Viaduct Harbour Marina

First 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 port baseline survey of the Viaduct Harbour Marina undertaken in March-April 2006. The survey provides an initial inventory of native, non indigenous and cryptogenic marine species within the marina.

- 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 yachts entering New Zealand from overseas.

- Sampling methods used in the survey 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 Viaduct Harbour Marina. 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 was distributed in the Viaduct Harbour Marina 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.

- During the survey, 151 species or higher taxa were recorded, including 86 native species, 19 non-indigenous species, 16 cryptogenic taxa and 30 indeterminate taxa.

- The 19 non-indigenous species found in the repeat survey of the Viaduct Harbour Marina included representatives of 14 phyla. The non-indigenous species detected were: (Annelida) *Hydroides elegans*, *Polydora hoplura*, *Pseudopolydora paucibranchiata Paralepidonotus ampulliferus*, (Bryozoa) *Bugula stolonifera*, *Schizoporella errata*, *Watersipora arcuata*, *Tricellaria catalinensis*, *Bowerbankia gracilis*, *Zoobotryon verticillatum Buskia socialis*, (Chordata) *Ascidiella aspersa*, *Diplosoma listerianum*, *Botryllus tuberatus Styela clava* (Cnidaria) *Pennaria disticha*, (Mollusca) *Limaria orientalis, Theora lubrica* and (Ochrophyta) *Undaria pinnatifida*.

- One species recorded in the survey, the cryptogenic category 1 shrimp *Lysmata vittata*, was a new record for New Zealand waters.

- Two species recorded during the survey of the Viaduct Harbour Marina – the clubbed tunicate, *Styela clava* and the Asian kelp *Undaria pinnatifida* - are on the New Zealand Register of Unwanted Organisms.

- Most non-indigenous species located in the Marina 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 53 % (10 of 19 species) of NIS recorded in the Viaduct Harbour Marina baseline survey are likely to have been introduced in hull fouling assemblages, 5 % (1 species) via ballast water and 42 % (8 species) could have been introduced by either ballast water or hull fouling vectors.

- The predominance of hull fouling species in the introduced biota of Viaduct Harbour Marina (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 taxa 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.

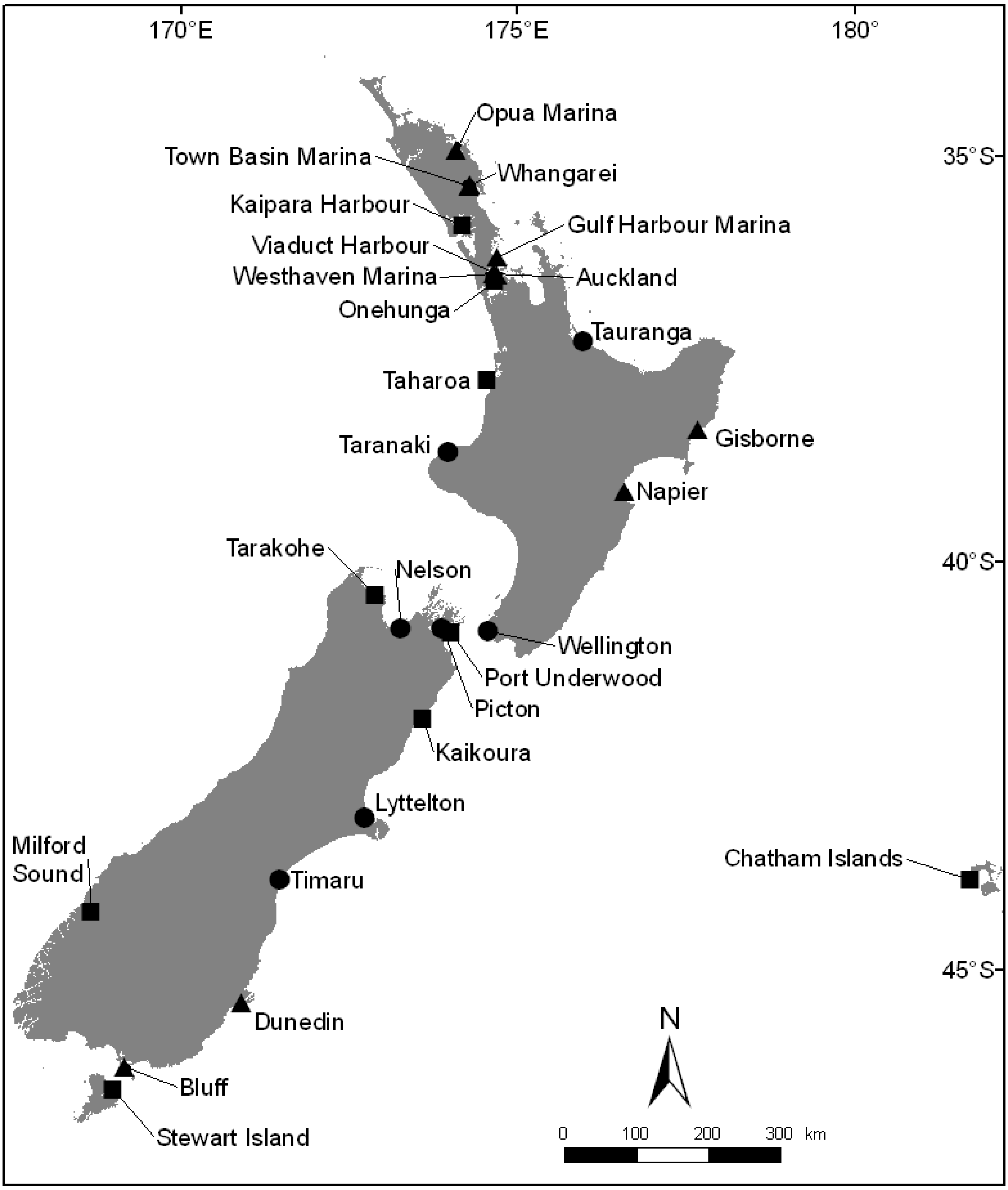

Figure 1: Commercial shipping ports in New Zealand where baseline non-indigenous species surveys have been conducted. Group 1 ports (circles) were surveyed in the summer of 2001/2002 and resurveyed in the summer of 2004/2005, Group 2 ports (triangles) were surveyed in the summer of 2002/2003 and resurveyed 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] taxa, 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 *et al*. (2007b) 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 taxa 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*. (2007b) and a 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 risk profiling of problem species through the sharing of information with other shipping nations (Hewitt and Martin 2001).

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

This report describes the results of a first baseline survey of the Viaduct Harbour Marina undertaken in March-April 2006. In this report we provide an inventory of species recorded during the survey and their biogeographic status as either native, introduced ("non-indigenous") or cryptogenic. Organisms that could not be identified to species level are also listed as indeterminate taxa (see "Definitions of species categories", in methods section).

The report is intended as a stand-alone record. We include background information on the Viaduct Harbour Marina, including its history, physical environment, shipping and trading patterns, development and maintenance activities, and biological environment.

DESCRIPTION OF THE VIADUCT HARBOUR MARINA

General features

The Viaduct Harbour Marina is located on the waterfront of Auckland's central business district on the southern shore of Waitemata Harbour (Figure 2). The multi-facility precinct provides a range of commercial and leisure marine activities to both private residential and commercial developers (Viaduct Harbour 2007).

Waitemata Harbour occupies a drowned valley system with numerous ancillary tidal rivers and is connected to the Hauraki Gulf via the Rangitoto channel (Thompson 1981). 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.

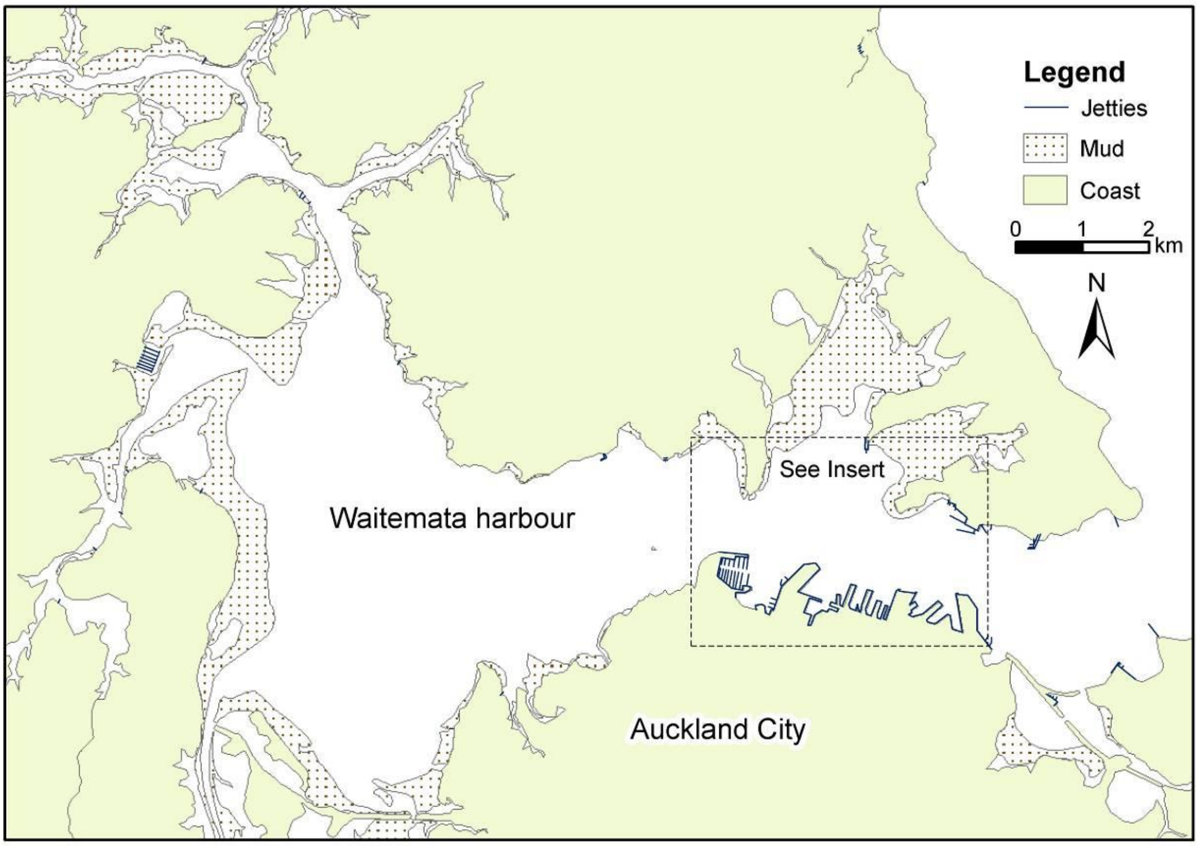

Figure 2: Waitemata Harbour showing the location of the Viaduct Harbour Marina (Figure 3)

