargo	LPG/ LNG	Passenger/ vehicle/ livestock	Other (inc pontoons, barges, mining & supply ships, etc)	Passenger ro/ro	Research	Tanker (inc chemical/ oil and asphalt)	Container/ unitised carrier and ro/ro	Tug	Total
Queensland	38				42		106	7		1	35	356	4	**589**
Victoria	4				12		67	1			26	292	5	**407**
New South Wales	18			2	99		8	2			34	161	1	**325**
South Australia	25				3		4				2	2		**36**
Tasmania	1				1		4	1		4	3	1		**15**
Western Australia					2							1		**3**
Total	**86**			**2**	**159**		**189**	**11**		**5**	**100**	**813**	**10**	**1375**

Table 6: Number of vessel departures from the Port of Auckland to overseas ports, by each general vessel type and next geographical area, between 2002 and 2005 inclusive (data from LMIU "SeaSearcher.com" database)

Geographical area of next port of call	Bulk/ cement carrier	Bulk/ oil carrier	Dredge	Fishing	General cargo	LPG/ LNG	Passenger/ vehicle/ livestock	Other (inc pontoons, barges, mining & supply ships, etc)	Passenger ro/ro	Research	Tanker (inc chemical/ oil and asphalt)	Container/ unitised carrier and ro/ro	Tug	Total
Pacific Islands	3			25	687	1	28	11		4	3	437		**1199**
Australia	32		1	3	75		117	6		3	65	376	3	**681**
Japan	5			24	28		36	1		1	1	141		**237**
West coast North America inc USA, Canada & Alaska	2			1	6			1		1		43		**54**
East Asian seas	8			1	5		1	1		1	5	26		**48**
Northwest Pacific	8			3	3		6	1		2	1	3		**27**
South America Pacific coast	1			1	13			1			1	9		**26**
Caribbean Islands												22		**22**
South America Atlantic coast				1	6		3			1		1		**12**
U.S, Atlantic coast including part of Canada					1			5				1		**7**
Gulf of Mexico					5									**5**
Central America inc Mexico to Panama												2		**2**
North European Atlantic coast					2									**2**
European Mediterranean coast								1						**1**
Central Indian Ocean												1		**1**
Red Sea coast inc up to the Persian Gulf											1			**1**
Total	**59**		**1**	**59**	**831**	**1**	**191**	**28**		**13**	**77**	**1062**	**3**	**2325**

Table 7: Number of vessel arrivals from New Zealand ports to the Port of Auckland by each general vessel type and previous port, between 2002 and 2005 inclusive (data from LMIU “SeaSearcher.com” database)

Previous port of call	Bulk/ cement carrier	Bulk/ oil carrier	Dredge	Fishing	General cargo	LPG/ LNG	Passenger/ vehicle/ livestock	Other (includes pontoons, barges, mining & supply ships, etc)	Passenger ro/ro	Research	Tanker (including chemical/ oil and asphalt)	Container/ unitised carrier and ro/ro	Tug	Total
Tauranga	30			2	152		24	4		1	29	269		**511**
Auckland	9			135	25		3	22		4	11	16	1	**226**
Nelson	14			4	87			2			4	53		**164**
Whangarei	49			2	33		2				24	13	1	**124**
Napier	7				80		3				9	23		**122**
Lyttelton	13			4	49		11				3	25		**105**
Westport	65													**65**
Wellington	3			4	6		15	2		9	2	19		**60**
Dunedin	8				31						4	17		**60**
New Plymouth	22			1	4	9					4	9		**49**
Timaru	1			3	7						4	2		**17**
Bluff	5			1	1					1	3		1	**12**
Gisborne	2		3		3									**8**
Bay of Islands							8							**8**
Onehunga					1							4		**5**
Greymouth								2					1	**3**
Picton							1							**1**
Opua							1							**1**
Total	**228**		**3**	**156**	**479**	**9**	**68**	**32**		**15**	**97**	**450**	**4**	**1541**

Table 8: Number of vessel departures from the Port of Auckland to other New Zealand ports by each general vessel type and next port of call, between 2002 and 2005 inclusive (data from LMIU "SeaSearcher.com" database)

Next port of call	Bulk/ cement carrier	Bulk/ oil carrier	Dredge	Fishing	General cargo	LPG/ LNG	Passenger/ vehicle/ livestock	Other (includes pontoons, barges, mining & supply ships, etc)	Passenger ro/ro	Research	Tanker (including chemical/ oil and asphalt)	Container/ unitised carrier and ro/ro	Tug	Total
Tauranga	67			3	292		99	5			63	389		**918**
Wellington	13			2	206		229	3		7	22	65	1	**548**
Lyttelton	20				93		95				16	289	4	**517**
Napier	10				80		5				18	209		**322**
Auckland	9			135	25		3	22		4	11	16	1	**226**
Nelson	19			6	35		18				5	75		**158**
Dunedin	21				51		1					59		**132**
Whangarei	60			1	42						9			**112**
Timaru	1			4	83						14	4		**106**
New Plymouth	22				28	9					18	9	1	**87**
Westport	47							1					1	**49**
Gisborne	9		3		19									**31**
Bluff				1	4						2			**7**
Onehunga	1				3							1	1	**6**
Bay of Islands							5							**5**
Picton	2						1							**3**
Chatham Islands					1									**1**
Greymouth								1						**1**
Total	**301**		**3**	**152**	**962**	**9**	**456**	**32**		**11**	**178**	**1116**	**9**	**3229**

Table 9: Marine pest species listed on the New Zealand register of Unwanted Organisms under the Biosecurity Act 1993.

Phylum	Class	Order	Genus and Species
Annelida	Polychaeta	Sabellida	*Sabella spallanzanii*
Arthropoda	Malacostraca	Decapoda	*Carcinus maenas*
Arthropoda	Malacostraca	Decapoda	*Eriocheir sinensis*
Echinodermata	Asteroidea	Forcipulatida	*Asterias amurensis*
Mollusca	Bivalvia	Myoida	*Potamocorbula amurensis*
Chlorophyta	Ulvophyceae	Caulerpales	*Caulerpa taxifolia*
Ochrophyta	Phaeophyceae	Laminariales	*Undaria pinnatifida*
Chordata	Ascidiacea	Pleurogona	*Styela clava*[1]

[1]*Styela clava* was added to the list of unwanted organisms in 2005, following its discovery in Auckland Harbour

Table 10: Comparison of survey methods used in this study with the CRIMP protocols (Hewitt and Martin 2001), indicating modifications made to the protocols following recommendations from a workshop of New Zealand scientists. Full details of the workshop recommendations can be found in Gust *et al*. (2001).

	CRIMP Protocol		NIWA Method		
Taxa sampled	**Survey method**	**Sample procedure**	**Survey method**	**Sample procedure**	**Notes**
Dinoflagellate cysts	Small hand core	Cores taken by divers from locations where sediment deposition occurs	TFO Gravity core ("javelin" core)	Cores taken from locations where sediment deposition occurs	Use of the javelin core eliminated the need to expose divers to unnecessary hazards (poor visibility, snags, boat movements, repetitive dives > 10 m). It is a method recommended by the WESTPAC/IOC Harmful Algal Bloom project for dinoflagellate cyst collection (Matsuoka and Fukuyo 2000)
Benthic infauna	Large core	3 cores close to (0 m) and 3 cores away (50 m) from each berth	Shipek benthic grab	3 cores within 10 m of each sampled berth and at sites in the port basin	Use of the benthic grab eliminated need to expose divers to unnecessary hazards (poor visibility, snags, boat movements, repetitive dives > 10 m).
Dinoflagellates	20µm plankton net	Horizontal and vertical net tows	Not sampled	Not sampled	Plankton assemblages spatially and temporally variable, time-consuming and difficult to identify to species. Workshop recommended using resources to sample other taxa more comprehensively
Zooplankton and/ phytoplankton	100 µm plankton net	Vertical net tow	Not sampled	Not sampled	Plankton assemblages spatially and temporally variable, time-consuming and difficult to identify to species. Workshop recommended using resources to sample other taxa more comprehensively
Crab/shrimp	Baited traps	3 traps of each kind left overnight at each site	Baited traps	4 traps (2 line x 2 traps) of each kind left overnight at each site	
Macrobiota	Qualitative visual survey	Visual searches of wharves & breakwaters for target species	Qualitative visual survey	Visual searches of wharves & breakwaters for target species	

	CRIMP Protocol		NIWA Method		
Taxa sampled	**Survey method**	**Sample procedure**	**Survey method**	**Sample procedure**	**Notes**
Sedentary / encrusting biota	Quadrat scraping	0.10 m^2 quadrats sampled at -0.5 m, -3.0 m and -7.0 m on 3 outer piles per berth	Quadrat scraping	0.10 m^2 quadrats sampled at -0.5 m, -1.5 m, -3.0 m and -7 m on 2 inner and 2 outer piles per berth	Workshop recommended extra quadrat in high diversity algal zone (-1.5 m) and to sample inner pilings for shade tolerant species
Sedentary / encrusting biota	Video / photo transect	Video transect of pile/rockwall facing. Still images taken of the three 0.10 m^2 quadrats	Video / photo transect	Video transect of pile/rockwall facing. Still images taken of the four 0.10 m^2 quadrats	
Mobile epifauna	Beam trawl or benthic sled	1 x 100 m or timed trawl at each site	Benthic sled	2 x 100 m (or 2 min.) tows at each site	
Fish	Poison station	Divers & snorkelers collect fish from poison stations	Opera house fish traps	4 traps (2 lines x 2 traps) left for min. 1 hr at each site	Poor capture rates anticipated from poison stations because of low visibility in NZ ports. Some poisons also an OS&H risk to personnel and may require resource consent.
Fish/mobile epifauna	Beach seine	25 m seine haul on sand or mud flat sites	Opera house fish traps / Whayman Holdsworth seastar traps	4 traps (2 lines x 2 traps) of left at each site (Whayman Holdworth seastar traps left overnight)	Few NZ ports have suitable intertidal areas to beach seine.

Table 11. Particle size classes used in grain size analyses of sediment samples from the baseline port surveys.

Particle size class	Method	Wentworth Size Class
> 8 mm	Sieve	~ Small pebbles (Wentworth division describes pebbles as 4 mm to 64 mm)
< 8 mm to > 5.6mm	Sieve	
< 5.6 mm to > 4 mm	Sieve	
< 4 mm to > 2.8 mm	Sieve	Gravel
< 2.8 mm to > 2 mm	Sieve	
< 2 mm to > 1 mm	Sieve	Very coarse sand
< 1 mm to > 0.5 mm	Sieve	Coarse sand
< 500 µm to > 250 µm	Laser analysis	Medium sand
< 250 µm to > 125 µm	Laser analysis	Fine sand
< 125 µm to > 62.5 µm	Laser analysis	Very fine sand
< 62.5 µm to > 31.3 µm	Laser analysis	Coarse silt
< 31.3 µm to > 15.6 µm	Laser analysis	Fine silt
< 15.6 µm to > 7.8 µm	Laser analysis	
< 7.8 µm to > 3.9 µm	Laser analysis	
< 3.9 µm to > 2 µm	Laser analysis	Clay

Table 12: Summary of sampling effort in the Port of Auckland. Exact geographic locations of survey sites are provided in Appendix 2.

	Sampling method and survey (T1: first survey; T2: second survey)																					
	FSHTP		CRBTP		SHRTP		STFTP		BGRB		BSLD		CYST		PSC		Photo stills & video		Qualitative visual pile searches (PSCM)		Sediment	
Site name	**T1**	**T2**	**T1**	**T2**	**T1**	**T2**	**T1**	**T2**	**T1**	**T2**	**T1**	**T2**	**T1**	**T2**	**T1**	**T2**	**T1**	**T2**	**T1**	**T2**	**T1**	**T2**
Axis Fergusson 1 Wharf		5		8		4		8		6		4		4		279		62		18		1
Jellicoe Wharf		8		4		2		4		3		9		5		200		62		23		1
Marsden Wharf		8		6		2		4		10		6		4		59		35				1
Queens Wharf		10		4		2		4		11		24		6		172		56				1
Princes Wharf		4		10		10		8						6				11				
Axis Bledisloe 1 Wharf		4		13		10		13		5		6										1
Wynyard Wharf		6		5		4		4		8		32		6		190		49		11		1
Axis Bledisloe 2 Wharf		4								3		16										1
Princes 2 Wharf		4								17		20										1
Axis Fergusson 2 Wharf		4								6		16										1
Princes 1 Wharf										11		9				185				33		1
Freyberg Wharf												6										
Captain Cook Wharf												6										
Auckland Port				109				21												7		
Wynyard	10		4		4		5		4		5		3		87		56		5			
Princes	4		4				4		4		15		4		142		64		2			
Queens	6		4		4		4		3		14		3		147		64		3			
Marsden	6		4		4		4		4		13				147		48		2			
Jellicoe	5		8		4		4		3		8				125		64		9			
Fergus	5		5		4		4		3		6				170		64		11			
Viaduct													2									
Westhaven													2									
Total	**36**	**57**	**29**	**159**	**20**	**34**	**25**	**66**	**21**	**80**	**61**	**154**	**14**	**31**	**818**	**1085**	**360**	**275**	**32**	**92**	**0**	**10**

Table 13: Preservatives used for the major taxonomic groups of organisms collected during the port survey.

5 % Formalin solution	10 % Formalin solution	70 % Ethanol solution	80 % Ethanol solution	100 % Ethanol solution	Press instead of preserving
Algae (except *Codium* and *Ulva*)	Ascidiacea (colonial) [1, 2]	Alcyonacea [2]	Ascidiacea (solitary) [1]	Bryozoa	*Ulva* [4]
	Asteroidea	Crustacea (small)			
	Echinoidea	Holothuria [1, 2]			
	Ophiuroidea	Zoantharia [1, 2]			
	Brachiopoda	Porifera [1]			
	Crustacea (large)	Mollusca (with shell)			
	Ctenophora [1]	Mollusca [1, 2] (without shell)			
	Scyphozoa [1, 2]	Platyhelminthes [1, 3]			
	Hydrozoa	*Codium* [4]			
	Actiniaria & Corallimorpharia[1, 2]				
	Scleractinia				
	Nudibranchia [1]				
	Polychaeta				
	Actinopterygii & Elasmobranchii [1]				

[1] photographs were taken before preservation
[2] relaxed in menthol prior to preservation
[3] a formalin fix was carried out before final preservation took place
[4] a sub-sample was retained in silica gel beads for DNA analysis

Table 14: Physical characteristics of the sites sampled during the resurvey of the Port of Auckland. Sites not sampled for a given characteristic are indicated with a dash (-).