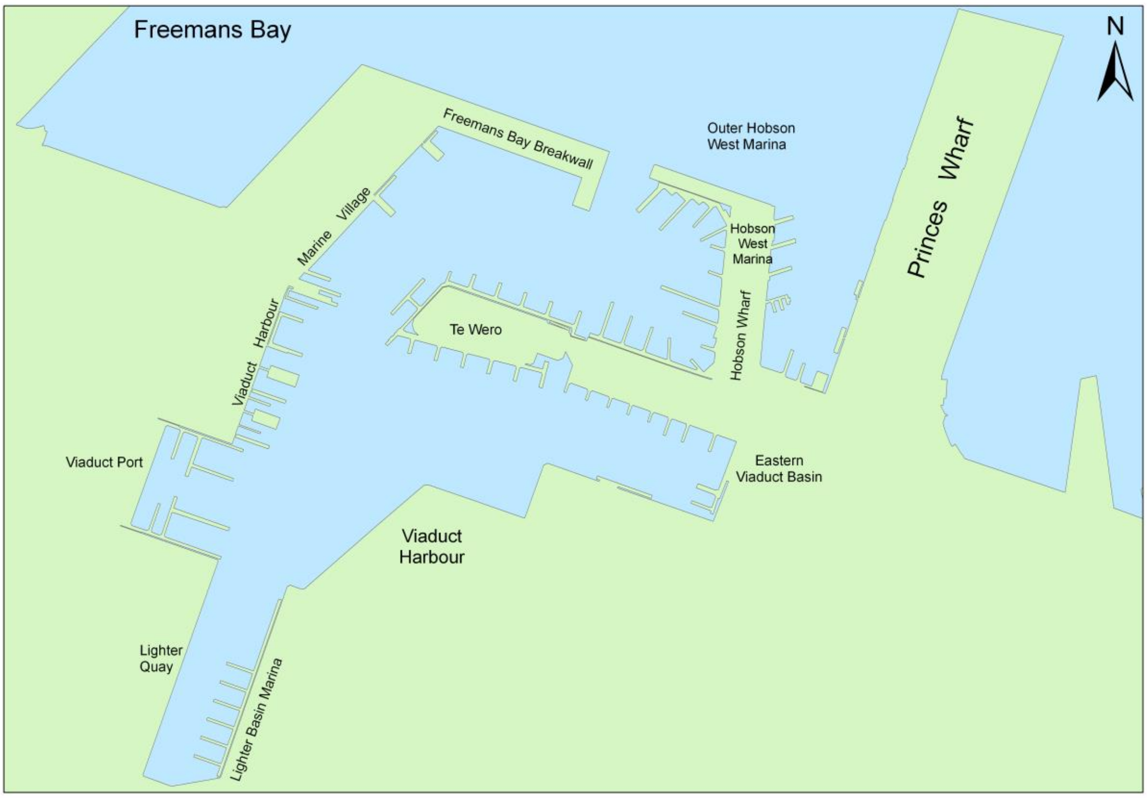

Figure 3 Viaduct Harbour Marina showing the main wharves and jetties

Marina operation, development and maintenance activities

The Viaduct Harbour Marina is situated within Freemans Bay, an area of the commercial Port of Auckland bounded by Wynyard Wharf in the west and Princes Wharf to the east. All vessel traffic and water exchange between the Viaduct Harbour Marina and surrounding areas occurs though the marina entrance which opens out north through Freemans Bay. Access to vessels within the Viaduct Harbour Marina is provided by a series of floating walkways and pontoons, restrained by piles on the seabed. Over 60 floating finger pontoons provide berthing space for more than 100 vessels. These floating pontoons are typically constructed from concrete-covered foam held in place by vertical wooden piles (Gust *et al.* 2005). Details of the major berthing facilities are provided in Table 1.

Major redevelopment of the Viaduct Harbour Marina occurred during 1999, in preparation for the Americas Cup races in 1999/2000 (Bebelman 1999). Construction involved dredging of the seabed, disposal of contaminated sediment, reclamation of an island and wharf as well as declamation of the existing 'Log Farm'structure. Investigation of surface sediments within the marina revealed contamination by heavy metal and organic compounds up to 2.5 m deep. Consequently dredging and construction involving around 300,000 m^3 of sediment was carried out in the confines of geotextile silt fences to prevent movement of contaminated material. Excavated spoil was mixed with concrete to create 'mudcrete' and used to reclaim land upon which some of the syndicate bases were built. The developer, Americas Cup Village Ltd, was granted a permit to ocean dispose clean sandstone beyond the 12 nm limit. Declamation of the Log Farm area was carfully monitored as this land was originally reclaimed in the 1940s by filling with refuge. This area was found to be heavily contaminated and a drainage system was installed to capture leachate passing through the area. Silt fences were used for declamation as well as a floating boom to absorb any released hydrocarbons. The Log Farm seawall proved effective in containing most contamination and a new seawall was constructed before the old one was removed (Bebelman 1999).

The marina can be divided into several different sectors which can be defined by the predominant ownership, function and usage. Located closest to the marina entrance and separated from the rest of the marina by Te Wero (The Island) and carparking facilities, is Hobson West Marina. This north eastern section of the marina provides the majority of berthing facilities for charter boats and larger recreational vessels. It has a total of 22 berths which range in size from 16m to 50m.

The southern side of the Viaduct Harbour basin is made up of the Eastern Viaduct Harbour Marina, Waitemata Plaza Marina, Lighter Basin Marina and the Viaduct Port, from where a number of charter and commercial services operate. To the south of the Viaduct Port is the Lighter Quay residential development and associated berthing facilities, and to the north lies the Viaduct Harbour Marine Village. The Marine Village operates a haul-out and hardstand facility for vessels up to 30 tonnes and has berthage facilities for vessels 5.5 m to 55 m length.

Vessel movements and ballast discharge patterns

Vessels entering New Zealand waters at Auckland must first clear the Customs/MAF facility in Waitemata harbour, after which many boats travel to a local marina for a few days (mainly Westhaven, Bayswater or Viaduct Harbour Marinas; O. Floerl, NIWA, pers .comm.). The Viaduct Harbour Marina is a no-discharge area for vessels.

Many of the daily vessel movments in and out of the Viaduct Harbour are private or commercial charter vessels on day trips to other locations in Waitemata Harbour or the inner Hauraki Gulf. The nearby islands of Great Barrier, Waiheke and Rangitoto are popular destinations for these trips. Popular overnight destinations for yachts from the Waitemata

Harbour include Great Barrier Island, Opua (Bay of Islands), Gulf Harbour Marina, Tutukaka Marina and Kawau Island (Gust *et al*. 2005).

The number of overseas yachts travelling to New Zealand has increased dramatically over the last three decades. Data from the New Zealand customs service show that around 900 international boats visited in 2000, almost three times as many as in 1993 (Inglis and Floerl 2002). Most vessels entering New Zealand waters clear customs in Opua, Whangarei and Auckland. The number of pleasure craft entering Opua Marina accounts for almost 70 % of all international recreational craft visits to NZ, and is more than four times that of Auckland, the next busiest location (Campbell 2004). Interviews with marina operators suggest that the majority of overseas vessels entering New Zealand waters spend most of their time in Northland and Auckland and do not travel further south than Tauranga. The peak period for arrivals of international yachts is between October and December as the vessels move south to avoid the austral tropical cyclone season, with most vessels departing in April and May when the cyclone season has ended. (Inglis and Floerl 2002)

The majority of international arrivals to New Zealand come from the South Pacific (around 80%) or Australia (16%; O. Floerl, NIWA, pers. comm.). The main points of origin in these areas are Fiji, Tonga, New Caledonia, Australia (Coffs Harbour, Lord Howe Island, Brisbane, Sydney, Norfolk Island, Bundaberg, Gladstone, Southport, Townsville, Launceston), Cook Islands, Vanuatu, Western Samoa, American Samoa, Niue, French Polynesia and the US Pacific Dependency (Inglis and Floerl 2002).

Movement of recreational yachts (domestic and international) to and from the Viaduct Harbour Marina were derived from a national questionnaire survey of approximately 1,300 yacht owners (O. Floerl, NIWA, unpublished data). National survey information was used to create an epidemiological model simulating yacht movements between main marinas around NZ. Annual movements of yachts between marinas were calculated from a 10-year simulation. The calculated average number of recreational vessels departing the Viaduct Harbour Marina and heading to one of 36 domestic destination ports was 273 annually. The five most common destination ports for vessels travelling from the Viaduct Harbour Marina were: Picton (165), Opua (23), Auckland Westhaven Marina (22), Gulf Harbour Marina (18) and Whangarei Town Basin Marina (12). A similar trend was seen in recreational vessels arriving at the Viaduct Harbour Marina (272 annual arrivals). The five most common origin ports were Picton (165), Opua (23), Auckland Westhaven Marina (22), Gulf Harbour Marina (17) and Whangarei Town Basin Marina (12; O. Floerl, NIWA, unpublished data).

EXISTING BIOLOGICAL INFORMATION

Over the last two decades, a variety of biological surveys have been carried out in the Waitemata Harbour and around Viaduct Marina and 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. Several surveys have included a specific focus on the Viaduct Harbour Marina. 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 recorded in 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 abundant 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* suggests that translocation of the invasive kelp to Auckland by fouled barge or associated vessel was the most likely mode of introduction. *Undaria pinnatifida* appears to have been present at the

Auckland CBD waterfront since roughly 2000. It has been detected in parts of Viaduct Harbour, Westhaven Marina, along the breakwall at Wynyard Wharf and at the Caltex and BP service station floating berths on the north-western side of Wynard Wharf (Stuart and McClary 2004).

The non-indigenous clubbed tunicate, *Styela clava*, was found to be widespread throughout the Viaduct Harbour and Freemans Bay during a rapid delimination survey carried out by NIWA (Gust *et al*. 2005). It was detected in all sections of the Viaduct Harbour, and was found to inhabit a range of substrates including finger wharves, pontoons, wharf pilings, rock walls, ropes, barges and moored vessels. Densities of *S. clava* were estimated to be in the range of 1 - 10 individuals per m^2. These densities are up to three orders of magnitude lower than nuisance densities reported for this species overseas where *S. clava* has caused significant ecological and economic impacts. At very high densities, *S. clava* is capable of smothering other fauna, competing for food resources with other suspension feeders, and causing a nuisance to long-line mussel culture (Bourque *et al*. 2003). *S. clava* is thought to be native to the coastal waters of Japan, Korea, Northern China and Siberia (Furlani 1996). It is capable of rapid proliferation and has a history of invasive spread in temperate marine environments, establishing many non-indigenous populations worldwide.

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 Organisms (i.e. *Undaria pinnatifida, Caulerpa taxifolia, Asterias amurensis, Sabella spallanzanii, Carcinus maenas, Eriocheir sinensis* and *Potamocorbula amurensis*) 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 introduced majid crab *Pyromaia tuberculata* was recorded from Waitemata Harbour. A single specimen was collected in a sled sample east of the Harbour Bridge.

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 (Creese *et al*. 1997; Crooks and Soule 1999).

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).

Methods

SURVEY METHOD DEVELOPMENT

The survey of Viaduct Harbour and Marina was undertaken from 22nd March – 4th April 2006. 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. 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 2. 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 survey of the Viaduct Harbour Marina.

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). If only outer facings were present, then four outer piles were sampled. On each piling, four quadrats (40 cm x 25 cm) were fixed to the outer surface of the pile at water depths of approximately -0.5 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 4). 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.