Site name	Maximum recorded depth (m)	Secchi depth (m)	Salinity (ppt)	Water temperature (°C)	Sea state (Beaufort scale)
Axis Bledisloe 1 Wharf	17	-	-	-	-
Axis Bledisloe 2 Wharf	14.1	-	-	-	-
Axis Fergusson 1 Wharf	18	0.5	31	20.9	4
Axis Fergusson 2 Wharf	17	-	-	-	-
Captain Cook Wharf	12.3	-	-	-	-
Freyberg Wharf	14	-	-	-	-
Jellicoe Wharf	15	0.5	31	20.9	4
Marsden Wharf	7.3	1.7	30	21	2
Princes 1 Wharf	14	1.8	30	20.8	2
Princes 2 Wharf	14	-	-	-	-
Princes Wharf	13.2	-	-	-	-
Queens Wharf	14	0.9	31	21	2
Wynyard Wharf	16	1.15	36	21.4	2
Average across all sites	**14.30**	**1.09**	**31.50**	**21.00**	**2.25**
SE of average across all sites	**0.74**	**0.23**	**0.92**	**0.09**	**0.63**

Table 15: Percentage of five sediment particle sizes at ten sites sampled during the second baseline survey of the Port of Auckland. Data are percent net dry weight in each size class.

Site name	Clay <3.9um, >2um	Silt <62.5um, >3.9um	Sand >62.5um, <2mm	Gravel >2mm, <4mm	Small pebbles >4mm, <8mm
Axis Fergusson 1 Wharf	0.05	10.56	89.40	0.00	0.00
Axis Bledisloe 1 Wharf	0.04	6.06	93.91	0.00	0.00
Axis Bledisloe 2 Wharf	0.02	4.83	54.86	7.02	33.26
Princes 1 Wharf	0.18	21.48	78.36	0.00	0.00
Queens Wharf	0.13	16.91	82.90	0.06	0.00
Princes 2 Wharf	0.19	21.76	78.06	0.00	0.00
Axis Fergusson 2 Wharf	0.15	13.67	79.37	3.04	3.77
Marsden Wharf	0.08	16.12	83.80	0.00	0.00
Wynyard Wharf	0.23	18.36	79.66	0.29	1.46
Jellicoe Wharf	0.11	12.15	86.11	0.81	0.82

Table 16: Native species recorded from the Port of Auckland in the first (T1) and second (T2) surveys.

Phylum, Class	Order	Family	Taxon name	T1*	T2*
Annelida					
Polychaeta	Eunicida	Lumbrineridae	*Abyssoninoe galatheae*		1
Polychaeta	Eunicida	Lumbrineridae	*Lumbrineris sphaerocephala*	1	
Polychaeta	Phyllodocida	Glyceridae	*Glycera lamelliformis*	1	1
Polychaeta	Phyllodocida	Hesionidae	*Ophiodromus angustifrons*		1
Polychaeta	Phyllodocida	Nephtyidae	*Aglaophamus verrilli*	1	1
Polychaeta	Phyllodocida	Nereididae	*Neanthes kerguelensis*		1
Polychaeta	Phyllodocida	Nereididae	*Nereis falcaria*		1
Polychaeta	Phyllodocida	Nereididae	*Perinereis camiguinoides*		1
Polychaeta	Phyllodocida	Nereididae	*Perinereis pseudocamiguina*	1	1
Polychaeta	Phyllodocida	Phyllodocidae	*Pterocirrus brevicornis*		1
Polychaeta	Phyllodocida	Phyllodocidae	*Eulalia microphylla*	1	1
Polychaeta	Phyllodocida	Polynoidae	*Harmothoe macrolepidota*	1	1
Polychaeta	Phyllodocida	Polynoidae	*Lepidastheniella comma*		1
Polychaeta	Phyllodocida	Polynoidae	*Lepidonotus polychromus*	1	1
Polychaeta	Phyllodocida	Sigalionidae	*Labiosthenolepis laevis*	1	1
Polychaeta	Phyllodocida	Syllidae	*Trypanosyllis zebra*	1	1
Polychaeta	Phyllodocida	Syllidae	*Haplosyllis spongicola*	1	
Polychaeta	Phyllodocida	Goniadidae	*Glycinde trifida*	1	1
Polychaeta	Sabellida	Sabellidae	*Megalomma suspiciens*	1	1
Polychaeta	Sabellida	Sabellidae	*Demonax aberrans*		1
Polychaeta	Sabellida	Sabellidae	*Pseudopotamilla laciniosa*	1	1
Polychaeta	Sabellida	Serpulidae	*Galeolaria hystrix*		1
Polychaeta	Sabellida	Serpulidae	*Spirobranchus cariniferus*	1	1
Polychaeta	Sabellida	Serpulidae	*Filograna implexa*	1	
Polychaeta	Sabellida	Sabellariidae	*Neosabellaria kaiparaensis*	1	
Polychaeta	Sabellida	Sabellariidae	*Paraidanthyrsus quadricornis*	1	
Polychaeta	Scolecida	Orbiniidae	*Phylo novazealandiae*	1	1
Polychaeta	Scolecida	Scalibregmatidae	*Hyboscolex longiseta*		1
Polychaeta	Scolecida	Cossuridae	*Cossura consimilis*		1
Polychaeta	Spionida	Spionidae	*Boccardia chilensis*		1
Polychaeta	Spionida	Spionidae	*Prionospio aucklandica*		1
Polychaeta	Terebellida	Cirratulidae	*Protocirrineris nuchalis*	1	1
Polychaeta	Terebellida	Cirratulidae	*Timarete anchylochaetus*	1	1
Polychaeta	Terebellida	Flabelligeridae	*Flabelligera affinis*	1	1
Polychaeta	Terebellida	Flabelligeridae	*Pherusa parmata*	1	1
Polychaeta	Terebellida	Pectinariidae	*Pectinaria australis*	1	1
Polychaeta	Terebellida	Terebellidae	*Pseudopista rostrata*	1	
Polychaeta	Terebellida	Terebellidae	*Streblosoma toddae*	1	1
Polychaeta	Terebellida	Acrocirridae	*Acrocirrus trisectus*	1	1
Arthropoda					
Malacostraca	Amphipoda	Liljeborgiidae	*Liljeborgia akaroica*	1	1
Malacostraca	Amphipoda	Melitidae	*Melita festiva*	1	1
Malacostraca	Amphipoda	Lysianassidae	*Parawaldeckia vesca*	1	1
Malacostraca	Amphipoda	Aoridae	*Haplocheira barbimana*		1
Malacostraca	Amphipoda	Leucothoidae	*Leucothoe trailli*		1
Malacostraca	Amphipoda	Podoceridae	*Podocerus cristatus*	1	
Malacostraca	Decapoda	Alpheidae	*Alpheus richardsoni*	1	1
Malacostraca	Decapoda	Crangonidae	*Philocheras australis*		1
Malacostraca	Decapoda	Crangonidae	*Pontophilus australis*	1	
Malacostraca	Decapoda	Hymenosomatidae	*Halicarcinus cookii*	1	
Malacostraca	Decapoda	Hymenosomatidae	*Halicarcinus varius*	1	1

Phylum, Class	Order	Family	Taxon name	T1*	T2*
Malacostraca	Decapoda	Hymenosomatidae	*Neohymenicus pubescens*		1
Malacostraca	Decapoda	Hymenosomatidae	*Halimena aoteoroa*	1	
Malacostraca	Decapoda	Majidae	*Notomithrax minor*	1	1
Malacostraca	Decapoda	Ocypodidae	*Macrophthalmus hirtipes*	1	1
Malacostraca	Decapoda	Palemonidae	*Periclimenes yaldwyni*	1	1
Malacostraca	Decapoda	Pilumnidae	*Pilumnopeus serratifrons*	1	1
Malacostraca	Decapoda	Pinnotheridae	*Pinnotheres atrinocola*	1	
Malacostraca	Decapoda	Pinnotheridae	*Pinnotheres novaezelandiae*	1	1
Malacostraca	Decapoda	Porcellanidae	*Petrolisthes elongatus*	1	1
Malacostraca	Decapoda	Porcellanidae	*Petrolisthes novaezelandiae*	1	1
Malacostraca	Decapoda	Xanthidae	*Pilumnus lumpinus*	1	
Malacostraca	Decapoda	Xanthidae	*Pilumnus novaezelandiae*	1	1
Malacostraca	Isopoda	Cirolanidae	*Natatolana rossi*	1	1
Malacostraca	Isopoda	Cirolanidae	*Cirolana kokoru*	1	
Malacostraca	Isopoda	Cirolanidae	*Cirolana quechso*	1	1
Malacostraca	Isopoda	Sphaeromatidae	*Pseudosphaeroma campbellensis*	1	
Malacostraca	Isopoda	Sphaeromatidae	*Ischyromene kokotahi*	1	1
Malacostraca	Isopoda	Sphaeromatidae	*Pseudophaeroma campbellensis*		1
Malacostraca	Isopoda	Arcturidae	*Neastacilla* aff. *tuberculata*	1	
Malacostraca	Mysida	Mysidae	*Tenagomysis longisquama*		1
Malacostraca	Tanaidacea	Apseudidae	*Gollumudes* new sp. 1 Bird		1
Maxillopoda	Sessilia	Archaeobalanidae	Austrominius modestus	1	1
Maxillopoda	Sessilia	Balanidae	*Balanus trigonus*	1	1
Maxillopoda	Sessilia	Tetraclitidae	*Tetraclitella purpurascens*		1
Maxillopoda	Sessilia	Chthamalidae	*Chamaesipho columna*	1	
Ostracoda	Myodocopida	Cylindroleberididae	*Diasterope grisea*		1
Pycnogonida	Pantopoda	Ammotheidae	*Achelia assimilis*	1	
Bryozoa					
Gymnolaemata	Cheilostomata	Beaniidae	*Beania plurispinosa*	1	1
Gymnolaemata	Cheilostomata	Beaniidae	*Beania* new sp. [whitten]	1	
Gymnolaemata	Cheilostomata	Beaniidae	*Beania* sp.		1
Gymnolaemata	Cheilostomata	Candidae	Caberea rostrata	1	1
Gymnolaemata	Cheilostomata	Chaperiidae	Chaperiopsis cervicornis	1	1
Gymnolaemata	Cheilostomata	Hippoporidridae	Odontoporella bishopi	1	
Gymnolaemata	Cheilostomata	Microporellidae	Microporella intermedia		1
Stenolaemata	Cyclostomata	Lichenoporidae	Disporella novaehollandiae		1
Chlorophyta					
Ulvophyceae	Bryopsidales	Codiaceae	*Codium convolutum*		1
Chordata					
Actinopterygii	Anguilliformes	Congridae	*Conger wilsoni*	1	1
Actinopterygii	Anguilliformes	Anguillidae	*Anguilla australis*	1	
Actinopterygii	Mugiliformes	Mugilidae	*Aldrichetta forsteri*	1	1
Actinopterygii	Perciformes	Labridae	*Notolabrus celidotus*	1	1
Actinopterygii	Perciformes	Sparidae	*Pagrus auratus*	1	1
Actinopterygii	Perciformes	Tripterygiidae	*Forsterygion lapillum*	1	
Actinopterygii	Perciformes	Tripterygiidae	*Forsterygion varium*		1
Actinopterygii	Perciformes	Cheilodactylidae	*Nemadactylus macropterus*		1
Actinopterygii	Perciformes	Gobiesocidae	*Trachelochismus melobesia*		1
Actinopterygii	Perciformes	Carangidae	*Caranx georgianus*		1
Actinopterygii	Perciformes	Carangidae	*Decapterus koheru*	1	
Actinopterygii	Perciformes	Carangidae	*Trachurus novaezelandiae*	1	1
Actinopterygii	Perciformes	Mullidae	*Upeneichthys lineatus*		1
Actinopterygii	Perciformes	Mullidae	*Upeneichthys porosus*		1
Actinopterygii	Perciformes	Scorpidinae	*Scorpis lineolata*		1
Actinopterygii	Gasterosteiformes	Syngnathidae	*Hippocampus abdominalis*		1
Ascidiacea	Enterogona	Polyclinidae	*Aplidium adamsi*	1	