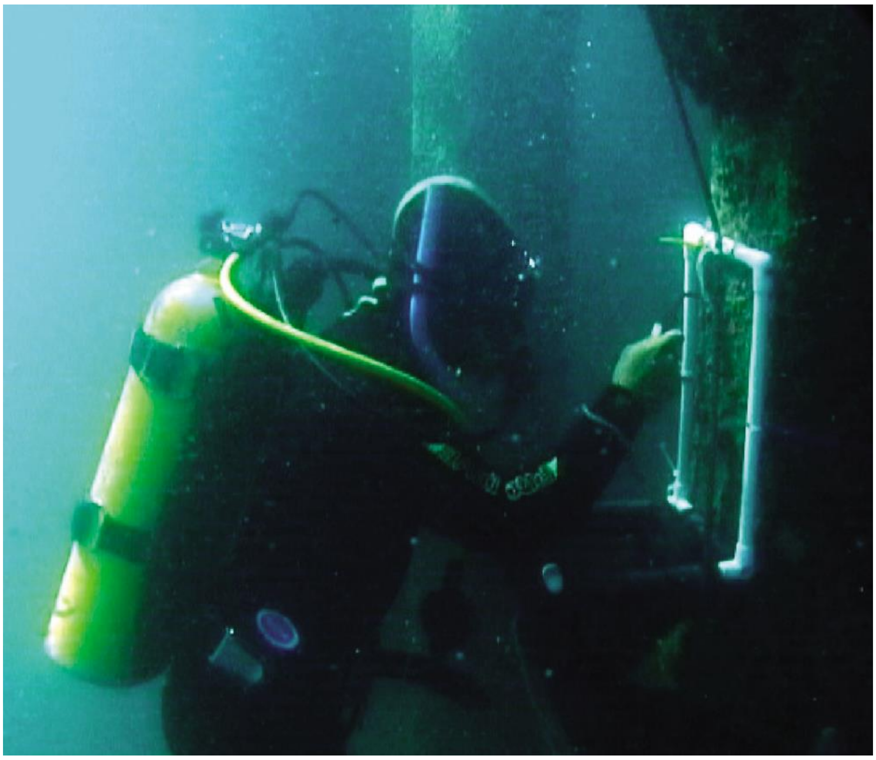

Figure 4: Diver sampling organisms on pier piles.

BENTHIC FAUNA

Benthic infauna was sampled using a Shipek grab sampler deployed from a research vessel moored adjacent to the berth (Figure 5), 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 5: 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 6). 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.

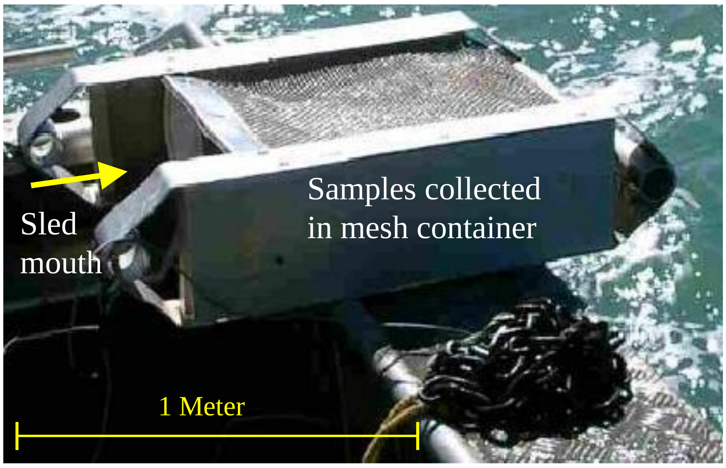

Figure 6: Benthic sled

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 7). 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).

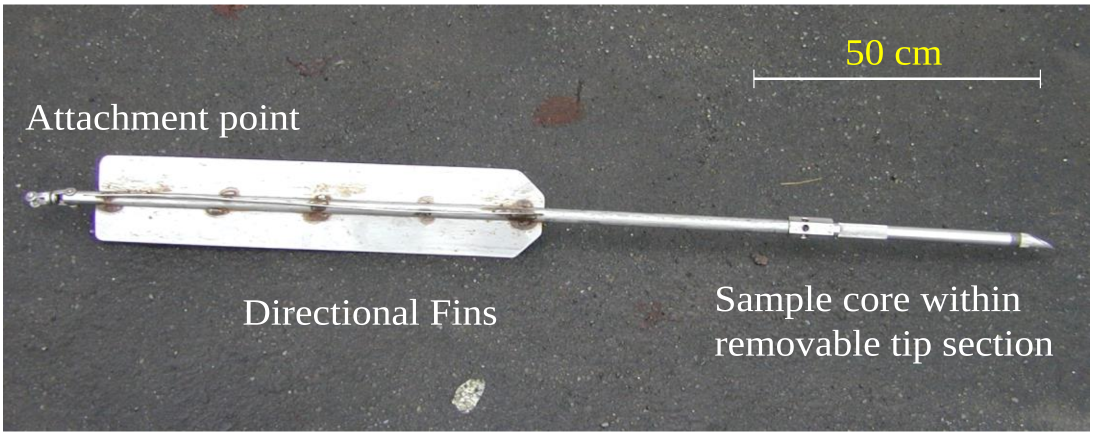

Figure 7: Javelin corer

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 8). 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 8). 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 8). 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.

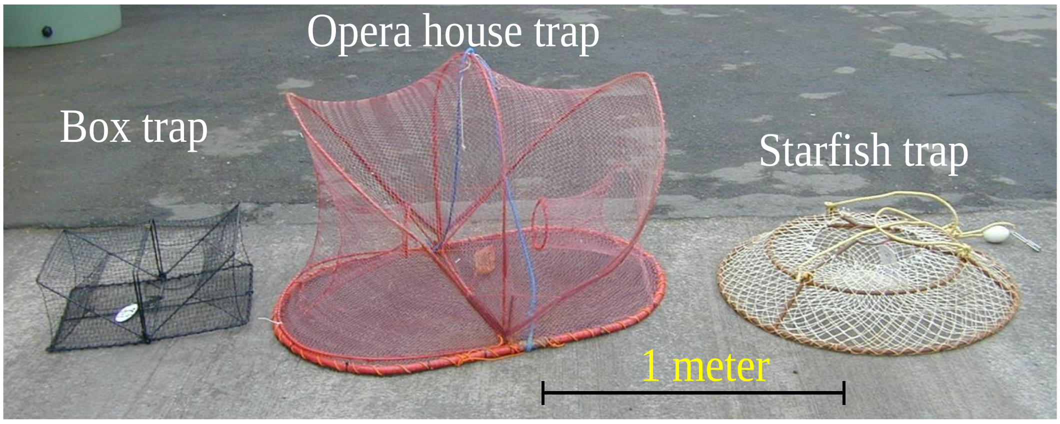

Figure 8: **Trap types deployed in the port.**

VISUAL SEARCHES

Qualitative above-water visual searches were conducted at fourteen sites in the Viaduct Harbour Marina. Observers searched for any potential invasive species fouling pontoons, rock facings, breakwalls, berths and associated structures.

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 3). 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 first baseline survey of the Viaduct Harbour Marina is provided in Table 4, 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 baseline survey, most sample effort was concentrated around eight areas – Viaduct Harbour Marine Village, Viaduct Port, Lighter Basin Marina, Te Wero North, Te Wero South, Eastern Viaduct Basin, Freemans Bay Breakwall and Hobson West Marina in the main marina area. These areas are spread throughout the marina and represented a range of active berths and lay-up areas (

Figure 3, Table 4). The spatial distribution of sampling effort for each of the sample methods is indicated in the following figures: diver pile scraping and javelin cyst coring (

Figure 9), benthic sled and benthic grab sampling (Figure 10), fish, crab, seastar and shrimp trapping (

Figure 11), and sediment sampling (

Figure 12).

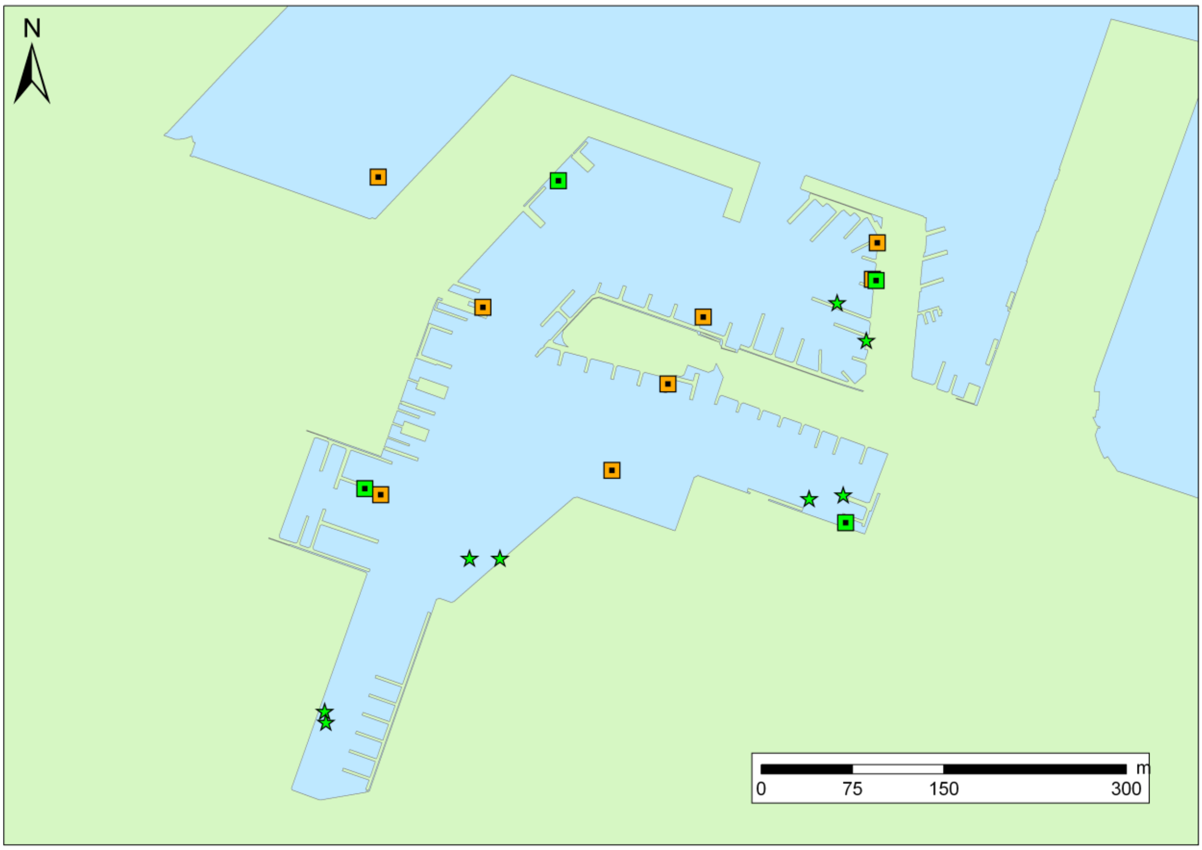

Figure 9: **Diver pile scraping (green squares), visual diver transect searches (orange squares) and dinoflagellate cyst core (green stars) sampling sites.**

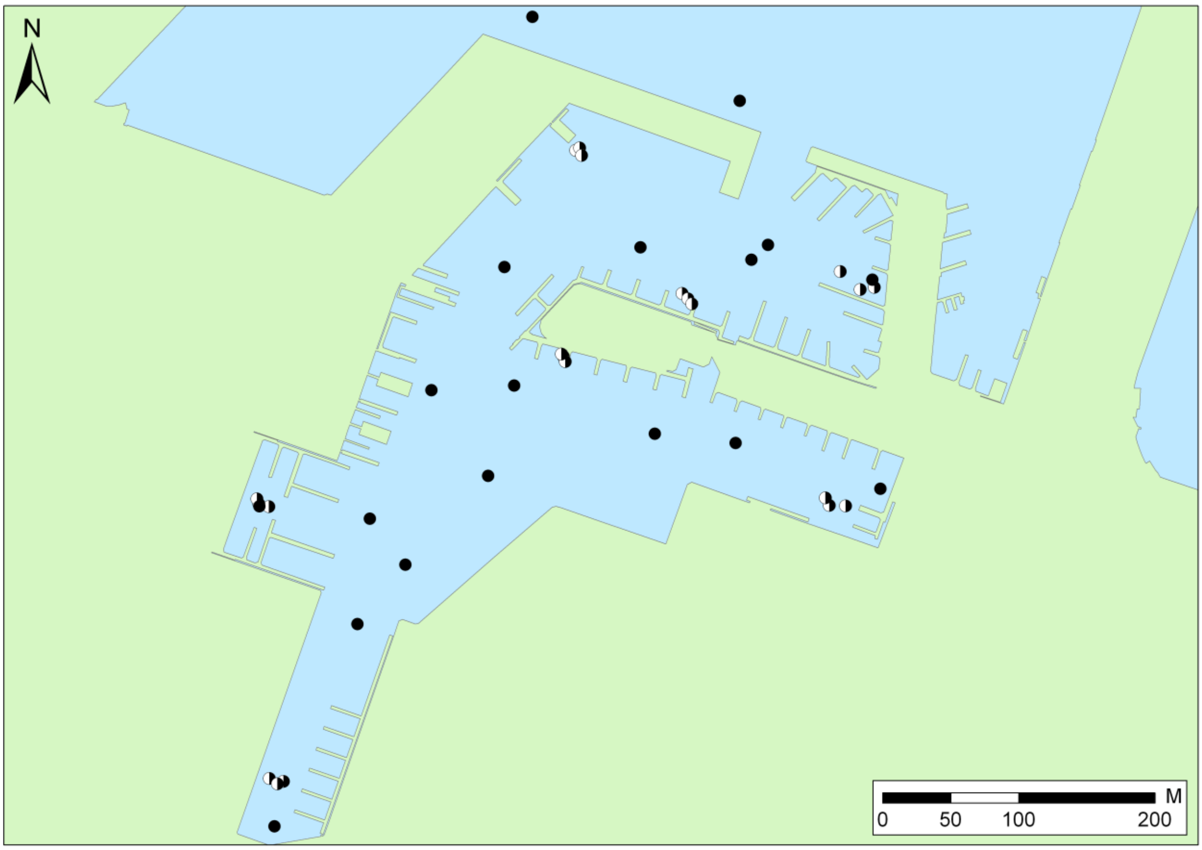

Figure 10: **Benthic sled (full black circles) and benthic grab (white/black circles) sampling sites.**

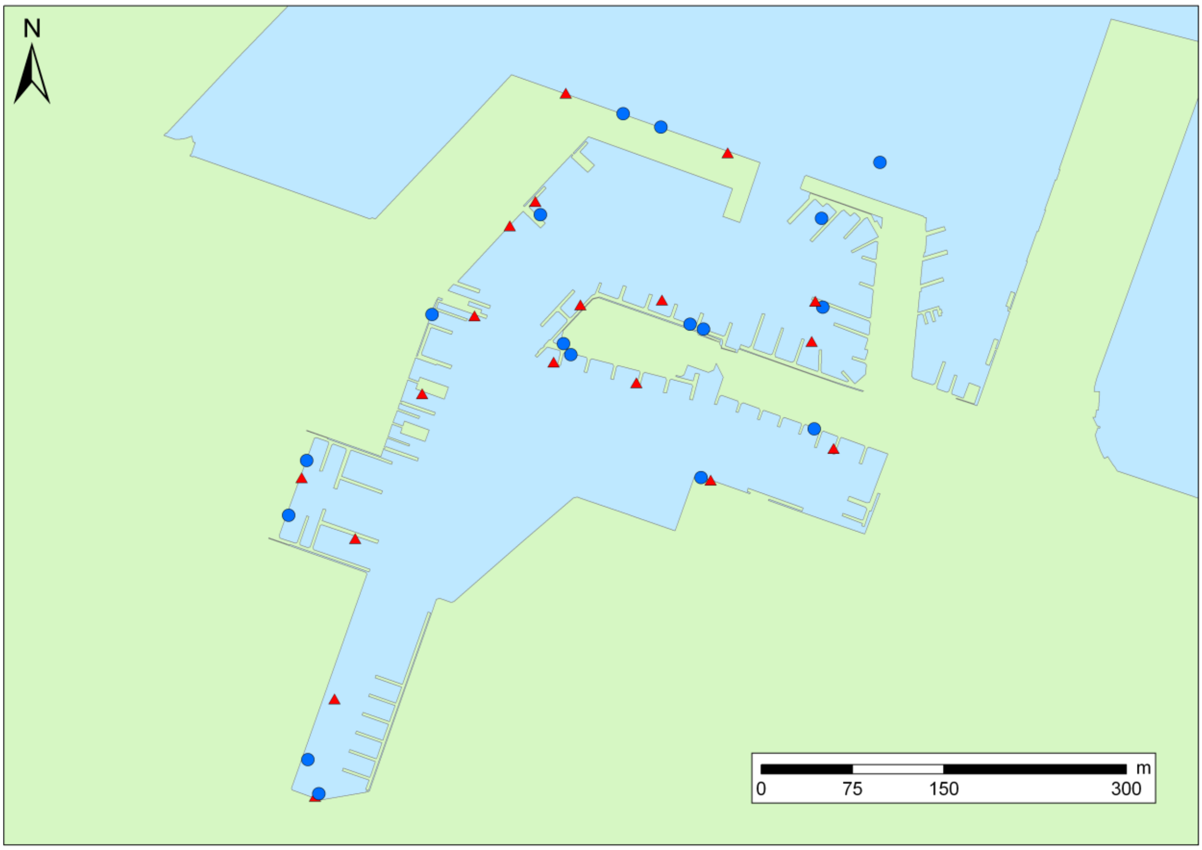

Figure 11: Sites sampled using fish traps (red triangles), and crab, shrimp and seastar traps (blue circles).

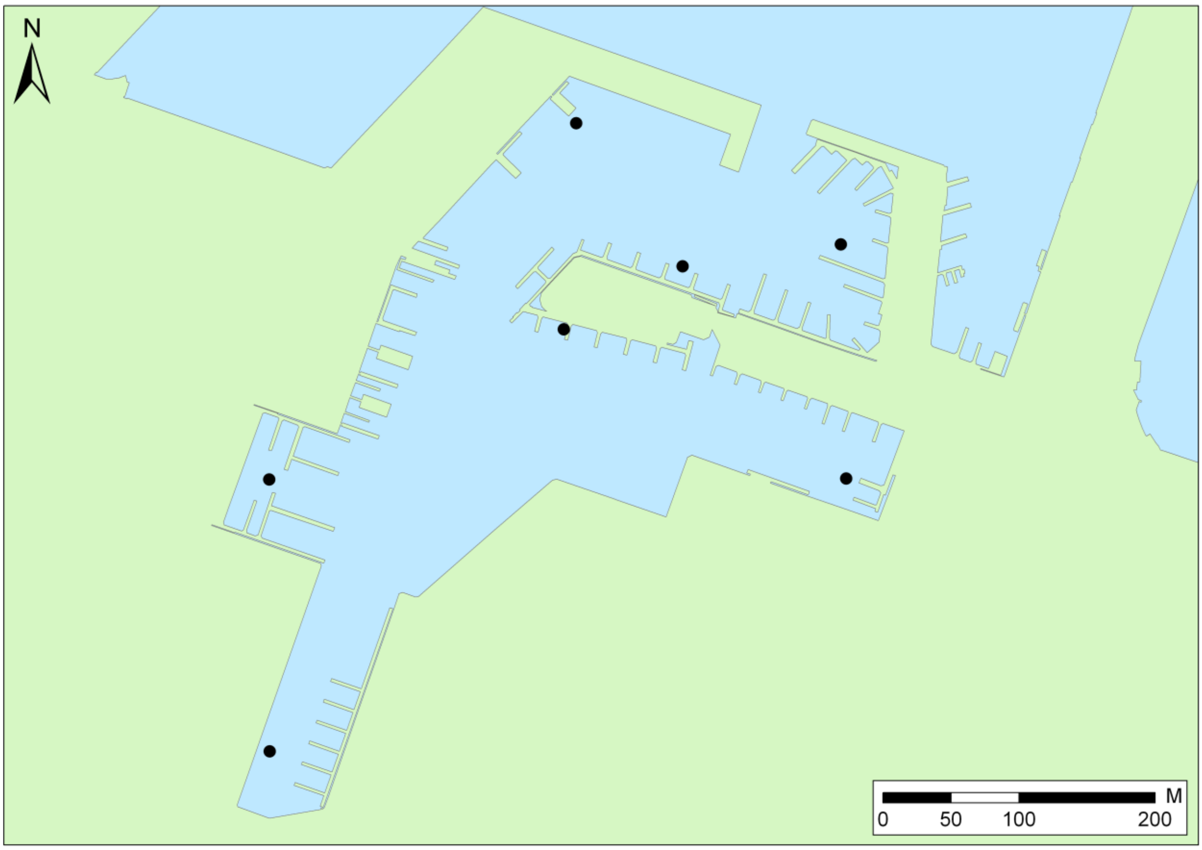

Figure 12: Sediment sampling sites.

Figure 13: Above-water visual search 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 5. 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). We also sought information from each taxonomist on the known biogeography of each species within New Zealand and overseas. Species lists compiled for each port were compared with the marine species listed on the New Zealand register of unwanted organisms under the Biosecurity Act 1993 (Table 6) and the Australian Consultative Committee on Introduced Marine Pest Emergencies (CCIMPE) Trigger List (Table 7).

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.

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; Chapman and Carlton); 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 and/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 is not sufficient taxonomic or systematic information available to allow identification to species level.

DATA ANALYSIS

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 evaluating the benefit of reducing or increasing sample effort in subsequent surveys (Gotelli and Colwell 2001). For each survey method we computed separate sample-based rarefaction curves (Gotelli and Colwell 2001). 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 three methods: pile scraping, benthic sleds and benthic grabs. 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 only pile scrapes; for the other survey methods, 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, crab 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.

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). 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) was > 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 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).

Survey results

PORT ENVIRONMENT

Sampling was carried out at seven different sites throughout the Viaduct Harbour Marina (
Figure 9 to
Figure 13;

Table 8). Maximum recorded depths ranged from 8.7 m at Freemans Bay Breakwall to around 5.8 m at the Viaduct Port. At the time of the survey, turbidity was variable across sites, ranging from secchi depths of 2.5 m at Eastern Viaduct Basin to 1.85 m at Viaduct Harbour Marine Village and Viaduct Port. Salinity averaged 26.5 ppt across all sites sampled and was highest at Eastern Viaduct Basin (29 ppt) and lowest at Viaduct Harbour Marine Village and Viaduct Port (25 ppt). Water temperature was very consistent across sites (20.5 ± 0.2 °C) and ranged from 20.3 °C at the Eastern Viaduct Basin to 20.7 at Hobson West Marina. During sampling, sea states ranged from 0-2 on the Beaufort scale (i.e. approximately 0-6 knots wind speed and 0-0.3 m wave height).

The organic content of sediments in the Viaduct Harbour Marina was moderate, with a mean LOI (loss on ignition) value across the seven analysed samples from seven sites of 6.0 % (Figure 14). This is likely to be due to the high level of human activity around the Viaduct Harbour Marina. Organic content was lowest (3 %) at the Viaduct Port site and highest (7 %) at Hobson West Marina, Viaduct Harbour Marine Village and Te Wero North sites.

Sediments at the sampling sites at the Viaduct Harbour Marina were dominated by sand and silt-sized particles (Table 9). Clay-sized particles were present at low proportions (0.04-0.54 %) in all samples. Pebble (20.19 %) and gravel (4.13 %) sized particles were only found at the Viaduct Port site.