Phylum, Class	Order	Family	Taxon name	T1*	T2*
Ascidiacea	Enterogona	Polyclinidae	*Aplidium phortax*	1	
Ascidiacea	Enterogona	Didemnidae	*Lissoclinum notti*	1	1
Ascidiacea	Pleurogona	Molgulidae	*Molgula mortenseni*	1	1
Ascidiacea	Pleurogona	Molgulidae	*Molgula amokurae*	1	
Ascidiacea	Pleurogona	Pyuridae	*Pyura rugata*	1	1
Ascidiacea	Pleurogona	Pyuridae	*Pyura subuculata*	1	1
Ascidiacea	Pleurogona	Pyuridae	*Pyura cancellata*	1	
Ascidiacea	Pleurogona	Pyuridae	*Pyura picta*	1	1
Ascidiacea	Pleurogona	Pyuridae	*Pyura pulla*		1
Ascidiacea	Pleurogona	Styelidae	*Asterocarpa cerea*		1
Ascidiacea	Pleurogona	Styelidae	*Cnemidocarpa bicornuta*	1	1
Ascidiacea	Pleurogona	Styelidae	*Cnemidocarpa nisiotis*	1	1
Ascidiacea	Pleurogona	Styelidae	*Cnemidocarpa otagoensis*		1
Ascidiacea	Pleurogona	Styelidae	*Asterocarpa coerulea*	1	
Ascidiacea	Pleurogona	Styelidae	*Polycarpa pegasus*	1	
Ascidiacea	Pleurogona	Polyzoinae	*Polyzoa opuntia*	1	
Cnidaria					
Anthozoa	Actiniaria	Sagartiidae	*Actinothoe albens*		1
Hydrozoa	Hydroida	Sertulariidae	*Amphisbetia fasciculata*	1	
Hydrozoa	Hydroida	Sertulariidae	*Amphisbetia bispinosa*		1
Hydrozoa	Hydroida	Solanderiidae	*Solanderia ericopsis*	1	1
Hydrozoa	Leptothecata	Aglaopheniidae	*Lytocarpia chiltoni*		1
Echinodermata					
Asteroidea	Forcipulatida	Asteriidae	*Coscinasterias muricata*		1
Asteroidea	Valvatida	Asterinidae	*Patiriella regularis*	1	1
Ophiuroidea	Ophiurida	Amphiuridae	*Amphipholis squamata*		1
Ophiuroidea	Ophiurida	Ophionereididae	*Ophionereis fasciata*		1
Mollusca					
Bivalvia	Myoida	Hiatellidae	*Hiatella arctica*	1	1
Bivalvia	Mytiloida	Mytilidae	*Modiolarca impacta*	1	1
Bivalvia	Mytiloida	Mytilidae	*Modiolus areolatus*	1	
Bivalvia	Mytiloida	Mytilidae	*Perna canaliculus*	1	1
Bivalvia	Mytiloida	Mytilidae	*Xenostrobus pulex*	1	1
Bivalvia	Ostreoida	Ostreidae	*Ostrea chilensis*	1	
Bivalvia	Pterioida	Pectinidae	*Talochlamys zelandiae*	1	
Bivalvia	Veneroida	Veneridae	*Austrovenus stutchburyi*		1
Bivalvia	Veneroida	Veneridae	*Tawera spissa*		1
Bivalvia	Veneroida	Carditidae	*Pleuromeris zelandica*		1
Bivalvia	Veneroida	Lasaeidae	*Lasaea hinemoa*	1	
Gastropoda	Neogastropoda	Buccinidae	*Cominella adspersa*	1	1
Gastropoda	Neotaenioglossa	Calyptraeidae	*Maoricrypta costata*	1	
Gastropoda	Neotaenioglossa	Calyptraeidae	*Sigapatella novaezelandiae*	1	1
Gastropoda	Neotaenioglossa	Calyptraeidae	*Crepidula costata*		1
Gastropoda	Neotaenioglossa	Turritellidae	*Maoricolpus roseus*		1
Gastropoda	Neotaenioglossa	Littorinidae	*Risellopsis varia*	1	1
Gastropoda	Nudibranchia	Dorididae	*Rostanga muscula*		1
Gastropoda	Basommatophora	Siphonariidae	*Siphonaria australis*		1
Gastropoda	Basommatophora	Ellobiidae	*Leuconopsis obsoleta*	1	
Gastropoda	Vetigastropoda	Fissurellidae	*Tugali suteri*	1	1
Gastropoda	Vetigastropoda	Trochidae	*Micrelenchus huttonii*		1
Gastropoda	Vetigastropoda	Trochidae	*Trochus viridis*		1
Gastropoda	Systellomatophora	Onchidiidae	*Onchidella nigricans*	1	1
Polyplacophora	Acanthochitonina	Acanthochitonidae	*Acanthochitona zelandica*	1	1
Polyplacophora	Acanthochitonina	Acanthochitonidae	*Cryptoconchus porosus*	1	1
Polyplacophora	Ischnochitonina	Chitonidae	*Sypharochiton pelliserpentis*	1	1
Polyplacophora	Ischnochitonina	Chitonidae	*Onithochiton neglectus*	1	

Phylum, Class	Order	Family	Taxon name	T1*	T2*
Polyplacophora	Ischnochitonina	Chitonidae	*Sypharochiton sinclairi*	1	
Myzozoa					
Dinophyceae	Peridiniales	Gonyaulacaceae	*Lingulodinium polyedrum*	1	
Dinophyceae	Peridiniales	Peridiniaceae	*Scrippsiella trochoidea*	1	1
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium avellana*		1
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium conicum*	1	1
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium conicum cf. conicoides*	1	
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium punctulatum*		1
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium subinerme*		1
Ochrophyta					
Phaeophyceae	Fucales	Sargassaceae	*Carpophyllum flexuosum*	1	1
Phaeophyceae	Ectocarpales	Scytosiphonaceae	*Endarachne binghamiae*		1
Phaeophyceae	Laminariales	Alariaceae	*Ecklonia radiata*		1
Porifera					
Demospongiae	Haplosclerida	Chalinidae	*Adocia* cf. *parietalioides*	1	1
Demospongiae	Haplosclerida	Chalinidae	*Adocia* cf. *venustina*	1	1
Demospongiae	Haplosclerida	Chalinidae	*Haliclona* cf. *isodictyale*		1
Demospongiae	Haplosclerida	Chalinidae	*Haliclona maxima*	1	1
Demospongiae	Haplosclerida	Chalinidae	*Haliclona stelliderma*	1	1
Demospongiae	Poecilosclerida	Microcionidae	*Clathria (Microciona) coccinea*		1
Demospongiae	Poecilosclerida	Mycalidae	*Mycale (Carmia) tasmani*		1
Demospongiae	Poecilosclerida	Hymedesmiidae	*Hymedesmia microstrongyla*		1
Demospongiae	Poecilosclerida	Hymedesmiidae	*Hymedesmia (Stylopus) lissostyla*		1
Demospongiae	Poecilosclerida	Raspaillidae	*Eurypon hispida*		1
Demospongiae	Astrophoria	Ancorinidae	*Ancorina alata*		1
Rhodophyta					
Florideophyceae	Ceramiales	Rhodomelaceae	*Adamsiella chauvinii*		1
Florideophyceae	Ceramiales	Rhodomelaceae	*Polysiphonia decipiens*		1
Florideophyceae	Ceramiales	Ceramiaceae	*Antithamnionella adnata*		1
Florideophyceae	Ceramiales	Ceramiaceae	*Ceramium flaccidum*		1
Florideophyceae	Gigartinales	Gigartinaceae	*Gigartina macrocarpa*		1
Florideophyceae	Gelidiales	Gelidiaceae	*Capreolia implexa*		1
Bangiophyceae	Bangiales	Bangiaceae	*Porphyra suborbiculata*		1

* 1 = Present, Blank = Absent

Table 17: Cryptogenic category 1 (C1) and category 2 (C2) marine taxa recorded from the Port of Auckland in the first (T1) and second (T2) surveys.

Phylum, Class	Order	Family	Taxon name	Status	T1*	T2*
Annelida						
Polychaeta	Phyllodocida	Nereididae	*Perinereis Perinereis*-A	C2		1
Polychaeta	Phyllodocida	Syllidae	*Typosyllis Typosyllis*-B	C2	1	
Polychaeta	Sabellida	Sabellidae	*Pseudopotamilla Pseudopotamilla*-A	C2	1	
Polychaeta	Sabellida	Serpulidae	*Neodexiospira pseudocorrugata*	C1		1
Polychaeta	Sabellida	Serpulidae	*Spirobranchus S. polytrema* complex	C2		1
Polychaeta	Scolecida	Capitellidae	*Heteromastus filiformis*	C1		1
Polychaeta	Spionida	Chaetopteridae	*Chaetopterus chaetopterus*-A	C1		1
Arthropoda						
Malacostraca	Amphipoda	Lysianassidae	*Acontiostoma* new sp.	C2	1	
Chordata						
Ascidiacea	Enterogona	Rhodosomatidae	*Corella eumyota*	C1	1	1
Ascidiacea	Enterogona	Didemnidae	*Didemnum* sp.#	C1	1	1
Ascidiacea	Enterogona	Didemnidae	*Diplosoma listerianum*	C1	1	1
Ascidiacea	Pleurogona	Pyuridae	*Microcosmus australis*	C1	1	1
Ascidiacea	Pleurogona	Pyuridae	*Microcosmus squamiger*	C1	1	1
Ascidiacea	Pleurogona	Styelidae	*Asterocarpa humilis*	C1	1	
Ascidiacea	Pleurogona	Styelidae	*Styela plicata*	C1	1	1
Cnidaria						
Hydrozoa	Hydroida	Bougainvilliidae	*Bougainvillia muscus*	C1	1	1
Hydrozoa	Hydroida	Campanulariidae	*Clytia hemisphaerica*	C1	1	
Hydrozoa	Hydroida	Campanulariidae	*Obelia bidentata*	C1	1	
Myzozoa						
Dinophyceae	Gymnodiniales	Gymnodiniaceae	*Gymnodinium catenatum*	C1	1	1
Porifera						
Demospongiae	Halichondrida	Halichondriidae	*Ciocalypta pencillus*	C1		1
Demospongiae	Halichondrida	Halichondriidae	*Ciocalypta polymastia*	C1		1
Demospongiae	Halichondrida	Halichondriidae	*Halichondria panicea*	C1		1
Demospongiae	Halichondrida	Halichondriidae	*Halichondria* cf. *rugosa*	C2		1
Demospongiae	Halichondrida	Dictyonellidae	*Scopalina* new sp. 1	C2		1
Demospongiae	Haplosclerida	Chalinidae	*Haliclona* new sp. 3	C2		1
Demospongiae	Haplosclerida	Chalinidae	*Haliclona* new sp. 9	C2		1
Demospongiae	Haplosclerida	Chalinidae	Adocia new sp. 4	C2	1	1
Demospongiae	Haplosclerida	Chalinidae	*Haliclona heterofibrosa*	C1	1	1
Demospongiae	Haplosclerida	Chalinidae	*Adocia* new sp. 2	C2	1	1
Demospongiae	Haplosclerida	Chalinidae	*Adocia* new sp. 6	C2	1	1
Demospongiae	Haplosclerida	Chalinidae	*Haliclona* new sp. 16	C2	1	1
Demospongiae	Haplosclerida	Chalinidae	*Haliclona* new sp. 5	C2	1	1
Demospongiae	Haplosclerida	Callyspongiidae	*Callyspongia ramosa*	C1	1	1
Demospongiae	Poecilosclerida	Mycalidae	*Paraesperella* new sp. 1	C2		1
Demospongiae	Poecilosclerida	Mycalidae	*Mycale (Carnia)* new. sp. 4	C2		1
Demospongiae	Poecilosclerida	Coelosphaeridae	*Lissodendoryx isodictyalis*	C1		1
Demospongiae	Dictyoceratida	Dysideidae	*Euryspongia* new sp. 1	C2	1	1
Demospongiae	Dictyoceratida	Dysideidae	*Euryspongia* new sp. 2	C2		1
Demospongiae	Dictyoceratida	Dysideidae	*Euryspongia* new sp. 3	C2	1	
Demospongiae	Hadromerida	Suberitidae	*Pseudosuberites sulcatus*	C1		1
Demospongiae	Homosclerophorida	Plakinidae	*Plakina monolopha*	C1	1	1

* 1 = Present, Blank = Absent# Because of the complex taxonomy of this genus, *Didemnum* specimens from the second survey could not be identified to species level, but are reported here collectively as a species group "*Didemnum* sp."

Table 18: Non-indigenous marine species recorded from the Port of Auckland during the first survey (T1) and second survey (T2). Likely vectors of introduction are largely derived from Cranfield *et al*. (1998), where H = Hull fouling and B = Ballast water transport.

Phylum, Class	Order	Family	Taxon name	Date of first record or introduction	Method of intro	T1*	T2*
Annelida							
Polychaeta	Sabellida	Serpulidae	*Hydroides elegans*	Pre-1952	H or B	1	1
Polychaeta	Phyllodocida	Polynoidae	*Paralepidonotus ampulliferus*	2003	H or B		1
Arthropoda							
Malacostraca	Amphipoda	Corophiidae	*Apocorophium acutum*	Pre-1921	H		1
Malacostraca	Decapoda	Portunidae	*Charybdis japonica*	pre-2000	H or B	1	1
Bryozoa							
Gymnolaemata	Cheilostomata	Bugulidae	*Bugula flabellata*	Pre-1949	H	1	1
Gymnolaemata	Cheilostomata	Bugulidae	*Bugula neritina*	Probably 1949	H	1	
Gymnolaemata	Cheilostomata	Watersiporidae	*Watersipora subtorquata*	Pre-1982	H or B		1
Gymnolaemata	Cheilostomata	Lepraliellidae	*Celleporaria* sp. 1	November 2002	H	1	
Gymnolaemata	Ctenostomata	Nolellidae	*Anguinella palmata*	1960	H	1	
Chordata							
Ascidiacea	Pleurogona	Styelidae	*Styela clava*	November 2004	H		1
Actinopterygii	Perciformes	Gobiidae	*Arenigobius bifrenatus*	1998	B	1	
Cnidaria							
Hydrozoa	Hydroida	Campanulariidae	*Obelia longissima*	Pre-1928	H	1	
Hydrozoa	Hydroida	Pennariidae	*Pennaria disticha*	Pre-1928	H	1	1
Mollusca							
Bivalvia	Pterioida	Limidae	*Limaria orientalis*	1972	H or B		1
Bivalvia	Pterioida	Ostreidae	*Crassostrea gigas*	1961	H	1	1
Bivalvia	Veneroida	Semelidae	*Theora lubrica*	1971	B	1	1
Porifera							
Demospongiae	Halisarcida	Halisarcidae	*Halisarca dujardini*	Pre-1973	H or B	1	
Demospongiae	Poecilosclerida	Esperiopsidae	*Amphilectus fucorum*	December 2001	0	1	1
Demospongiae	Haplosclerida	Callyspongiidae	*Callyspongia robusta*	?			1
Entoprocta							
Entoprocta	Coloniales	Barentsiidae	*Barentsia matsushimana*	Pre-1995	H or B		1

* 1 = Present, Blank = Absent
? = Date of introduction currently unknown but species had been encountered in New Zealand prior to the present survey.

Table 19: Indeterminate taxa recorded from the Port of Auckland in the first (T1) and second (T2) surveys. This group includes either organisms that were damaged or juvenile and lacked crucial morphological characteristics, or taxa for which there is not sufficient taxonomic or systematic information available to allow positive identification to species level.