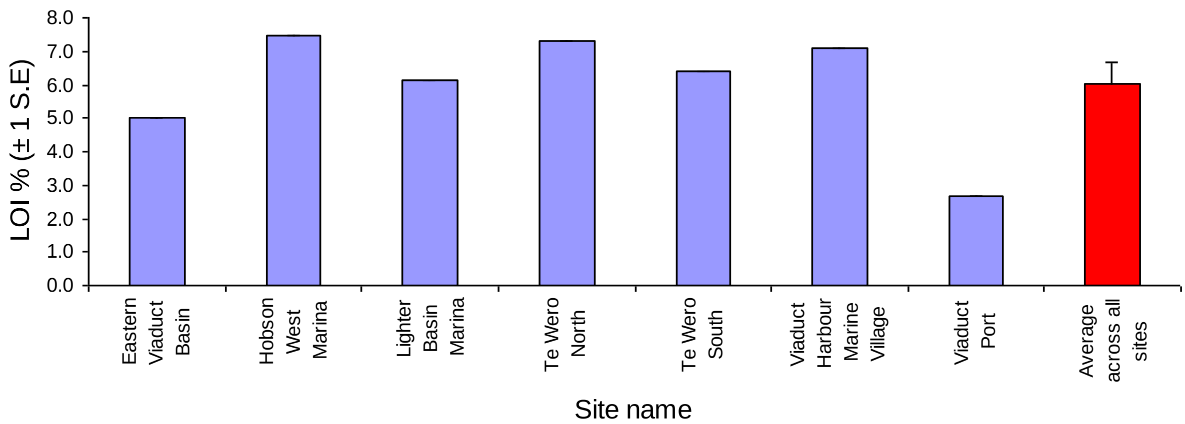

Figure 14: Organic content as determined by loss on ignition analyses of sediments from 6 sites at and aroundViaduct Harbour Marina.

Species recorded

A total of 151 species or higher taxa were identified from the Viaduct Harbour Marina. This collection consisted of 86 native (Table 10), 16 cryptogenic (Table 11), and 19 non-indigenous species (Table 12), with the remaining 30 taxa being made up of indeterminate taxa (Table 13, Figure 15).

The biota in the survey included a diverse array of organisms from 14 phyla (Figure 16). For general descriptions of phyla encountered during this study refer to Appendix 2, and for detailed species lists collected using each method refer to Appendix 3.

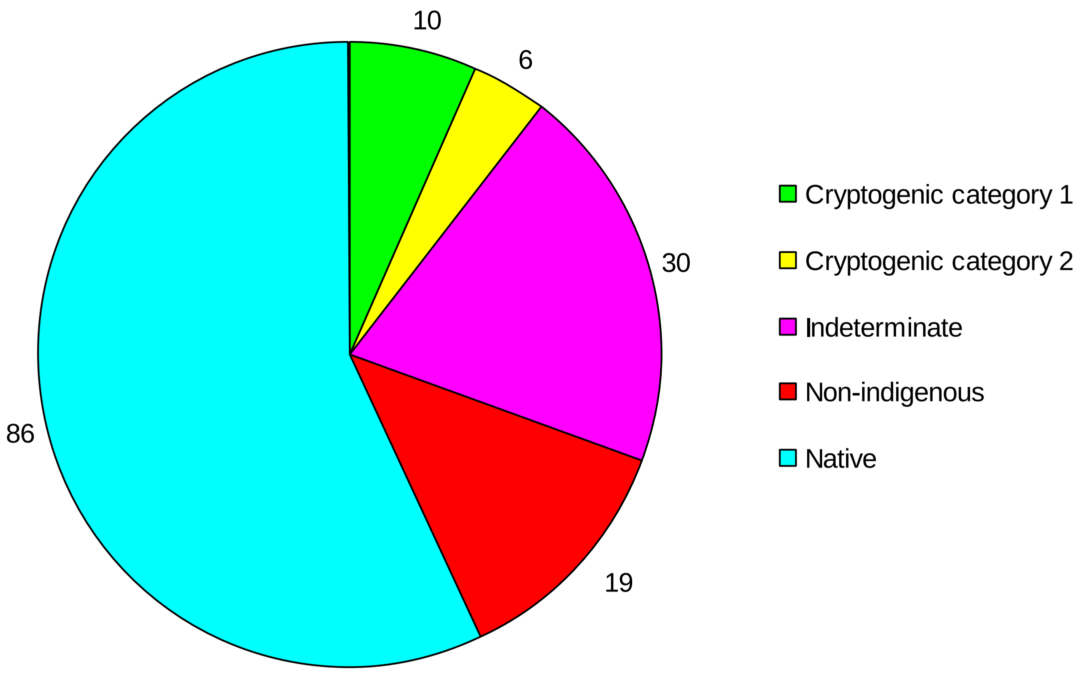

Figure 15: **Diversity of marine species sampled in the Viaduct Harbour Marina. Values indicate the number of taxa in each category.**

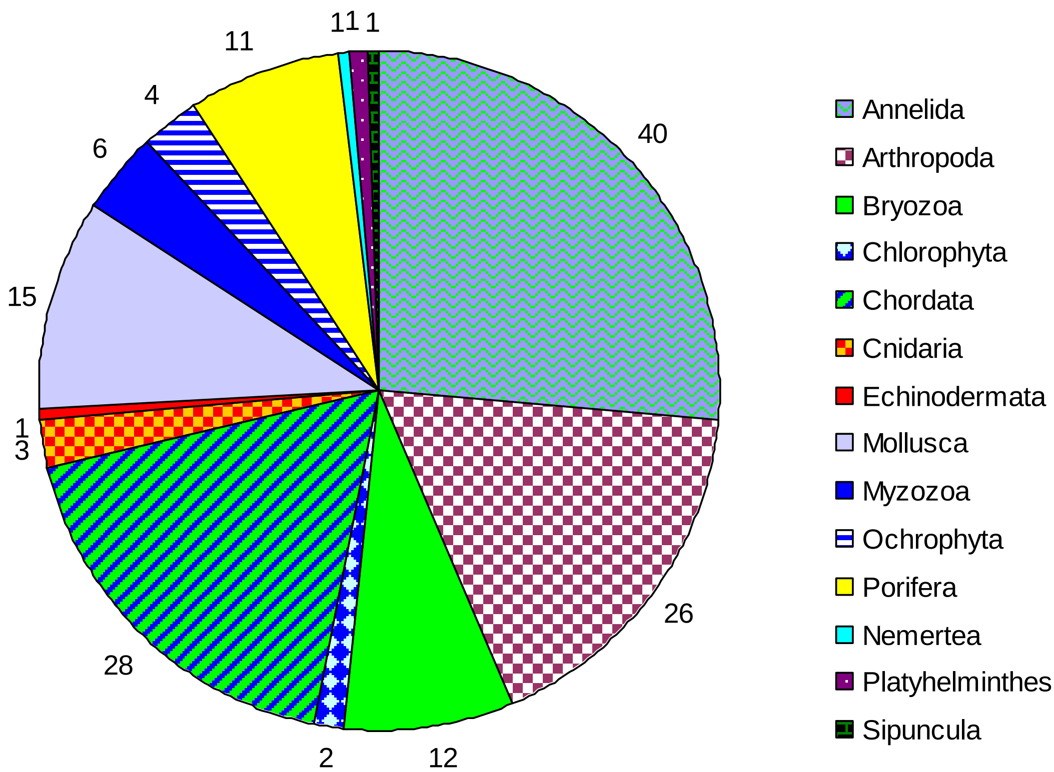

Figure 16: **Phyla recorded in the Viaduct Harbour Marina. Values indicate the number of taxa in each of the major taxonomic groups.**

Native species

The 86 native species recorded during the survey of the Viaduct Harbour Marina represented 57 % of all species identified from this location (Table 10) and included diverse assemblages of annelids (27 species), crustaceans (20 species), molluscs (12 species), fish (seven species), ascidians (7 species), dinoflagellates (four speceies), bryozoans (three species), sponges (three species), one green alga, one echinoderm and one brown alga. (Table 10).

Cryptogenic taxa

Cryptogenic taxa (*n* = 16) represented 10.6 % of all species or higher taxa identified from the Marina. The cryptogenic organisms identified included 10 (6.6 %) category 1 taxa (C1) and six (4 %) cryptogenic category 2 taxa (C2), as defined in "Definitions of species categories" above. These organisms included eight sponges, four ascidians, two annelids, a bryozoan and a crustacean (Table 11). Several of the Category 1 cryptogenic species (e.g the annelid *Heteromastus filiformis*, the bryozoan *Scruparia ambigua* and the ascidian *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 4

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 charactertistics (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 (including this initial survey of Viaduct Harbour Marina), and all *Didemnum* specimens were identified only to genus level. We have reported these species collectively, as a species group (*Didemnum* sp., Table 11).

Non-indigenous species

The 19 non-indigenous species (NIS) recorded in the resurvey of the Viaduct Harbour Marina included seven bryozoans, four annelids, four ascidians, two molluscs, a cnidarian and a brown alga (Table 12).

None of the NIS are new records for New Zealand. *Styela clava* was identified for the first time in New Zealand in Viaduct Harbour in September 2005, but has since been shown to be more widespread (see the species description below).

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 (2002b)

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 17). 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 (

Figure 18) and the Port of Auckland (Inglis *et al*. 2006b, d). During the second baseline surveys of it was recorded from the Ports of Nelson, Auckland and Westhaven Marina (Inglis *et al*. 2006u; Inglis *et al.* in press) and in this survey of Viaduct Harbour Marina (

Figure 18; Table 14).

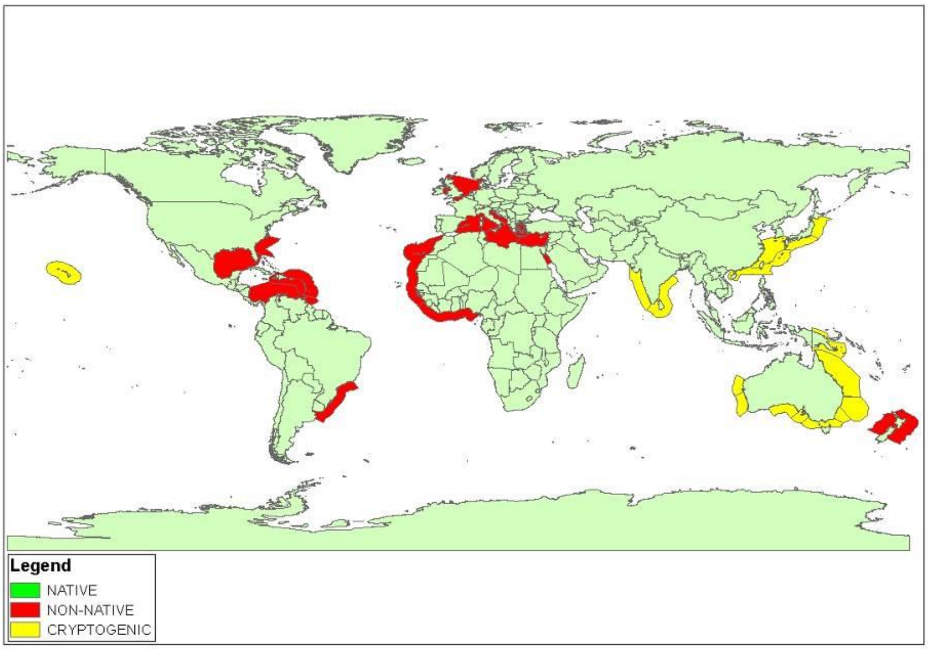

Figure 17: Global distribution of *Hydroides elegans*

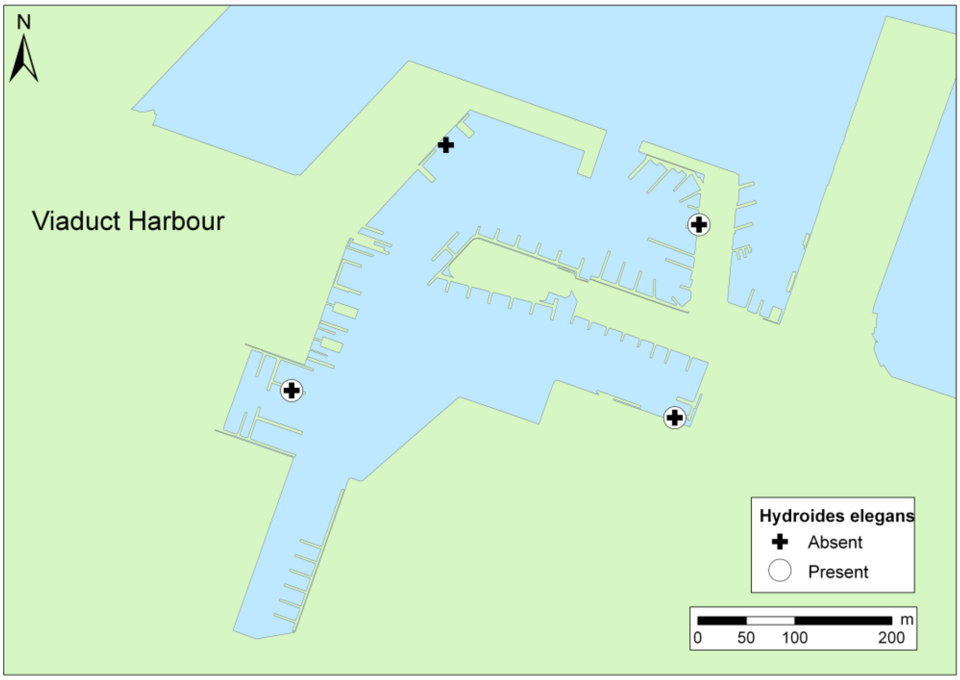

Figure 18: *Hydroides elegans* distribution in the initial survey of Viaduct Harbour Marina.

Polydora hoplura (Claparède, 1870)

Image: Read (2004)

(Left) with eggmass in an opened blister; (top R) posterior; (bottom R) lateral head

Polydora hoplura is a spionid polychaete worm that bores into the shells of molluscs. It is a common pest of shellfish mariculture as its burrows cause blisters in the shells of farmed oysters, mussels and abalone (Pregenzer 1983; Handley 1995; Read 2001; Lleonart *et al*. 2003). It is considered one of New Zealand's worst pest worms (Read 2004). It is often found below the tide mark on jetty piles (Australian Faunal Directory 2005). The type specimen for this species was recorded from the Gulf of Naples, Italy (Claparède, E. 1870). Its native range is thought to be the Atlantic coast of Europe and the Mediterranean (Cranfield *et al*. 1998). *P. hoplura* has also been recorded from South Africa, southeast Australia (Bass Strait and Victoria, Central East Coast, southern Gulf Coast, and Tasmania) and New Zealand where it is thought to have been introduced (Australian Faunal Directory 2005). It is not known when *P. hoplura* first arrived in New Zealand (Read 2001). In Europe and New Zealand, *P. hoplura* is often associated with shells of the introduced Pacific oyster *Crassostrea gigas* (Handley 1995; Read 2004).

Polydora hoplura had previously been recorded from Wellington and the Marlborough Sounds (Cranfield *et al*. 1998). In the initial port surveys *P. hoplura* was recorded in Dunedin, Whanagrei, Nelson, Wellington, Tauranga, Picton and Westhaven Marina (Inglis *et al*. 2006a, d; Inglis *et al*. 2006h; Inglis *et al*. 2006i, k, l, n). In the repeat surveys *P. hoplura* was recorded in Whangarei, Napier, Wellington, Lyttelton, Timaru, Dunedin, Bluff, and in this initial survey of Viaduct Harbour Marina (Table 12; Table 14)(Inglis *et al*. 2006o, s; Inglis *et al*. 2006t).

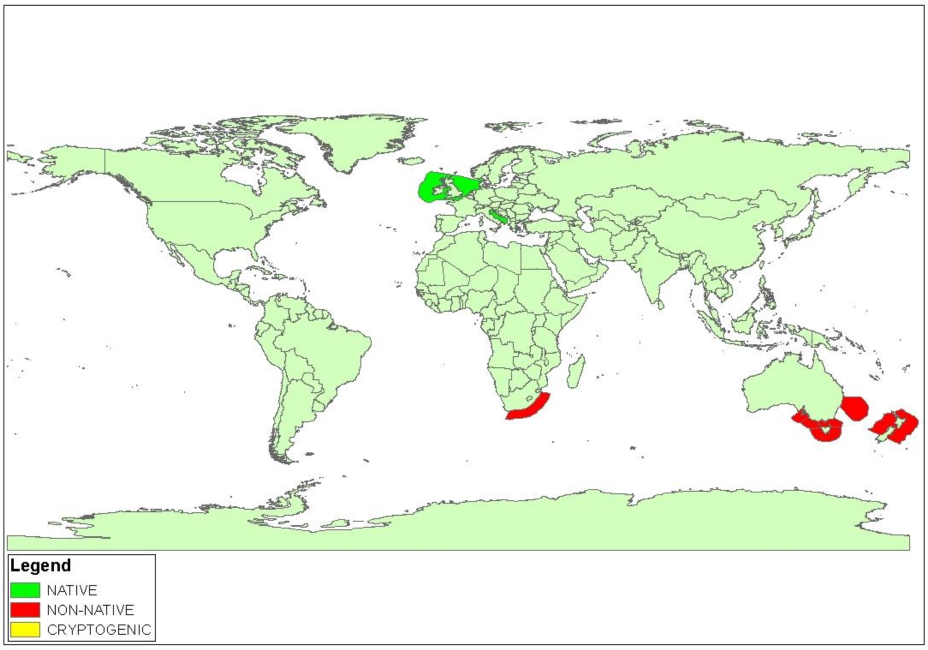

Figure 19: Global distribution of *Polydora hoplura*

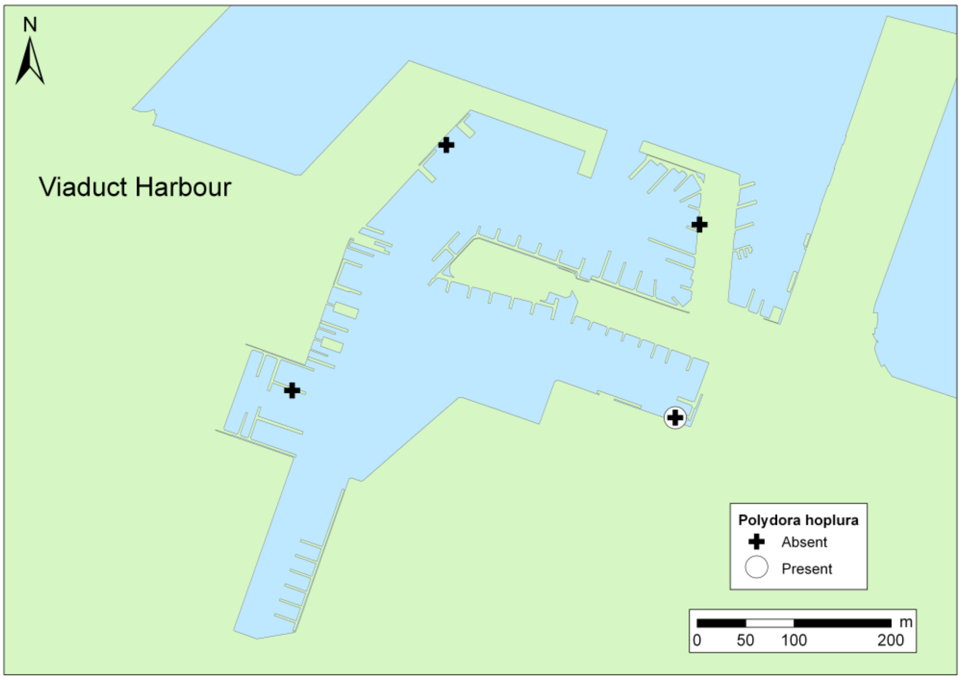

Figure 20: *Polydora hoplura* distribution in the initial survey of Viaduct Harbour Marina

Pseudopolydora paucibranchiata **(Okuda, 1937)**

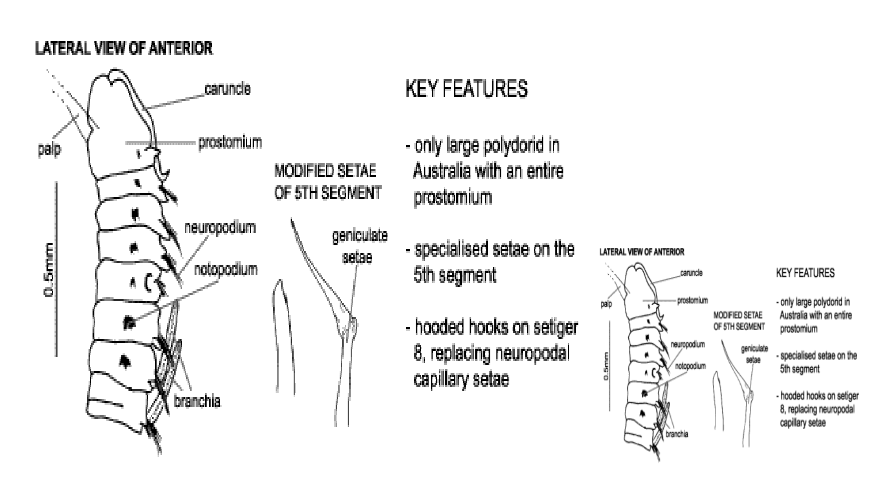

Diagram: Swaleh and Mustaquim, 1993, in NIMPIS (2002c)

Pseudopolydora paucibranchiata (common name Elkhorn slough spionid or Japanese polydorid) is a burrowing, sedentary spionid polychaete worm. It constructs tubes from sand and silt. It is a creamy colour with yellow-white bands. The first segment is reduced, with no notosetae (hairs). The fifth segment is not enlarged or modified, but has distinct parapodial (foot) lobes with major spines placed in a U-shaped line. From the eighth segment, hooded hooks are present which replace the capillary setae (NIMPIS 2002c).

Pseudopolydora paucibranchiata is most abundant in the low tidal zone, but also occurs subtidally. It occurs in sand and mudflats, but prefers fine sediments. It is also occurs in fouling communities and is a fouler on oyster shells. It is a deposit/suspension feeder, consuming algae, invertebrate larvae, detritus and other polychaetes (NIMPIS 2002c). *P. paucibranchiata* has been recorded at a maximum depth of 63m, in water temperatures from 8.5 to 21 degrees Celsius, and in salinities from 21.5 to 34.8 ppt (see NIMPIS 2002c and references therein).

Males and females are separate and fertilisation is internal. In a breeding season up to 800 eggs are deposited inside the female's tube. Larvae remain in the plankton between 7 and 47 days, after which they settle, metamorphose, begin burrowing and constructing a tube. Sexual maturity is reached by approximately 4 weeks age (see NIMPIS 2002c and references therein). In New Zealand the reproductive season is March to September (Read 1975).

P. paucibranchiata can be a dominant member of the infaunal community; densities of up to 60,000 individuals per square metre have been recorded (Levin 1981, in NIMPIS 2002c). These high densities may alter habitat and bio-geochemical cycles due to the concentration of tubes in the sediment. Faunal composition may also be altered through competition and predation. *P. paucibranchiata* loses interspecific interactions against gammarid and caprellid amphipods but dominates interactions with other polychaetes. It has been recorded to negatively affect recruitment of an opheliid polychaete, *Armandia* sp., through predation of larvae. *P. paucibranciata* has been recorded to be inhibited by mats of the invasive mussel *Musculista senhousia* in San Diego (see NIMPIS 2002c and references therein). *M. senhousia* is also non-indigenous in New Zealand, known from several locations in northern New Zealand, including Waitemata Harbour (Cranfield *et al*. 1998). *P. paucibranchiata* is ranked 33rd of 53 species in terms of its potential impact in a listing of domestic marine priority pests in Australia (Hayes *et al*. 2005a).