Phylum, Class	Order	Family	Taxon name	T1*	T2*
Annelida					
Polychaeta			Polychaeta		1
Polychaeta	Eunicida	Lumbrineridae	Lumbrineridae Indet.	1	
Polychaeta	Phyllodocida	Glyceridae	*Glycera* sp.		1
Polychaeta	Phyllodocida	Nereididae	Nereididae Indet.	1	
Polychaeta	Sabellida	Sabellidae	Sabellidae Indet.	1	
Polychaeta	Sabellida	Sabellidae	*Pseudopotamilla* Indet.	1	
Polychaeta	Scolecida	Orbiniidae	Orbiniidae Indet.	1	
Polychaeta	Terebellida	Cirratulidae	Cirratulidae Indet.	1	
Polychaeta	Terebellida	Terebellidae	Terebellidae Indet.	1	
Polychaeta	Terebellida	Trichobranchidae	Terebellides sp.		1
Arthropoda					
Malacostraca	Amphipoda		*Amphipod*a Indet.		1
Malacostraca	Amphipoda	Lysianassidae	*Acontiostoma* sp.		1
Malacostraca	Amphipoda	Lysianassidae	*Parawaldeckia* sp.		1
Malacostraca	Amphipoda	Aoridae	Aoridae	1	
Malacostraca	Decapoda	Majidae	*Notomithrax* sp.		1
Malacostraca	Decapoda	Paguridae	*Pagurus* sp.		1
Malacostraca	Isopoda		Isopoda	1	1
Malacostraca	Isopoda	Sphaeromatidae	*Cilicaea* sp.	1	
Malacostraca	Isopoda	Cymothoidae	*Ceratothoa* sp.		1
Malacostraca	Isopoda	Janiridae	*Iathrippa* sp.		1
Malacostraca	Mysida		*Mysida* Indet.	1	
Maxillopoda	Sessilia	Archaeobalanidae	*Austrominius* sp.		1
Maxillopoda	Sessilia	Balanidae	*Balanus* sp.	1	
Maxillopoda	Sessilia		*Maxillopoda* Indet.		1
Bryozoa					
			Bryozoa Indet.		1
Gymnolaemata	Cheilostomata	Chaperiidae	*Chaperia* sp.		1
Gymnolaemata	Cheilostomata	Lepraliellidae	*Celleporaria* sp.		1
Stenolaemata	Cyclostomata	Tubuliporidae	*Tubulipora* sp.		1
Chlorophyta					
Ulvophyceae	Cladophorales	Cladophoraceae	*Cladophora* sp.		1
Ulvophyceae	Ulvales	Ulvaceae	*Ulva* sp.		1
Chordata					
Actinopterygii	Perciformes	Gobiidae	*Eviota* sp.		1
Actinopterygii	Perciformes	Gobiidae	Gobiidae	1	
Actinopterygii	Perciformes	Labridae	Labridae Indet.		1
Actinopterygii	Perciformes	Mugilidae	Mugilidae		1
Actinopterygii	Perciformes	Tripterygiidae	Tripterygiidae		1
Ascidiacea	Enterogona	Didemnidae	Didemnidae		1
Cnidaria					
Anthozoa			Anthozoa		1
Anthozoa	Actiniaria	Actiniidae	*Anthopleura* sp.		1
Hydrozoa			Hydrozoa		1
Hydrozoa	Hydroida	Campanulariidae	*Obelia* sp.	1	
Hydrozoa	Hydroida	Campanulariidae	*Clytia* sp. 1	1	

Phylum, Class	Order	Family	Taxon name	T1*	T2*
Scyphozoa			Scyphozoa		1
Echinodermata					
Asteroidea	Valvatida	Asterinidae	*Patiriella* sp.		1
Mollusca					
Bivalvia			Bivalvia		1
Gastropoda			Gastropoda	1	1
Gastropoda	Neogastropoda	Buccinidae	*Cominella* sp.		1
Myzozoa					
Dinophyceae			Unidentifiable cyst		1
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium* sp.	1	
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium* sp. 1		1
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium* sp. 2		1
Porifera					
			Porifera		1
Rhodophyta					
Florideophyceae	Ceramiales	Rhodomelaceae	*Polysiphonia* sp.		1
Florideophyceae	Ceramiales	Ceramiaceae	*Ceramium* sp.		1
Florideophyceae	Ceramiales	Ceramiaceae	*Anotrichium* sp.		1
Florideophyceae	Ceramiales	Delesseriaceae	*Hymenena* sp.		1
Florideophyceae	Gracilariales	Gracilariaceae	*Gracilaria* sp. Indet.	1	
Florideophyceae	Plocamiales	Plocamiaceae	*Plocamium* sp.		1
Algae					
Unidentified algae			Unidentified algae		1
Nemertea					
Nemertea			Unidentified sp. 1		1
Platyhelminthes					
Platyhelminthes			Platyhelminthes		1
Sipuncula					
Sipuncula			Sipuncula		1

* 1 = Present, Blank = Absent

Table 20: Non-indigenous marine organisms recorded from the Port of Auckland survey and the techniques used to capture each species. Species distributions throughout the port and in other ports and marinas around New Zealand are indicated.

Taxon name	Capture techniques in the Port of Auckland	Locations detected in the Port of Auckland		Detected in other locations surveyed in ZBS2000_04, ZBS2005_18 & ZBS 2005_19
		First Survey	Second Survey	
Annelida				
Hydroides elegans	PSC	Jellicoe	Axis Fergusson 1 Wharf	Whangarei, Gulf Harbour Marina, Viaduct Harbour Marina
Paralepidonotus ampulliferus	BGRB		Marsden Wharf, Princes 1 Wharf	Whangarei, Westhaven Marina, Viaduct Harbour Marina
Arthropoda				
Apocorophium acutum	BSLD, PSC		Axis Fergusson 2 Wharf, Jellicoe Wharf, Wynyard Wharf	Opua, Whangarei, Gulf Harbour Marina, Westhaven Marina, Tauranga, Gisborne, Napier, Port Underwood, Lyttelton, Dunedin, Bluff
Charybdis japonica	CRBTP, STFTP, FSHTP	Fergus, Jellicoe, Marsden, Princes, Wynard	Auckland Port, Queens Wharf	Westhaven Marina
Bryozoa				
Anguinella palmata	PSC	Queens		Kaipara Harbour, Nelson
Bugula flabellata	PSC, BSLD	Fergus, Jellicoe	Queens Wharf, Queens Wharf, Wynyard Wharf	Opua, Whangarei, Tauranga, Gisborne, Napier, Taranaki, Wellington, Port Underwood, Picton, Nelson, Lyttelton, Timaru, Dunedin, Bluff
Bugula neritina	PSC	Jellicoe		Opua, Whangarei, Gulf Harbour Marina, Westhaven Marina, Tauranga, Gisborne, Napier, Taranaki, Picton, Lyttelton, Timaru, Dunedin
Celleporaria sp. 1	PSC, BSLD	Marsden, Princes, Queens, Wynyard		Whangarei
Watersipora subtorquata	PSC		Wynyard Wharf	Opua, Whangarei, Gulf Harbour Marina, Westhaven Marina, Tauranga, Gisborne, Napier, New Plymouth, Wellington, Port Underwood, Lyttelton, Dunedin, Bluff
Chordata				
Arenigobius bifrenatus	BSLD	Jellicoe, Marsden, Princes, Queens, Wynyard		
Styela clava	PSCM, PSC		Auckland Port, Axis Fergusson 1 Wharf, Wynyard Wharf	Gulf Harbour Marina, Westhaven Marina, Lyttelton
Cnidaria				
Obelia longissima	PSC	Queens		
Pennaria disticha	BSLD, PSC, PSCM, BGRB	Jellicoe, Princes, Queens	Axis Bledisloe 2 Wharf, Captain Cook Wharf, Jellicoe Wharf, Princes 1 Wharf,	Westhaven Marina, Kaikoura area, Dunedin, Bluff

Taxon name	Capture techniques in the Port of Auckland	Locations detected in the Port of Auckland		Detected in other locations surveyed in ZBS2000_04, ZBS2005_18 & ZBS 2005_19
		First Survey	Second Survey	
			Princes 2 Wharf, Queens Wharf, Wynyard Wharf	
Entoprocta				
Barentsia matsushimana	PSC		Axis Fergusson 1 Wharf	Whangarei
Mollusca				
Crassostrea gigas	PSC, PSCM, BSLD,	Fergus, Jellicoe, Marsden, Princes, Queens, Wynyard	Axis Fergusson 1 Wharf, Jellicoe Wharf, Marsden Wharf, Princes 1 Wharf, Queens Wharf, Wynyard Wharf	Opua, Whangarei, Kaipara Harbour, Gulf Harbour Marina, Westhaven Marina, Taranaki, Nelson, Dunedin
Limaria orientalis	STFTP, BGRB		Auckland Port, Axis Fergusson 2 Wharf	Opua, Whangarei, Gulf Harbour Marina, Viaduct Harbour Marina
Theora lubrica	BSLD, BGRB	Fergus, Jellicoe, Marsden, Princes, Queens, Wynyard	Axis Bledisloe 1 Wharf, Captain Cook Wharf, Freyberg Wharf, Jellicoe Wharf, Marsden Wharf, Princes 1 Wharf, Princes 2 Wharf, Queens Wharf, Wynyard Wharf	Opua, Whangarei, Gulf Harbour Marina, Viaduct Harbour Marina, Westhaven Marina, Gisborne, Napier, Taranaki, Wellington, Nelson, Picton, Port Underwood, Kaikoura area, Lyttelton
Porifera				
Amphilectus fucorum	PSC, PSCM, BSLD,	Marsden	Axis Fergusson 1 Wharf, Jellicoe Wharf, Princes 1 Wharf, Queens Wharf	Opua, Whangarei, Westhaven Marina, Tauranga, Taranaki, Picton
Callyspongia robusta	PSCM		Princes 1 Wharf	
Halisarca dujardini	PSC	Jellicoe		Taranaki, Wellington, Picton, Dunedin, Bluff

Table 21: Consultative Committee on Introduced Marine Pest Emergencies (CCIMPE) Trigger List (Endorsed by the National Introduced Marine Pest Coordinating Group, 2006).

	Scientific Name/s	Common Name/s
Species Still Exotic to Australia		
1 *	*Eriocheir* spp.	Chinese Mitten Crab
2	*Hemigrapsus sanguineus*	Japanese/Asian Shore Crab
3	*Crepidula fornicata*	American Slipper Limpet
4 *	*Mytilopsis sallei*	Black Striped Mussel
5	*Perna viridis*	Asian Green Mussel
6	*Perna perna*	Brown Mussel
7 *	*Corbula* (*Potamocorbula*) *amurensis*	Asian Clam, Brackish-Water Corbula
8 *	*Rapana venosa* (syn *Rapana thomasiana*)	Rapa Whelk
9 *	*Mnemiopsis leidyi*	Comb Jelly
10 *	*Caulerpa taxifolia* (exotic strains only)	Green Macroalga
11	*Didemnum* spp. (exotic invasive strains only)	Colonial Sea Squirt
12 *	*Sargassum muticum*	Asian Seaweed
13	*Neogobius melanostomus* (marine/estuarine incursions only)	Round Goby
14	*Marenzelleria* spp. (invasive species and marine/estuarine incursions only)	Red Gilled Mudworm
15	*Balanus improvisus*	Barnacle
16	*Siganus rivulatus*	Marbled Spinefoot, Rabbit Fish
17	*Mya arenaria*	Soft Shell Clam
18	*Ensis directus*	Jack-Knife Clam
19	*Hemigrapsus takanoi/penicillatus*	Pacific Crab
20	*Charybdis japonica*	Lady Crab
Species Established in Australia, but not Widespread		
21 *	*Asterias amurensis*	Northern Pacific Seastar
22	*Carcinus maenas*	European Green Crab
23	*Varicorbula gibba*	European Clam
24 *	*Musculista senhousia*	Asian Bag Mussel, Asian Date Mussel
25	*Sabella spallanzanii*	European Fan Worm
26 *	*Undaria pinnatifida*	Japanese Seaweed
27 *	*Codium fragile* spp. *tomentosoides*	Green Macroalga
28	*Grateloupia turuturu*	Red Macroalga
29	*Maoricolpus roseus*	New Zealand Screwshell
Holoplankton Alert Species * For notification purposes, eradication response from CCIMPE is highly unlikely		
30 *	*Pfiesteria piscicida*	Toxic Dinoflagellate
31	*Pseudo-nitzschia seriata*	Pennate Diatom
32	*Dinophysis norvegica*	Toxic Dinoflagellate
33	*Alexandrium monilatum*	Toxic Dinoflagellate
34	*Chaetoceros concavicornis*	Centric Diatom
35	*Chaetoceros convolutus*	Centric Diatom

* Species on Interim CCIMPE Trigger List

Table 22: Depth class and method of collection for each NIS and C1 species collected during the second Auckland port survey. Data are numbers of samples each species occurred in.

Species	Biosecurity Status	Method *	0 - 5 m	> 5 - 10 m	> 10 - 15 m	> 15 - 20 m	Total
Apocorophium acutum	NIS	BSLD			1		1
		PSC	1	1			2
Bugula flabellata	NIS	BSLD			1		1
		PSC	2				2
		BGRB				1	1
Corella eumyota	C1	PSC	18	5			23
Crassostrea gigas	NIS	PSC	42	13			55
Microcosmus squamiger	C1	PSC	13	5			18
Styela plicata	C1	PSC	2	1			3
Theora lubrica	NIS	BSLD		3	23		26
		BGRB		3	10		13
Watersipora subtorquata	NIS	PSC	1				1
Bougainvillia muscus	C1	BSLD			1		1
		PSC	1	1			2
Callyspongia ramosa	C1	BSLD			1		1
		PSC	1				1
Ciocalypta pencillus	C1	BGRB				1	1
Ciocalypta polymastia	C1	BSLD			1		1
Didemnum sp.	C1	PSC	15	7			22
Diplosoma listerianum	C1	PSC		1			1
Gymnodinium catenatum	C1	CYST	1	1	1		3
Halichondria panicea	C1	PSC		1			1
Haliclona heterofibrosa	C1	BSLD			1		1
		PSC	15	9			24
		BGRB			1		1
Heteromastus filiformis	C1	BGRB		2	1		3
Lissodendoryx isodictyalis	C1	PSC	7	2			9
Microcosmus australis	C1	PSC	1				1
Neodexiospira pseudocorrugata	C1	PSC	1				1
Plakina monolopha	C1	PSC	2				2
Pseudosuberites sulcatus	C1	PSC	1				1
Amphilectus fucorum	NIS	PSC	3	1			4
Barentsia matsushimana	NIS	PSC	1				1
Charybdis japonica	NIS	CRBTP	1	5	9		15
		STFTP	1		1		2
Hydroides elegans	NIS	PSC	2				2
Limaria orientalis	NIS	BGRB				1	1
		STFTP			1		1
Paralepidonotus ampulliferus	NIS	BGRB		1	1		2
Pennaria disticha	NIS	BSLD		1	5		6
		PSC	9	4			13
		BGRB			4	1	5
Styela clava	NIS	PSC	1				1
Total number of NIS & C1 specimens			**142**	**67**	**63**	**4**	**276**
Proportion of all NIS & C1 specimens (%)			**51.4**	**24.3**	**22.8**	**1.4**	**100**
Total number of NIS & C1 taxa			**23**	**18**	**13**	**4**	**31[1]**
Proportion of all NIS & C1 taxa (%)			**74.2**	**58.1**	**41.9**	**12.9**	**#**

* Survey methods: BGRB = benthic grab; BSLD = benthic sled; CYST = dinoflagellate cyst core; CRBTP = crab trap; FSHTP = fish trap; SHRTP = shrimp trap; STFTP = seastar trap; PSC = piling quadrat scrapings.