P. paucibranchiata may be introduced to new locations and dispersed around New Zealand through attached or free-living fouling individuals on ships, through translocations of fish or shellfish, dredge spoil, ballast water, sea water systems, live wells or other deck basins and by natural planktonic dispersal.

The type locality of *Pseudopolydora paucibranchiata* is in Japan (Okuda 1937). It is thought to be native to the north-west Pacific, from China to the coast of Russia, and has been introduced to the north-east Atlantic, the west Coast of the U.S.A., southern Australia and New Zealand (
Figure **21**). *P. paucibranchiata* was first recorded in Australia in 1972, where it was possibly introduced with *Crassostrea gigas*, the Pacific oyster (NIMPIS 2002c; Australian Faunal Directory 2005).

P. paucibranchiata has been present in New Zealand since at least 1975, and was known from Wellington prior to the port baseline surveys (Read 1975). During the initial port baseline surveys it was recorded from the Port of Gisborne (Inglis *et al*. 2006e) and also in a single sample from Marsden Point, Whangarei and Gulf Harbour Marina (Inglis *et al*. 2006m). During the repeat surveys it was recorded in the Port of Gisborne, Westhaven Marina (Inglis *et al*. in press) and in this survey of the Viaduct Harbour Marina (
Figure 22; Table 14).

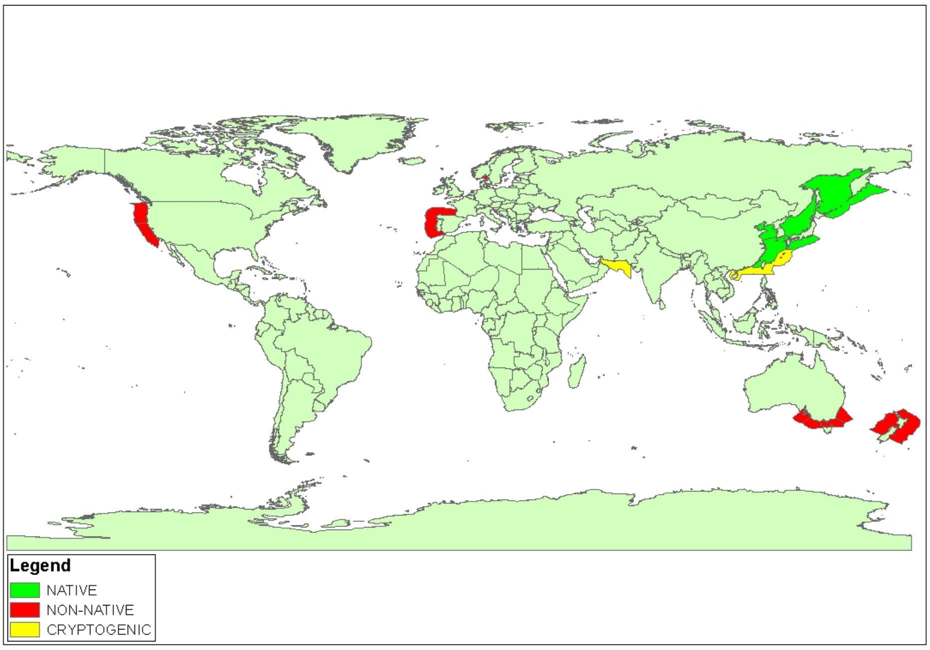

Figure 21: Global distribution of *Pseudopolydora paucibranchiata*

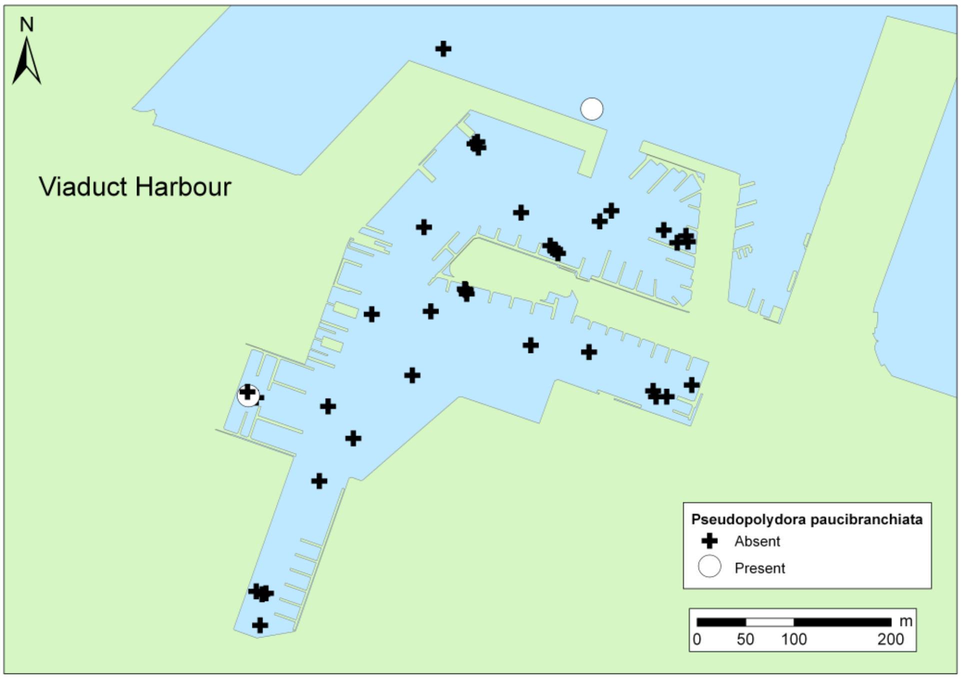

Figure 22: ***Pseudopolydora paucibranchiata*** **distribution in the initial survey of Viaduct Harbour Marina**

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. The scale worm most likely arrived in New Zealand via ship ballast water, or vessel hull fouling. *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 was found subtidally during the repeat port survey of the port of Whangarei (Inglis *et al*, *in prep*), and is widespread around the soft-shores of Waitemata Harbour (Auckland) and nearby Hauraki Gulf inlets. The earliest records date from late 1998 and it seems to have a restricted but expanding national distribution (Read 2006). *P. ampulliferus* was recorded in the second baseline surveys of the ports of Whangarei and Auckland, and also in the initial survey of Westhaven Marina and in this survey of Viaduct Harbour Marina (Table 12; Table 14).

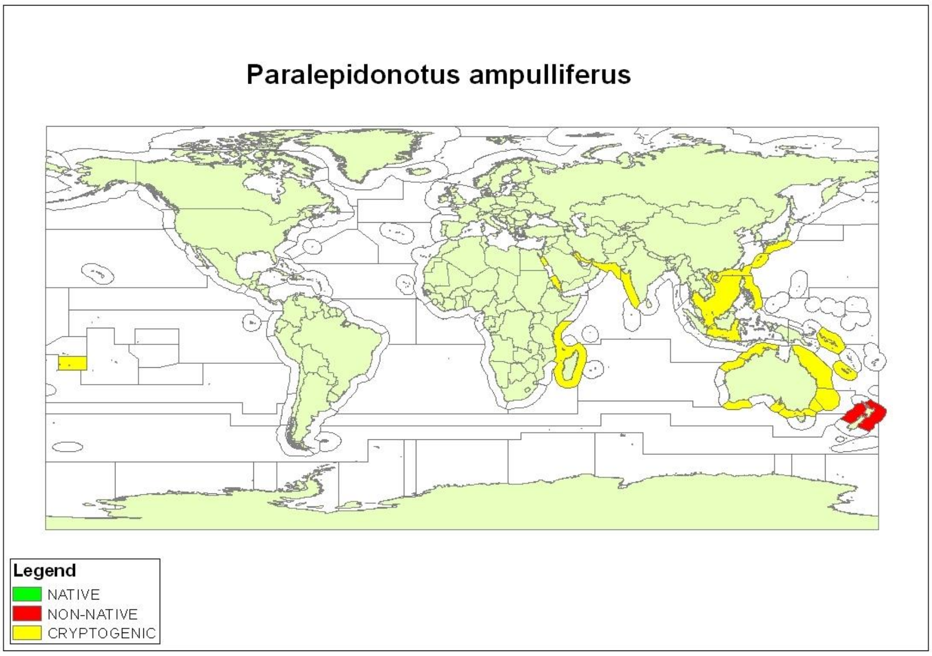

Figure 23: Global distribution of *Paralepidonotus ampulliferus*

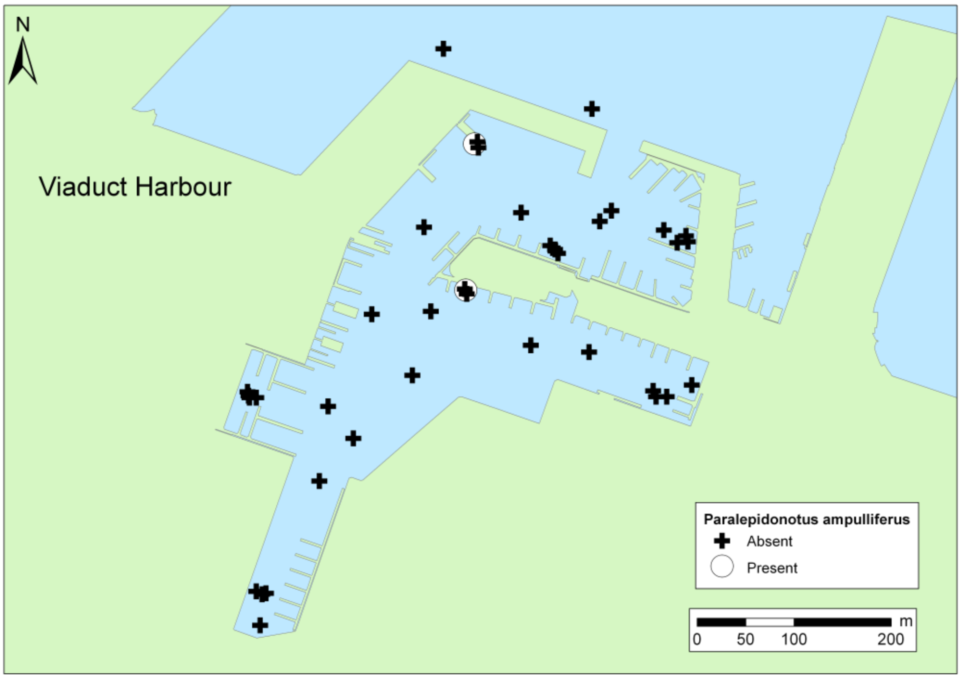

Figure 24: ***Paralepidonotus ampulliferus*** **distribution in the initial survey of Viaduct Harbour Marina**

***Bugula stolonifera* (Ryland, 1960)**

Image: California Academy of Sciences (2002)

Bugula stolonifera forms dense tufted colonies of 30-40 mm high. It is a greyish-buff colour and lives attached to the substratum by rhizoids. Its basal and lateral walls are lightly calcified. Young colonies take on a fan or funnel shape, while established colonies form dense tufts. The zooids of *B. stolonifera* are smaller than those of *B. neritina*, yet they still taper proximally (Gordon and Mawatari 1992; Hill 2001).

Like other species within the genus, *B. stolonifera* is a prolific fouling organism that readily occupies available hard substrata, as well as the exposed shells or carapaces of other organisms, or attaches itself onto attached or floating seagrass and algae (Hill 2001). Specimens collected during the surveys were from pile scrapings. *Bugula stolonifera* is a filter feeder.