The proportion of taxa in each depth class sums to greater than 100%, as some taxa were recorded from more than one depth class

[1]Although the total number of NIS and C1 taxa recorded in the survey was 33, the total here excludes *Callyspongia robusta* and *Chaetopterus Chaetopterus*-A which were recorded from pile scrape miscellaneous searches for which depths were not recorded.

Table 23: Depth class and method of collection for each native species collected during the second Auckland port survey. Data are numbers of samples each species occurred in.

Taxon Name	Method *	0 - 5 m	> 5 - 10 m	> 10 - 15 m	> 15 - 20 m	Total
Adocia cf. *parietalioides*	PSC	9	7			16
Aglaophamus verrilli	BSLD			2		2
	BGRB			3		3
Aldrichetta forsteri	CRBTP		1			1
	FSHTP		1			1
Alpheus richardsoni	BSLD		2	7		9
	PSC		1			1
	SHRTP			1		1
	BGRB			1	1	2
Austrominius modestus	PSC	18	3			21
Austrovenus stutchburyi	BSLD			1		1
Balanus trigonus	BSLD			1		1
	PSC	1				1
Beania plurispinosa	PSC	5				5
Boccardia chilensis	PSC	1				1
Cnemidocarpa bicornuta	PSC	13	7			20
Cnemidocarpa nisiotis	PSC	12	3			15
Cominella adspersa	CRBTP			3		3
	STFTP		1	1		2
Coscinasterias muricata	CRBTP			3		3
	PSC	1				1
	STFTP			2		2
Flabelligera affinis	PSC	1	1			2
Galeolaria hystrix	PSC	1				1
Glycera lamelliformis	BSLD			2		2
	BGRB		1	2		3
Halicarcinus varius	BSLD			2		2
	PSC	4	1			5
Harmothoe macrolepidota	BSLD			1		1
	PSC	6	6			12
Hyboscolex longiseta	PSC	2				2
Labiosthenolepis laevis	BSLD			10		10
	BGRB			2		2
Lepidastheniella comma	PSC	1				1
Lepidonotus polychromus	PSC	15	4			19
Macrophthalmus hirtipes	BSLD			1		1
	CRBTP		1			1
Maoricolpus roseus	BSLD			2		2
	CRBTP		1	1		2
	BGRB				1	1
Megalomma suspiciens	PSC	10	5			15
Modiolarca impacta	PSC	3	1			4
Molgula mortenseni	PSC	18	5			23
Natatolana rossi	BSLD			1		1
	SHRTP		1	5		6
Neanthes kerguelensis	PSC	5				5
Neohymenicus pubescens	PSC	10	1			11
Nereis falcaria	PSC	1				1
Notolabrus celidotus	CRBTP	1	5	5		11
	FSHTP	2	1	5		8
	STFTP			1		1

Taxon Name	Method *	0 - 5 m	> 5 - 10 m	> 10 - 15 m	> 15 - 20 m	Total
Notomithrax minor	PSC	9	6			15
Pagrus auratus	CRBTP FSHTP STFTP	2 2 	6 1	7 11 1	 2 	15 15 2
Patiriella regularis	CRBTP STFTP			2 3		2 3
Pectinaria australis	BSLD			2		2
Periclimenes yaldwyni	BSLD PSC BGRB	 6 	 2 	5 1		5 8 1
Perna canaliculus	PSC	1				1
Petrolisthes elongatus	PSC	12	3			15
Petrolisthes novaezelandiae	PSC	8	8			16
Philocheras australis	BSLD			2		2
Phylo novazealandiae	BSLD BGRB		1 	2 5	 1	3 6
Pilumnopeus serratifrons	PSC	1				1
Protocirrineris nuchalis	PSC	4	1			5
Protoperidinium avellana	CYST		1	2		3
Protoperidinium subinerme	CYST		1			1
Pyura rugata	PSC	31	4			35
Sigapatella novaezelandiae	BSLD PSC	 8	 2	1 		1 10
Spirobranchus cariniferus	PSC	5				5
Streblosoma toddae	PSC	3	1			4
Timarete anchylochaetus	PSC	9				9
Xenostrobus pulex	PSC	41	2			43
Abyssoninoe galatheae	BSLD BGRB			1 3		1 3
Acanthochitona zelandica	BSLD PSC	 21		2 		2 21
Acrocirrus trisectus	PSC	1				1
Adamsiella chauvinii	BSLD			2		2
Adocia cf. *venustina*	PSC	3				3
Amphipholis squamata	PSC BGRB	1 			 1	1 1
Amphisbetia bispinosa	PSC	1				1
Ancorina alata	PSC	1				1
Antithamnionella adnata	BSLD PSC	 1		1 		1 1
Asterocarpa cerea	PSC	2				2
Beania sp.	PSC	2				2
Caberea rostrata	BSLD PSC BGRB	 33 	 16 	3 1	 1	3 49 2
Capreolia implexa	PSC	2				2
Caranx georgianus	FSHTP	1		2		3
Carpophyllum flexuosum	BSLD			1		1
Ceramium flaccidum	BSLD			1		1
Chaperiopsis cervicornis	PSC	3				3
Cirolana quechso	BSLD PSC SHRTP STFTP	 1 2 1	 5 4 	1 12 		1 6 18 1
Clathria (Microciona) coccinea	PSC	1				1
Cnemidocarpa otagoensis	PSC	1				1

Taxon Name	Method *	0 - 5 m	> 5 - 10 m	> 10 - 15 m	> 15 - 20 m	Total
Codium convolutum	PSC	1				1
Conger wilsoni	FSHTP			1		1
Cossura consimilis	BSLD		1	3		4
	BGRB		2	7	1	10
Crepidula costata	PSC	18	12			30
	BGRB			1		1
Cryptoconchus porosus	PSC	2				2
Demonax aberrans	PSC	1	1			2
Diasterope grisea	BSLD			1		1
Disporella novaehollandiae	BSLD			1		1
Ecklonia radiata	BSLD			1		1
Endarachne binghamiae	PSC	1				1
Eulalia microphylla	PSC	9				9
Eurypon hispida	PSC	6	4			10
Forsterygion varium	PSC	1				1
Gigartina macrocarpa	PSC	3				3
Glycinde trifida	BSLD		1	3		4
Gollumudes new sp. 1 Bird	PSC	1				1
Haliclona cf. *isodictyale*	PSC	1				1
Haliclona maxima	PSC	1				1
Haliclona stelliderma	PSC	6	4			10
Haplocheira barbimana	BSLD			1		1
Hiatella arctica	PSC	4				4
Hippocampus abdominalis	FSHTP			1		1
Hymedesmia (Stylopus) lissostyla	PSC	2				2
Hymedesmia microstrongyla	PSC	2	3			5
Ischyromene kokotahi	PSC	7				7
Leucothoe trailli	PSC	3	1			4
Liljeborgia akaroica	PSC	1				1
Lissoclinum notti	PSC		1			1
Lytocarpia chiltoni	BSLD			1		1
Melita festiva	BSLD			1		1
	PSC	8	7			15
Micrelenchus huttonii	BSLD			4		4
Microporella intermedia	BGRB				1	1
Mycale (Carmia) tasmani	PSC	10	6			16
	BGRB			1		1
Nemadactylus macropterus	STFTP		1			1
Onchidella nigricans	PSC	10				10
Ophiodromus angustifrons	PSC		1			1
Ophionereis fasciata	PSC	1				1
Parawaldeckia vesca	PSC		1			1
	SHRTP		1			1
Perinereis camiguinoides	PSC	2				2
Perinereis pseudocamiguina	PSC	5				5
Pherusa parmata	PSC	18	7			25
Pilumnus novaezelandiae	BSLD			1		1
	PSC	10	5			15
Pinnotheres novaezelandiae	PSC	3				3
Pleuromeris zelandica	BSLD			2		2
Polysiphonia decipiens	BSLD			3		3
	PSC	1				1
Porphyra suborbiculata	PSC	1				1
Prionospio aucklandica	BGRB		1			1
Protoperidinium conicum	CYST			3		3
Protoperidinium punctulatum	CYST	1	1			2

Taxon Name	Method *	0 - 5 m	> 5 - 10 m	> 10 - 15 m	> 15 - 20 m	Total
Pseudophaeroma campbellensis	PSC	7				7
Pseudopotamilla laciniosa	PSC	15	1			16
Pterocirrus brevicornis	PSC	1				1
Pyura picta	PSC	16	7			23
Pyura pulla	PSC		1			1
Pyura subuculata	PSC	1	1			2
Risellopsis varia	PSC	4				4
Scorpis lineolata	FSHTP		2	1		3
Scrippsiella trochoidea	CYST		1			1
Siphonaria australis	PSC	1				1
Solanderia ericopsis	PSC	3				3
Sypharochiton pelliserpentis	PSC	19				19
Tawera spissa	BSLD			1		1
Tenagomysis longisquama	PSC	2	2			4
Tetraclitella purpurascens	PSC	1				1
Trachelochismus melobesia	FSHTP			1		1
Trachurus novaezelandiae	FSHTP			1		1
Trochus viridis	STFTP			1		1
Trypanosyllis zebra	PSC	6	4			10
Tugali suteri	PSC	8	1			9
Upeneichthys lineatus	STFTP			1		1
Upeneichthys porosus	CRBTP		1			1
Total number of native specimens		**584**	**206**	**181**	**9**	**980**
Proportion of all native specimens (%)		**59.6**	**21.0**	**18.5**	**0.9**	**100.0**
Total number of native taxa		**96**	**63**	**54**	**8**	**143**[1]
Proportion of all native taxa (%)		**67.1**	**44.1**	**37.8**	**5.6**	**#**

* Survey methods: BGRB = benthic grab; BSLD = benthic sled; CYST = dinoflagellate cyst core; CRBTP = crab trap; FSHTP = fish trap; SHRTP = shrimp trap; STFTP = seastar trap; PSC = piling quadrat scrapings

The proportion of taxa in each depth class sums to greater than 100%, as some taxa were recorded from more than one depth class

[1]Although the total number of native taxa recorded in the survey was 145, the total here excludes *Actinothoe albens* and *Rostanga muscula* which were recorded from pile scrape miscellaneous searches for which depths were not recorded.

Table 24: Summary statistics for taxon assemblages collected in the Port of Auckland using four different methods, and similarity indices comparing assemblages between the first and second survey. See "Definitions of species categories" for definitions of Native, C1 and C2 (cryptogenic category 1 and 2) and NIS (non-indigenous species) taxa.

	No. of samples in first survey	No. of samples in second survey	No. of taxa in first survey	No. of taxa in second survey	No. (%) of taxa shared between surveys	No. of taxa in first survey only	No. of taxa in second survey only	No. (%) of taxa in only one sample in first survey	No. (%) of taxa in only one sample in second survey	Chao Shared Estimate	Jaccard Classic	Sorensen Classic	Chao-Jaccard-Est Incidence -based	Chao-Sorensen -Est Incidence -based
Pile scrape quadrats														
Native	90	86	88	96	54 (42 %)	34	42	34 (39 %)	32 (33 %)	72.868	0.415	0.587	0.766	0.868
C2	90	86	10	14	7 (41 %)	3	7	2 (20 %)	4 (29 %)	9.223	0.412	0.583	0.764	0.866
NIS & C1	90	86	23	23	15 (48 %)	8	8	8.82 (38 %)	9 (.39 %)	20.734	0.484	0.652	0.854	0.921
Benthic sleds														
Native	12	30	18	37	11 (25 %)	7	26	12 (67 %)	19 (51 %)	16.021	0.25	0.4	0.667	0.801
C2	12	30	1	1	0	1	1	1 (100 %)	1 (100 %)	Not enough taxa encountered for meaningful analysis				
NIS & C1	12	30	7	8	3 (25 %)	4	5	3 (43 %)	6 (75 %)	Not enough taxa encountered for meaningful analysis				
Benthic grabs														
Native	18	30	8	15	4 (21 %)	4	11	5 (63 %)	7 (47 %)	5.511	0.211	0.348	0.251	0.402
C2	18	30	0	0	0	0	0	0	0	Not enough taxa encountered for meaningful analysis				
NIS & C1	18	30	1	8	1 (13 %)	0	7	0	4 (50 %)	Not enough taxa encountered for meaningful analysis				
Crab traps														
Native	24	31	4	9	3 (30 %)	1	6	1 (25 %)	3 (30 %)	See analysis for all taxa combined				
C2	24	31	0	0	0	0	0	0	0	Not enough taxa encountered for meaningful analysis				
NIS & C1	24	31	1	1	1 (100 %)	0	0	0	0	Not enough taxa encountered for meaningful analysis				
Native, C2, NIS & C1 taxa combined	24	31	5	10	4 (37 %)	1	6	1 (20 %)	3 (33 %)	Not enough taxa encountered for meaningful analysis				

Appendices

Appendix 1: Definitions of vessel types and geographical areas used in analyses of the LMIU shipping movements database

A. Groupings of countries into geographical areas. A country may be included in more than one geographical area category if different parts of that country are considered (by LMIU) to belong to different geographical areas (for example, Canada occurs in the NE Canada and Great Lakes area and in the West Coast North America area). Only countries that occur in the database are listed in the table below.

Geographical area	Countries / locations included
Africa Atlantic coast	Angola
	The Congo
	Nigeria
Antarctica (includes Southern Ocean)	Antarctica
	Australia (Macquarie Is)
Australia	Australia (general)
	Australia (VIC)
	Australia (QLD)
	Australia (NSW)
	Australia (TAS)
	Australia (WA)
	Australia (NT)
	Australia (SA)
Black Sea coast	Russian Federation
Caribbean Islands	Bahamas
	Cuba
	Jamaica
	Puerto Rico
Central America inc Mexico to Panama	Costa Rica
	El Salvador
	Guatemala
	Mexico
	Panama
North-west Pacific	People's Republic of China
	Republic of Korea
	Russian Federation
	Taiwan
	Vietnam
Eastern Mediterranean inc Cyprus, Turkey	Turkey

Geographical area	Countries / locations included
European Mediterranean coast	France
	Gibraltar
	Italy
	Malta
	Spain
Gulf of Mexico	United States of America
Gulf States	Iran
	Kuwait
	Saudi Arabia
	State of Qatar
	Sultanate of Oman
	United Arab Emirates
Central Indian Ocean	Bangladesh
	India
	Pakistan
	Sri Lanka
Japan	Japan
N.E. Canada and Great Lakes	Canada
New Zealand	New Zealand
North African coast	Algeria
	Arab Republic of Egypt
	Morocco
	Spain
	Tunisia
	Western Sahara
North European Atlantic coast	Belgium
	France
	Germany
	Netherlands
Pacific Islands	American Samoa
	Cook Islands
	Fiji
	French Polynesia
	Guam
	Independent State of Samoa
	Kiribati
	Marshall Islands
	New Caledonia
	Niue Island

Geographical area	Countries / locations included
	Norfolk Island
	Northern Marianas
	Papua New Guinea
	Pitcairn Islands
	Solomon Islands
	Tokelau Islands
	Tonga
	Tuvalu
	Vanuatu
	Wallis & Futuna
Red Sea coast inc up to the Persian Gulf	Arab Republic of Egypt
	Saudi Arabia
	Sudan
	Yemeni Republic
Scandinavia inc Baltic, Greenland, Iceland etc	Denmark
	Norway
	Poland
	Russian Federation
South & East African coasts	Heard & McDonald Islands
	Kenya
	Mauritius
	Mozambique
	Republic of Djibouti
	Republic of Namibia
	Reunion
	South Africa
South America Atlantic coast	Argentina
	Aruba
	Brazil
	Colombia
	Falkland Islands
	Netherlands Antilles
	Uruguay
	Venezuela
South America Pacific coast	Chile
	Ecuador
	Peru
Spain / Portugal inc Atlantic Islands	Canary Islands
	Portugal

Geographical area	Countries / locations included
	Spain
U.S, Atlantic coast including part of Canada	United States of America
United Kingdom inc Eire	United Kingdom
East Asian seas	Indonesia
	Malaysia
	Philippines
	Republic of Singapore
	Sultanate of Brunei
	Thailand
West coast North America inc USA, Canada & Alaska	Canada
	United States of America

B. Groupings of vessel sub-types according to LMIU definitions.

Vessel type definition in this report	General type as listed in LMIU database	Sub type code from LMIU database	Definition of sub type in LMIU database
Bulk/ cement carrier	B	BU	bulk
	B	CB	bulk/c.c.
	B	CE	cement
	B	OR	ore
	B	WC	wood-chip
Bulk/ oil carrier	C	BO	bulk/oil
	C	OO	ore/oil
Dredge	D	BD	bucket dredger
	D	CH	cutter suction hopper dredger
	D	CS	cutter suction dredger
	D	DR	dredger
	D	GD	grab dredger
	D	GH	grab hopper dredger
	D	HD	hopper dredger
	D	SD	suction dredger
	D	SH	suction hopper dredger
	D	SS	sand suction dredger
	D	TD	trailing suction dredger
	D	TS	trailing suction hopper dredger
Fishing	F	FC	fish carrier
	F	FF	fish factory
	F	FP	fishery protection
	F	FS	fishing
	F	TR	trawler
	F	WF	whale factory
	F	WH	whaler
General cargo	G	CT	cargo/training
	G	GC	general cargo
	G	PC	part c.c.
	G	RF	ref
LPG / LNG	L	FP	floating production

Vessel type definition in this report	General type as listed in LMIU database	Sub type code from LMIU database	Definition of sub type in LMIU database
	L	FS	floating storage
	L	NG	Lng
	L	NP	Lng/Lpg
	L	PG	Lpg
Passenger/ vehicle/ livestock	M	LV	livestock
	M	PR	passenger
	M	VE	vehicle
Other (includes pontoons, barges, mining & supply ships, etc)	O	BA	barge
	O	BS	buoy ship/supply
	O	BY	buoy ship
	O	CL	cable
	O	CP	cable pontoon
	O	CS	crane ship
	O	CX	crane barge
	O	DE	depot ship
	O	DS	diving support
	O	ES	exhibition ship
	O	FL	floating crane
	O	FY	ferry
	O	HB	hopper barge
	O	HF	hydrofoil
	O	HL	semi-sub HL vessel
	O	HS	hospital ship
	O	HT	semi-sub HL/tank
	O	IB	icebreaker
	O	IF	icebreaker/ferry
	O	IS	icebreaker/supply
	O	IT	icebreaker/tender
	O	LC	landing craft
	O	LT	lighthouse tender
	O	MN	mining ship
	O	MS	mission ship
	O	MT	maintenance
	O	OS	offshore safety
	O	PA	patrol ship
	O	PC	pollution control vessel
	O	PD	paddle
	O	PI	pilot ship
	O	PL	pipe layer
	O	PO	pontoon
	O	PP	pipe carrier
	O	RD	radio ship
	O	RN	ro/ro pontoon
	O	RP	repair ship
	O	RX	repair barge
	O	SB	storage barge
	O	SC	sludge carrier

Vessel type definition in this report	General type as listed in LMIU database	Sub type code from LMIU database	Definition of sub type in LMIU database
	O	SP	semi-sub pontoon
	O	SS	storage ship
	O	SU	support
	O	SV	salvage
	O	SY	supply
	O	SZ	standby safety vessel
	O	TB	tank barge
	O	TC	tank cleaning ship
	O	TN	tender
	O	TR	training
	O	WA	waste ship
	O	WO	work ship
	O	YT	yacht
Passenger ro/ro	P	RR	passenger ro/ro
Research	R	HR	hydrographic research
	R	MR	meteorological research
	R	OR	oceanographic research
	R	RB	research/buoy ship
	R	RE	research
	R	RS	research/supply ship
	R	SR	seismographic research
Tanker (including chemical/ oil / ashphalt etc)	T	AC	acid tanker
	T	AS	asphalt tanker
	T	BK	bunkering tanker
	T	CH	chem.tank
	T	CO	chemical/oil carrier
	T	CR	crude oil tanker
	T	EO	edible oil tanker
	T	FJ	fruit juice tanker
	T	FO	fish oil tanker
	T	FP	floating production
	T	FS	floating storage
	T	MO	molasses tanker
	T	NA	naval auxiliary
	T	PD	product tanker
	T	TA	non specific tanker
	T	WN	wine tank
	T	WT	water tanker
Container/ unitised carrier and ro/ro	U	BC	barge carrier/c.c.
	U	BG	barge carrier
	U	CC	c.c. container/unitised carrier
	U	CR	c.c.ref
	U	RC	ro/ro/c.c.
	U	RR	ro/ro
Tug	X	AA	anchor handling salvage tug
	X	AF	anchor handling firefighting tug/supply

Vessel type definition in this report	General type as listed in LMIU database	Sub type code from LMIU database	Definition of sub type in LMIU database
	X	AG	anchor handling firefighting tug
	X	AH	anchor handling tug/supply
	X	AT	anchor handling tug
	X	CT	catamaran tug
	X	FF	firefighting tug
	X	FS	firefighting tug/supply
	X	FT	firefighting tractor tug
	X	PT	pusher tug
	X	ST	salvage tug
	X	TG	tug
	X	TI	tug/icebreaker
	X	TP	tug/pilot ship
	X	TR	tractor tug
	X	TS	tug/supply
	X	TT	tug/tender
	X	TX	tug/support

Appendix 2: Geographic locations of sample sites in the Port of Auckland second baseline survey (NZGD49)

Site	Easting	Northing	Survey Method*	Number of sample units
Auckland Port	2667372	6483429	CRBTP	3
Auckland Port	2667384	6483464	CRBTP	3
Auckland Port	2667750	6482957	CRBTP	3
Auckland Port	2667818	6483129	CRBTP	3
Auckland Port	2667833	6482853	CRBTP	3
Auckland Port	2667858	6483217	CRBTP	3
Auckland Port	2667929	6483168	CRBTP	3
Auckland Port	2668059	6483021	CRBTP	3
Auckland Port	2668145	6482980	CRBTP	3
Auckland Port	2668175	6482784	CRBTP	3
Auckland Port	2668177	6483107	CRBTP	3
Auckland Port	2668262	6482771	CRBTP	3
Auckland Port	2668400	6482883	CRBTP	3
Auckland Port	2668566	6483131	CRBTP	3
Auckland Port	2668747	6482768	CRBTP	3
Auckland Port	2668750	6483116	CRBTP	3
Auckland Port	2668816	6482944	CRBTP	3
Auckland Port	2668845	6482908	CRBTP	3
Auckland Port	2668916	6482759	CRBTP	3
Auckland Port	2668981	6482671	CRBTP	3
Auckland Port	2669099	6482613	CRBTP	3
Auckland Port	2669186	6483048	CRBTP	3
Auckland Port	2669191	6482942	CRBTP	3
Auckland Port	2669316	6482756	CRBTP	3
Auckland Port	2669334	6482747	CRBTP	3
Auckland Port	2669351	6482656	CRBTP	3
Auckland Port	2669382	6482535	CRBTP	3
Auckland Port	2669421	6483056	CRBTP	3
Auckland Port	2669446	6483072	CRBTP	3
Auckland Port	2669531	6482476	CRBTP	3
Auckland Port	2667383	6483440	STFTP	2
Auckland Port	2667818	6483139	STFTP	2
Auckland Port	2668055	6483002	STFTP	2
Auckland Port	2668175	6482784	STFTP	2
Auckland Port	2668340	6482838	STFTP	2
Auckland Port	2668573	6483121	STFTP	2
Auckland Port	2669163	6482965	STFTP	2
Auckland Port	2669288	6482759	STFTP	2
Auckland Port	2667324	6483380	PSCM	1
Auckland Port	2667837	6482932	PSCM	1
Auckland Port	2668114	6482943	PSCM	1
Auckland Port	2668360	6482757	PSCM	1
Auckland Port	2668847	6483080	PSCM	1
Auckland Port	2669075	6482874	PSCM	1
Auckland Port	2669446	6482903	PSCM	1
Axis Bledisloe 1 Wharf	2668500	6483102	BGRB	1
Axis Bledisloe 1 Wharf	2668503	6483112	BGRB	1
Axis Bledisloe 1 Wharf	2668512	6483104	BGRB	1
Axis Bledisloe 1 Wharf	2668472	6482956	BSLD	1

Site	Easting	Northing	Survey Method*	Number of sample units
Axis Bledisloe 1 Wharf	2668527	6483124	BSLD	1
Axis Bledisloe 1 Wharf	2668531	6483107	CRBTP	2
Axis Bledisloe 1 Wharf	2668579	6483119	CRBTP	2
Axis Bledisloe 1 Wharf	2668839	6483107	CRBTP	2
Axis Bledisloe 1 Wharf	2668868	6483091	CRBTP	2
Axis Bledisloe 1 Wharf	2668572	6483140	FSHTP	2
Axis Bledisloe 1 Wharf	2668619	6483139	FSHTP	2
Axis Bledisloe 1 Wharf	2668512	6483104	SEDIMENT	1
Axis Bledisloe 1 Wharf	2668531	6483107	SHRTP	1
Axis Bledisloe 1 Wharf	2668579	6483119	SHRTP	2
Axis Bledisloe 1 Wharf	2668839	6483107	SHRTP	1
Axis Bledisloe 1 Wharf	2668868	6483091	SHRTP	1
Axis Bledisloe 1 Wharf	2668531	6483107	STFTP	2
Axis Bledisloe 1 Wharf	2668579	6483119	STFTP	2
Axis Bledisloe 1 Wharf	2668839	6483107	STFTP	2
Axis Bledisloe 1 Wharf	2668868	6483091	STFTP	2
Axis Bledisloe 2 Wharf	2668838	6483049	BGRB	1
Axis Bledisloe 2 Wharf	2668845	6483062	BGRB	1
Axis Bledisloe 2 Wharf	2668856	6483075	BGRB	1
Axis Bledisloe 2 Wharf	2668822	6483112	BSLD	1
Axis Bledisloe 2 Wharf	2668830	6482953	BSLD	1
Axis Bledisloe 2 Wharf	2668856	6483065	BSLD	1
Axis Bledisloe 2 Wharf	2668799	6483098	FSHTP	2
Axis Bledisloe 2 Wharf	2668865	6483088	FSHTP	2
Axis Bledisloe 2 Wharf	2668856	6483075	SEDIMENT	1
Axis Fergusson 1 Wharf	2669490	6482521	BGRB	1
Axis Fergusson 1 Wharf	2669501	6482538	BGRB	1
Axis Fergusson 1 Wharf	2669514	6482538	BGRB	1
Axis Fergusson 1 Wharf	2669388	6482558	BSLD	1
Axis Fergusson 1 Wharf	2669441	6482593	BSLD	1
Axis Fergusson 1 Wharf	2669405	6483080	CRBTP	2
Axis Fergusson 1 Wharf	2669428	6483044	CRBTP	2
Axis Fergusson 1 Wharf	2669512	6482491	CRBTP	2
Axis Fergusson 1 Wharf	2669512	6482577	CRBTP	2
Axis Fergusson 1 Wharf	2669436	6482605	CYST	1
Axis Fergusson 1 Wharf	2669445	6482587	CYST	1
Axis Fergusson 1 Wharf	2669470	6482803	FSHTP	2
Axis Fergusson 1 Wharf	2669531	6482517	FSHTP	2
Axis Fergusson 1 Wharf	2669462	6482806	PSC	16
Axis Fergusson 1 Wharf	2669462	6482806	PSCM	2
Axis Fergusson 1 Wharf	2669490	6482521	SEDIMENT	1
Axis Fergusson 1 Wharf	2669405	6483080	SHRTP	1
Axis Fergusson 1 Wharf	2669428	6483044	SHRTP	1
Axis Fergusson 1 Wharf	2669512	6482491	SHRTP	1
Axis Fergusson 1 Wharf	2669512	6482577	SHRTP	1
Axis Fergusson 1 Wharf	2669405	6483080	STFTP	2
Axis Fergusson 1 Wharf	2669428	6483044	STFTP	2
Axis Fergusson 1 Wharf	2669512	6482491	STFTP	2
Axis Fergusson 1 Wharf	2669512	6482577	STFTP	2
Axis Fergusson 2 Wharf	2669410	6483054	BGRB	1
Axis Fergusson 2 Wharf	2669413	6483065	BGRB	1
Axis Fergusson 2 Wharf	2669415	6483047	BGRB	1

Site	Easting	Northing	Survey Method*	Number of sample units
Axis Fergusson 2 Wharf	2669422	6482985	BSLD	1
Axis Fergusson 2 Wharf	2669436	6482979	BSLD	1
Axis Fergusson 2 Wharf	2669687	6483157	BSLD	1
Axis Fergusson 2 Wharf	2669769	6482941	BSLD	1
Axis Fergusson 2 Wharf	2669431	6483050	FSHTP	2
Axis Fergusson 2 Wharf	2669476	6483058	FSHTP	2
Axis Fergusson 2 Wharf	2669415	6483047	SEDIMENT	1
Captain Cook Wharf	2668135	6482921	BSLD	1
Freyberg Wharf	2669057	6482725	BSLD	1
Freyberg Wharf	2669222	6482725	BSLD	1
Jellicoe Wharf	2668978	6482850	BGRB	1
Jellicoe Wharf	2668980	6482832	BGRB	1
Jellicoe Wharf	2668993	6482861	BGRB	1
Jellicoe Wharf	2668980	6482850	BSLD	1
Jellicoe Wharf	2669101	6482952	BSLD	1
Jellicoe Wharf	2668818	6482733	CRBTP	2
Jellicoe Wharf	2668901	6482745	CRBTP	2
Jellicoe Wharf	2668875	6482789	CYST	1
Jellicoe Wharf	2668904	6482810	CYST	1
Jellicoe Wharf	2668800	6482734	FSHTP	2
Jellicoe Wharf	2668909	6482765	FSHTP	2
Jellicoe Wharf	2669073	6482884	PSC	16
Jellicoe Wharf	2669073	6482884	PSCM	1
Jellicoe Wharf	2668980	6482832	SEDIMENT	1
Jellicoe Wharf	2668818	6482733	SHRTP	1
Jellicoe Wharf	2668901	6482745	SHRTP	1
Jellicoe Wharf	2668818	6482733	STFTP	2
Jellicoe Wharf	2668901	6482745	STFTP	2
Marsden Wharf	2668370	6482726	BGRB	1
Marsden Wharf	2668377	6482713	BGRB	1
Marsden Wharf	2668377	6482716	BGRB	1
Marsden Wharf	2668315	6482783	BSLD	1
Marsden Wharf	2668384	6482794	BSLD	1
Marsden Wharf	2668388	6482803	CRBTP	2
Marsden Wharf	2668396	6482831	CRBTP	2
Marsden Wharf	2668375	6482780	CYST	1
Marsden Wharf	2668388	6482816	CYST	1
Marsden Wharf	2668382	6482800	FSHTP	2
Marsden Wharf	2668400	6482886	FSHTP	2
Marsden Wharf	2668391	6482822	PSC	8
Marsden Wharf	2668370	6482726	SEDIMENT	1
Marsden Wharf	2668388	6482803	SHRTP	1
Marsden Wharf	2668396	6482831	SHRTP	1
Marsden Wharf	2668388	6482803	STFTP	2
Marsden Wharf	2668396	6482831	STFTP	2
Princes 1 Wharf	2667851	6482918	BGRB	1
Princes 1 Wharf	2667869	6482930	BGRB	1
Princes 1 Wharf	2667875	6482932	BGRB	1
Princes 1 Wharf	2667910	6483097	BSLD	1
Princes 1 Wharf	2667936	6483186	BSLD	1
Princes 1 Wharf	2667894	6483081	PSC	16
Princes 1 Wharf	2667894	6483081	PSCM	2

Site	Easting	Northing	Survey Method*	Number of sample units
Princes 1 Wharf	2667851	6482918	SEDIMENT	1
Princes 2 Wharf	2667795	6483169	BGRB	1
Princes 2 Wharf	2667808	6483180	BGRB	1
Princes 2 Wharf	2667828	6483190	BGRB	1
Princes 2 Wharf	2667773	6483093	BSLD	1
Princes 2 Wharf	2667812	6483176	BSLD	1
Princes 2 Wharf	2667798	6483077	FSHTP	2
Princes 2 Wharf	2667826	6483158	FSHTP	2
Princes 2 Wharf	2667795	6483169	SEDIMENT	1
Princes Wharf	2667785	6483031	CRBTP	2
Princes Wharf	2667835	6483188	CRBTP	2
Princes Wharf	2667862	6482996	CRBTP	2
Princes Wharf	2667896	6483076	CRBTP	2
Princes Wharf	2667852	6482923	CYST	1
Princes Wharf	2667871	6482969	CYST	1
Princes Wharf	2667861	6482995	FSHTP	2
Princes Wharf	2667902	6483087	FSHTP	2
Princes Wharf	2667785	6483031	SHRTP	1
Princes Wharf	2667835	6483188	SHRTP	1
Princes Wharf	2667862	6482996	SHRTP	2
Princes Wharf	2667896	6483076	SHRTP	2
Princes Wharf	2667785	6483031	STFTP	2
Princes Wharf	2667835	6483188	STFTP	2
Princes Wharf	2667862	6482996	STFTP	2
Princes Wharf	2667896	6483076	STFTP	2
Queens Wharf	2668102	6482796	BGRB	1
Queens Wharf	2668107	6482816	BGRB	1
Queens Wharf	2668111	6482798	BGRB	1
Queens Wharf	2668058	6483021	BSLD	1
Queens Wharf	2668147	6482956	BSLD	1
Queens Wharf	2668184	6483069	BSLD	1
Queens Wharf	2668122	6482905	CRBTP	2
Queens Wharf	2668144	6482977	CRBTP	2
Queens Wharf	2668107	6482842	CYST	1
Queens Wharf	2668117	6482878	CYST	1
Queens Wharf	2668123	6482927	FSHTP	2
Queens Wharf	2668185	6483059	FSHTP	2
Queens Wharf	2668110	6482924	PSC	14
Queens Wharf	2668107	6482816	SEDIMENT	1
Queens Wharf	2668122	6482905	SHRTP	1
Queens Wharf	2668144	6482977	SHRTP	1
Queens Wharf	2668122	6482905	STFTP	2
Queens Wharf	2668144	6482977	STFTP	2
Wynyard Wharf	2667445	6483390	BGRB	1
Wynyard Wharf	2667481	6483368	BGRB	1
Wynyard Wharf	2667486	6483336	BGRB	1
Wynyard Wharf	2667322	6483328	BSLD	1
Wynyard Wharf	2667328	6483587	BSLD	1
Wynyard Wharf	2667381	6483407	BSLD	1
Wynyard Wharf	2667460	6483146	BSLD	1
Wynyard Wharf	2667635	6483340	BSLD	1
Wynyard Wharf	2667126	6483162	CRBTP	2

Site	Easting	Northing	Survey Method*	Number of sample units
Wynyard Wharf	2667261	6483322	CRBTP	2
Wynyard Wharf	2667168	6483194	CYST	1
Wynyard Wharf	2667174	6483203	CYST	1
Wynyard Wharf	2667172	6483198	FSHTP	2
Wynyard Wharf	2667214	6483256	FSHTP	2
Wynyard Wharf	2667169	6483217	PSC	16
Wynyard Wharf	2667169	6483217	PSCM	3
Wynyard Wharf	2667445	6483390	SEDIMENT	1
Wynyard Wharf	2667126	6483162	SHRTP	1
Wynyard Wharf	2667261	6483322	SHRTP	1
Wynyard Wharf	2667126	6483162	STFTP	2
Wynyard Wharf	2667261	6483322	STFTP	2

*Survey methods: PSC = pile scrape quadrats, PSCM = diver observations on wharf pilings, BSLD = benthic sled, BGRB = benthic grab, CYST = dinoflagellate cyst core, CRBTP = crab trap, FSHTP = fish trap, SEDIMENT = sediment core, STFTP = seastar trap, SHRTP = shrimp trap

Appendix 3: Generic descriptions of representative groups of the main marine phyla collected during sampling

Phylum Annelida
Polychaetes: The polychaetes are the largest group of marine worms and are closely related to the earthworms and leeches found on land. Polychaetes are widely distributed in the marine environment and are commonly found under stones and rocks, buried in the sediment or attached to submerged natural and artificial surfaces including rocks, pilings, ropes and the shells or carapaces of other species. All polychaete worms have visible legs or bristles attached to each of their body segments as well as external gills. The anterior segments bear the tentacles used as sensory organs, tasting palps and eyespots, however, some are blind. Many species live in tubes secreted by the body or assembled from debris and sediments, while others are free-living. Depending on species, polychaetes feed by filtering small food particles from the water or by preying upon smaller creatures.

Phylum Arthropoda
The Arthropoda are a very large group of organisms, with well-known members including crustaceans, insects and spiders.
Crustaceans: The crustaceans (including Classes Malacostra, Cirripedia and other smaller classes) represent one of the sea's most diverse groups of organisms, including shrimps, crabs, lobsters, amphipods, tanaids and several other groups. Most crustaceans are motile (capable of movement) although there are also a variety of sessile species (e.g. barnacles). All crustaceans are protected by an external carapace, and most can be recognised by having two pairs of antennae.
Pycnogonids: The pycnogonids, or sea spiders, are closely related to land spiders. They are commonly encountered living among sponges, hydroids and bryozoans on the seafloor. They range in size from a few millimetres to many centimetres and superficially resemble spiders found on land.

Phylum Bacillariophyta
Diatoms: Diatoms are abundant unicellular organisms that are capable of inhabiting marine and freshwater environments. Their cell walls are made of silica which form radial or bilaterally symmetrical patterns. They reproduce asexually and produce energy via photosynthesis.

Phylum Brachiopoda
Brachiopods have a shell consisting of two valves that enclose the animal. Most living brachiopods are fixed to the substrate with a leathery holdfast called a pedicle. They feed via a lophophore; a cartilage based fan with flexible filaments. They are specialists in nutrient poor environments, have low metabolic rates and very small body to lophophore ratios.

Phylum Bryozoa
Bryozoans: This group of organisms is also referred to as 'moss animals' or 'lace corals'. Bryozoans are sessile and live attached to submerged natural and artificial surfaces including rocks, pilings, ropes and the shells or carapaces of other species. They are all colonial, with individual colonies consisting of hundreds of individual 'zooids'. Bryozoans can have encrusting growth forms that are sheet-like and approximately 1 mm thick, or can form erect or branching structures several centimetres high. Bryozoans feed by filtering small food particles from the water column, and colonies grow by producing additional zooids.

Phyla Chlorophyta, Rhodophyta and Ochrophyta

Macroalgae: Marine macroalgae are highly diverse and are grouped under several phyla. The green algae are in phylum Chlorophyta; red algae are in phylum Rhodophyta, and the brown algae are in phylum Ochrophyta. Whilst the green and red algae fall under Kingdom Plantae, the brown algae (Phylum Ochrophyta) are grouped in the Kingdom Chromista. Despite their disparate systematics, most red, green and brown algae perform many similar ecological functions. Large macroalgae were sampled that live attached to submerged natural and artificial surfaces including rocks, pilings, ropes and the shells or carapaces of other species.

Phylum Chordata

Ascidiacea: Ascidians are sometimes referred to as 'sea squirts' or 'tunicates'. Adult ascidians are sessile (permanently attached to the substrate) organisms that live on submerged natural and artificial surfaces including rocks, pilings, ropes and the shells or carapaces of other species. Ascidians can occur as individuals (solitary ascidians) or merged together into colonies (colonial ascidians). They are soft-bodied and have a rubbery or jelly-like outer coating (test). They feed by pumping water into the body through an inhalant siphon. Inside the body, food particles are filtered out of the water, which is then expelled through an exhalant siphon. Ascidians reproduce via swimming larvae (ascidian tadpoles) that retain a notochord, which explains why these animals are included in the Phylum Chordata along with vertebrates.

Actinopterygii: The class Actinopterygii refers to the ray-finned fishes. This is an extremely diverse group. Approximately 200 families of fish are represented in New Zealand waters ranging from tropical and subtropical groups in the north to sub Antarctic groups in the south. They can be classified ecologically according to depth habitat preferences; for example, fish that live on or near the sea floor are considered demersal while those living in the upper water column are termed pelagics.

Elasmobranchii: The class Elasmobranchii are one of two classes of cartilaginous fishes, including sharks, skates and rays.

Phylum Cyanobacteria

Cyanobacteria or blue-green algae are photosynthetic prokaryotes. They form a pigment during photosynthesis that leads to their blue-green colour and some species are also capable of fixing nitrogen under certain circumstances. They lack cilia and perform locomotion by gliding across surfaces. They also possess thick cell walls to protect them from desiccation. They show considerable morphological diversity and are found in a wide variety of terrestrial and aquatic habitats.

Phylum Cnidaria

Anthozoa: The class Anthozoa includes the true corals, sea anemones and sea pens.

Hydrozoa: The class Hydrozoa includes hydroids, fire corals and many medusae. Of these, only hydroids were recorded in the port surveys. Hydroids can easily be mistaken for erect and branching bryozoans. They are also sessile organisms that live attached to submerged natural and artificial surfaces including rocks, pilings, ropes and the shells or carapaces of other species. All hydroids are colonial, with individual colonies consisting of hundreds of individual 'polyps'. Like bryozoans, they feed by filtering small food particles from the water column.

Scyphozoa: Scyphozoans are the true jellyfish.

Phylum Echinodermata

Echinoderms: The phylum echinodermata is made up of five classes. They are: Crinoidea (sea lilies), Asteroidea (sea stars), Holothuroidea (sea cucumbers), Ophiuroidea (brittle stars), and Echinoidea (sea urchins). This phylum is an exclusively marine phylum that lack eyes or brains but have radially symmetrical body plans. Their most notable features are their external calcareous plates and spines from which they get their name (Echinoderm means 'spinyskinned'). Internally they are unique as well with a hydraulic water vascular system that controls their movement and is monitored by the madreporite which controls their intake of water. They occupy a wide range of habitats including subtidal and intertidal zones.

Phylum Entoprocta

Superficially this phylum is very similar to the Bryozoans and both are referred to as moss animals. There are about 60 known species worldwide and all of them are small with no individual exceeding 1.5mm in length. They live in moss-like colonies containing thousands of individuals, forming mats of considerable size. Each animal is crowned with a circlet of ciliated tentacles, within which lies the mouth. The defining characteristic between entoprocts and bryozoans is the location of the anal opening. In entoprocts it is within the crown circlet, in bryozoans the anus is located outside the tentacles.

Phylum Haptophyta

Most species from this phylum are single-celled flagellates, also having amoeboid, coccoid, palmelloid or filamentous stages. The cells are golden or yellow-brown due to the presence of accessory pigments. It usually has two flagella of equal or sub equal length both of which are smooth and an appendage between them called a haptonema which may be used for capturing food. The surface of the cell is covered in granules and calcified scales may potentially be visible under a light microscope.

Phylum Magnoliophyta

Seagrasses: The Magnoliophyta are the flowering plants, or angiosperms. Most of these are terrestrial, but the Magnoliophyta also include marine representatives – the seagrasses.

Phylum Mollusca

Molluscs: There are 4 main classes of Mollusca which include Polyplacophora (Chitons), Gastropoda (marine snails, sea hares, nudibranchs and limpets), Bivalvia (mussels, clams, oysters), and Cephalopoda (squid, cuttlefish and octopus). They are a highly diverse group of marine animals characterised by the presence of an external or internal shell. There are two structures in this phylum that are found no where else in the animal kingdom; they are the mantle and the radula. The mantle is a fold in the body wall that secretes the calcareous shell which is typical of the phylum. The radula is a toothed, tongue or ribbon like organ variously modified for special feeding techniques.

Phylum Myzozoa

Dinoflagellates: Dinoflagellates are a large group of unicellular algae that live in the water column or within the sediments. About half of all dinoflagellates are capable of photosynthesis and some are symbionts, living inside organisms such as jellyfish and corals. Some dinoflagellates are phosphorescent and can be responsible for the phosphorescence visible at night in the sea. The phenomenon known as red tide occurs when the rapid reproduction of certain dinoflagellate species results in large brownish red algal blooms. Some dinoflagellates are highly toxic and can kill fish and shellfish, or poison humans that eat these infected organisms.

Phylum Nemertea

Ribbon worms: The ribbon worms are cylindrical to somewhat flattened, highly contractile, soft-bodied, unsegmented worms. Generally they are small but a few species can reach up to 6m in length. They are usually very slender, brightly coloured, and have an unusual anterior proboscis equipped with a sharp spine to capture prey. They live by either burrowing in sand, living in algal clumps or mats or in oyster shells. They reproduce sexually as well as asexually by fragmentation.

Phylum Platyhelminthes

Flatworms: The flatworms are unsegmented, flattened, and very soft-bodied. The mouth is located ventrally near the midpoint of the animal or at the anterior end. There are three Classes of flatworm; Turbellaria, Trematoda, and the Cestoda. Many are very small but some can reach considerable sizes and they range in colour from very drab, transparent animals to ones with bright colours.

Phylum Porifera

Sponges: Sponges are very simple colonial organisms that live attached to submerged natural and artificial surfaces including rocks, pilings, ropes and the shells or carapaces of other species. They are a taxonomically difficult group of marine invertebrates. Most sponges possess skeletal support from need-like spicules and they vary greatly in colour and shape, and include sheet-like encrusting forms, branching forms and tubular forms. Sponge surfaces have thousands of small pores to through which water is drawn into the colony, where small food particles are filtered out before the water is again expelled through one or several other holes.

Phylum Sipuncula

Sipunculids: The phylum Sipuncula (peanut worms) is a group of unsegmented, marine coelomates that are closely related to annelids and molluscs. They have two body regions: a trunk and a more slender proboscis or introvert. This introvert lies enrolled in the body cavity of the animal giving it an oval or peanut shape and only when it is feeding does the introvert fold out. They have a variety of epidermal structures, such as papillae, hooks and shields. They live in a variety of habitats including burrows in silt and sand, under rock crevices and some species bore into coral or soft rock. They have also been known to inhabit the empty shells and tubes of other species.

Please email surveillance@mpi.govt.nz to receive the results for each sampling method used below

Appendix 4a: Results from the pile scraping quadrats.
Appendix 4b: Results from the benthic grab samples.
Appendix 4c: Results from the benthic sled samples.
Appendix 4d: Results from the dinoflagellate cyst core samples.
Appendix 4e: Results from the fish trap samples.
Appendix 4f: Results from the crab trap samples.
Appendix 4g: Results from the seastar trap samples.
Appendix 4h: Results from the shrimp trap samples.
Appendix 4i: Results from the wharf piling miscellaneous searches.

Appendix 5: Chapman and Carlton criteria applicable to each non-indigenous and C1 taxon recorded from the Port of Auckland.

Chapman and Carlton's (1994) nine criteria (C1 – C9) were assessed for each non-indigenous and cryptogenic category 1 taxon recorded from the Port of Auckland. Criteria that apply to each species are indicated with a "Yes" or another comment. Cranfield *et al*'s (1998) analysis was used for species previously known from New Zealand waters. For non-indigenous species that were first detected in New Zealand since the publication of that report, criteria were assigned using advice from the taxonomists that identified them.

Taxon name	Bio-security Status	C1: Has the species suddenly appeared locally where it has not been found before?	C2: Has the species spread subsequently?	C3: Is the species' distribution associated with human mechanisms of dispersal?	C4: Is the species associated with, or dependent on, other introduced species?	C5: Is the species prevalent in, or restricted to, new or artificial environments?	C6: Is the species' distribution restricted compared to natives?	C7: Does the species have a disjunct worldwide distribution?	C8: Are dispersal mechanisms of the species inadequate to reach New Zealand, and is passive dispersal in ocean currents unlikely to bridge ocean gaps to reach NZ?	C9: Is the species isolated from the genetically and morphologically most similar species elsewhere in the world?
Annelida										
Paralepidonotus ampulliferus	NIS	yes	yes	no	no	no	yes	yes	yes	yes
Hydroides elegans	NIS	yes	yes	yes	yes	yes	yes	yes	yes	yes
Neodexiospira pseudocorrugata	C1	no	no	no	no	no	no	no	no	no
Heteromastus filiformis	C1	no	no	no	no	no	no	no	yes	no
Chaetopterus chaetopterus-A	C1	no	no	no	no	no	no	no	no	no
Arthropoda										
Apocorophium acutum	NIS	no	no	yes	no	no	yes	no	yes	yes
Charybdis japonica	NIS	yes	yes	yes	no	no	yes	yes	yes	yes
Bryozoa										

Taxon name	Bio-security Status	C1: Has the species suddenly appeared locally where it has not been found before?	C2: Has the species spread subsequently?	C3: Is the species' distribution associated with human mechanisms of dispersal?	C4: Is the species associated with, or dependent on, other introduced species?	C5: Is the species prevalent in, or restricted to, new or artificial environments?	C6: Is the species' distribution restricted compared to natives?	C7: Does the species have a disjunct worldwide distribution?	C8: Are dispersal mechanisms of the species inadequate to reach New Zealand, and is passive dispersal in ocean currents unlikely to bridge ocean gaps to reach NZ?	C9: Is the species isolated from the genetically and morphologically most similar species elsewhere in the world?
Bugula flabellata	NIS	yes	yes	yes	no	yes	yes	yes	yes	no
Watersipora subtorquata	NIS	yes	yes	yes	no	yes	yes	yes	yes	yes
Chordata										
Didemnum sp.	C1	Unsure	no	no	no	no	no	no	no	no
Diplosoma listerianum	C1	yes	yes	yes	no	yes	yes	yes	yes	no
Corella eumyota	C1	yes	yes	yes	no	yes	no	yes	yes	no
Microcosmus australis	C1	no	no	no	no	no	no	no	no	no
Microcosmus squamiger	C1	No specific studies on distribution, so records just indicate research progress, not necessarily new introductions	Unknown, there is no published data to support subsequent spread or indeed time of introduction.	Possibly because it is associated with artificial structures and boat hulls, but no published studies support this	No	Not really. In port surveys, found mostly on quadrat scrapings, but also found on rocky coastlines	The information on biogeography of NZ ascidians is fragmented at best.	yes	Unsure, but is most likely to have arrived in NZ on ships hulls	Unknown
Styela clava	NIS	yes	yes	yes	no	yes	yes	yes	yes	yes
Styela plicata	C1	yes	yes	yes	no	yes	yes	yes	yes	no

Taxon name	Bio-security Status	C1: Has the species suddenly appeared locally where it has not been found before?	C2: Has the species spread subsequently?	C3: Is the species' distribution associated with human mechanisms of dispersal?	C4: Is the species associated with, or dependent on, other introduced species?	C5: Is the species prevalent in, or restricted to, new or artificial environments?	C6: Is the species' distribution restricted compared to natives?	C7: Does the species have a disjunct worldwide distribution?	C8: Are dispersal mechanisms of the species inadequate to reach New Zealand, and is passive dispersal in ocean currents unlikely to bridge ocean gaps to reach NZ?	C9: Is the species isolated from the genetically and morphologically most similar species elsewhere in the world?
Cnidaria										
Bougainvillia muscus	C1	no	no	no	no	no	no	no	no	no
Pennaria disticha	NIS	yes	no	yes	no	yes	yes	no	no	no
Entoprocta										
Barentsia matsushimana	NIS	yes	yes	yes	no	yes	yes	yes	yes	no
Mollusca										
Limaria orientalis	NIS	yes	yes	yes	no	no	yes	yes	yes	yes
Crassostrea gigas	NIS	yes	yes	yes	no	no	yes	yes	yes	yes
Theora lubrica	NIS	yes	yes	no	no	yes	yes	yes	yes	yes
Myzozoa										
Gymnodinium catenatum	C1	yes	yes	no	no	no	no	no	no	no
Porifera										
Pseudosuberites sulcatus	C1	no	Unsure	Unsure. Common where they occur.	no	no	no	yes	Unlikely (short-lived viviparous larvae)	Unknown. Insufficient information on interocean genetics.
Halichondria panicea	C1	yes	yes	yes	no	no	yes	yes	yes	no
Ciocalypta pencillus	C1									

Taxon name	Bio-security Status	C1: Has the species suddenly appeared locally where it has not been found before?	C2: Has the species spread subsequently?	C3: Is the species' distribution associated with human mechanisms of dispersal?	C4: Is the species associated with, or dependent on, other introduced species?	C5: Is the species prevalent in, or restricted to, new or artificial environments?	C6: Is the species' distribution restricted compared to natives?	C7: Does the species have a disjunct worldwide distribution?	C8: Are dispersal mechanisms of the species inadequate to reach New Zealand, and is passive dispersal in ocean currents unlikely to bridge ocean gaps to reach NZ?	C9: Is the species isolated from the genetically and morphologically most similar species elsewhere in the world?
Ciocalypta polymastia	C1									
Callyspongia ramosa	C1	yes	Unknown. Early collections in these locations were not at all comprehensive and the species could have been overlooked.	Unsure. These are particularly common sponges where they dooccurr around New Zealand	no	no	no	yes	Unlikely (short-lived viviparous larvae)	Unknown. Insufficient information on interocean genetics, however most work on so called cosmopolitan species that are similar to these species have ben found to be genetically isolated.
Callyspongia robusta	NIS									
Haliclona heterofibrosa	C1	no	Unknown. Early collections in these locations were not at all comprehensive	Unsure. These are particularly common sponges	no	no	no	yes	Unlikely (short-lived viviparous larvae)	Unknown. Insufficient information on interocean genetics,

Taxon name	Bio-security Status	C1: Has the species suddenly appeared locally where it has not been found before?	C2: Has the species spread subsequently?	C3: Is the species' distribution associated with human mechanisms of dispersal?	C4: Is the species associated with, or dependent on, other introduced species?	C5: Is the species prevalent in, or restricted to, new or artificial environments?	C6: Is the species' distribution restricted compared to natives?	C7: Does the species have a disjunct worldwide distribution?	C8: Are dispersal mechanisms of the species inadequate to reach New Zealand, and is passive dispersal in ocean currents unlikely to bridge ocean gaps to reach NZ?	C9: Is the species isolated from the genetically and morphologically most similar species elsewhere in the world?
			and the species could have been overlooked.	where they dooccurr around New Zealand						however most work on so called cosmopolitan species that are similar to these species have ben found to be genetically isolated.
Plakina monolopha	C1	Unknown.	Unknown.	no	no	no	no	no	no	Unknown. Insufficient information on interocean genetics.
Lissodendoryx isodictyalis	C1	Only a single specimen was described and identified with *L. isodictyalis* by Bergquist & Fromont (1988). The species has never been	Unknown	yes	No	Likely to have preferences for sheltered and rather shallow habitats such as mangrove	yes	no	Yes	Unsure

Taxon name	Bio-security Status	C1: Has the species suddenly appeared locally where it has not been found before?	C2: Has the species spread subsequently?	C3: Is the species' distribution associated with human mechanisms of dispersal?	C4: Is the species associated with, or dependent on, other introduced species?	C5: Is the species prevalent in, or restricted to, new or artificial environments?	C6: Is the species' distribution restricted compared to natives?	C7: Does the species have a disjunct worldwide distribution?	C8: Are dispersal mechanisms of the species inadequate to reach New Zealand, and is passive dispersal in ocean currents unlikely to bridge ocean gaps to reach NZ?	C9: Is the species isolated from the genetically and morphologically most similar species elsewhere in the world?
		picked up again in general subtidal surveys in the past 9 years.								
Amphilectus fucorum	NIS	no	no	no	no	no	no	no	no	no