The impacts of *B. stolonifera* on New Zealand ecosystems have not been documented. As an abundant fouling organism, *B. neritina* colonizes underwater structures and may interfere with vessel performance, aquaculture and potentially out-compete native species. Possible pathways for introductions to new locations and dispersal within New Zealand include attachment to ships as free-living fouling organisms, through translocations of fish, shellfish, and fishery products and packing and through dispersal on biogenic and artifical substrata.

Bugula stolonifera is native to southern Britain. It has been introduced to California, Hawaii, Mexico, Brazil, the Mediterranean and the eastern Atlantic (Gordon and Mawatari 1992; Hill 2001); (
Figure 25). In New Zealand it has been recorded from Auckland, Napier, Nelson, Lyttelton, Timaru and Bluff (Gordon and Mawatari 1992). During the initial port baseline surveys, *B. stolonifera* was recorded from the ports of New Plymouth, Whangarei and Whangarei Marina (Inglis *et al*. 2006j, m) and in the second survey of Gisborne, Napier, Opua, Whangarei Harbour, Westhaven, Gulf Harbour Marina (Inglis *et al*, in press) and in this survey of Viaduct Harbour Marina (Table 12; Table 14).

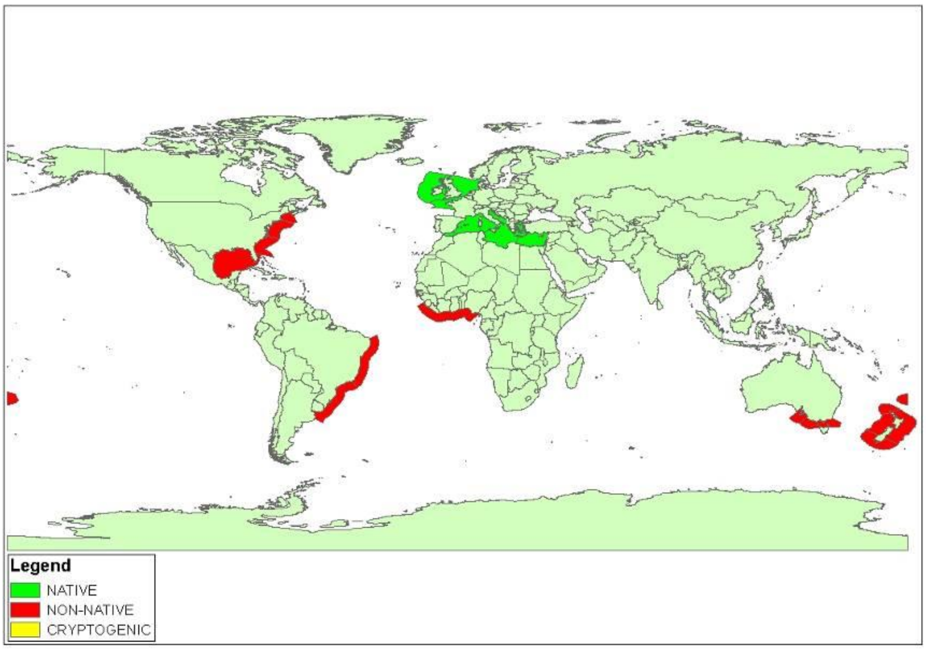

Figure 25: Global distribution of *Bugula stolonifera*

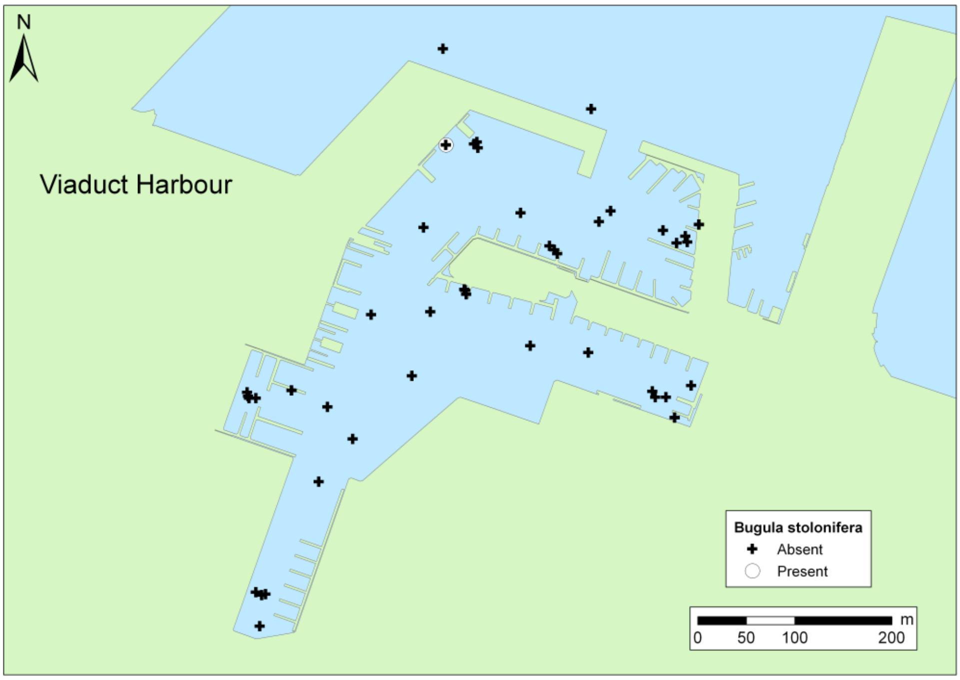

Figure 26: *Bugula stolonifera* distribution in the initial survey of Viaduct Harbour Marina

Schizoporella errata (Waters, 1878)

Image: O. Floerl 2003; information: Eldredge and Smith (2001)

Schizoporella errata is a heavily calcified, encrusting bryozoan that is typically dark brick red with orange-red growing margins. It assumes the shape of whatever it overgrows. This species may form heavy knobbly incrustations on flexible surfaces such as algae or worm tubes, turning them into solid, sometimes erect branching structures. The thickness of the growth is dependent upon the age of the colony. Multilaminar encrustations 1 cm thick are common. The frontal surface of the zoecium (secreted exoskeleton housing of individual zooids) is porous with a wide semicircular aperture and proximal sinus. It also has single avicularia on the right or left side of the aperture sinus.

Schizoporella errata is thought to be native to the Mediterranean. It has been introduced to many worldwide locations in warm temperate-subtropical seas. It has been reported from West Africa, the Red Sea, the Persian Gulf, South Australia, New Zealand, the Hawaiian Islands, the Pacific coast of North America, the east coast of North America through to the Caribbean and Brazil (
Figure 27). *S. errata* occurs in shallow water on various hard substrates (pilings, hulls, coral rubble, etc.) in harbours and embayments. It is also occasionally found on rocky or coral reefs. *S. errata* can compete with other fouling organisms for space and large encrustations of this species are known to smother other biota (Cocito *et al*. 2000). It is present in Waitemata Harbour and the Bay of Islands. During the baseline port *surveys* *S. errata* was recorded from Nelson, Whangarei Harbour and the Gulf Harbour Marina (Inglis *et al*. 2006h; Inglis *et al*. 2006m, n). During the repeat surveys *S. errata* was recorded in the Gulf Harbour Marina, Westhaven and Opua Marina, Whangarei Port (Inglis *et al*. 2007a) and in this survey of the Viaduct Harbour Marina (
Figure 28; Table 12; Table 14).

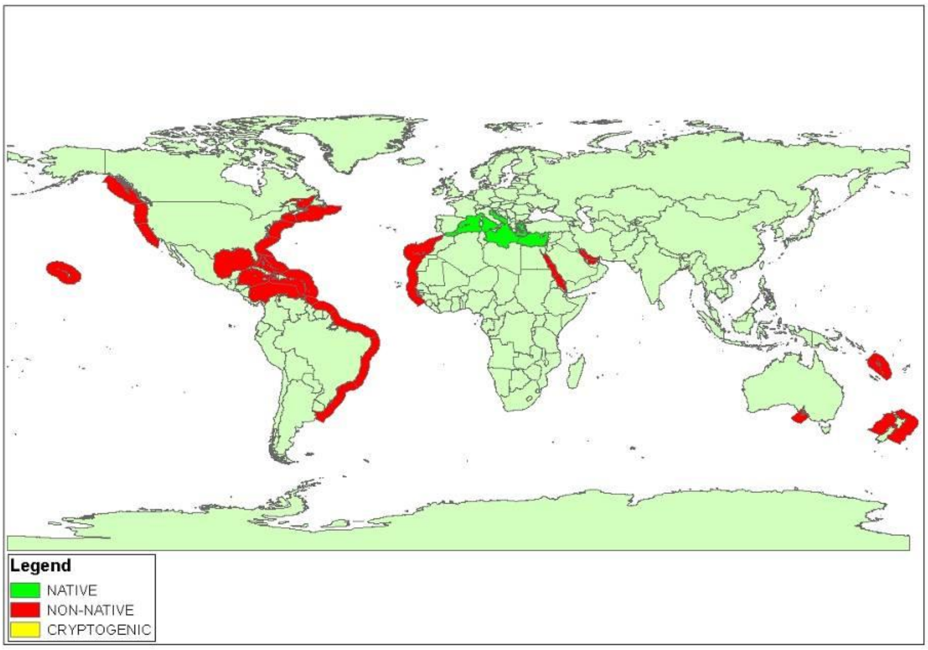

Figure 27: Global distribution of *Schizoporella errata*

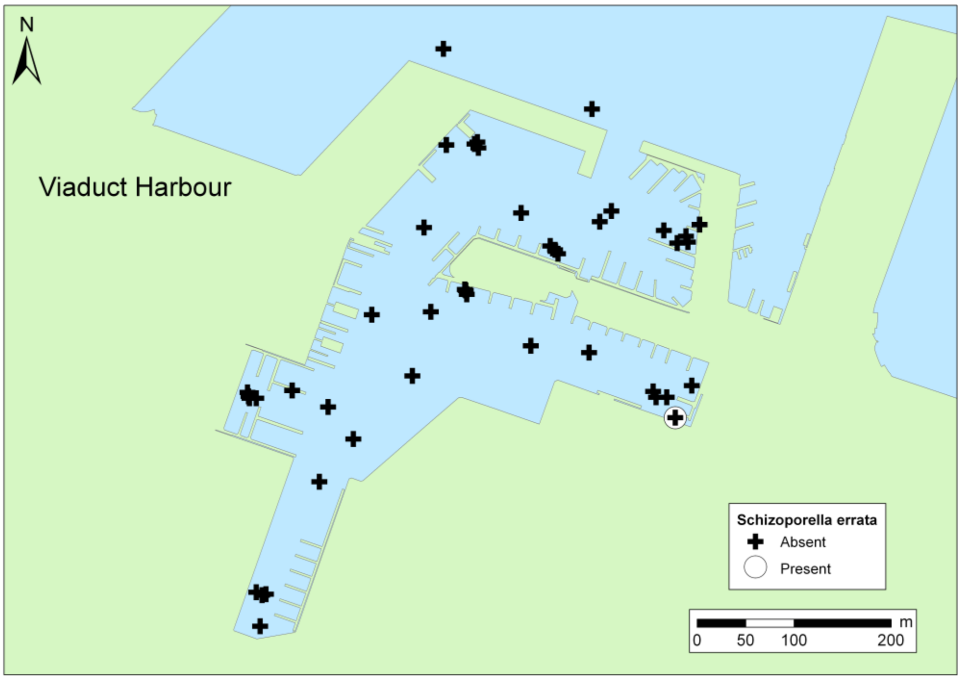

Figure 28: *Schizoporella errata* distribution in the initial survey of Viaduct Harbour Marina

***Watersipora arcuata* (Banta, 1969)**

Image and information: NIMPIS (2000d)

Watersipora arcuata is a loosely encrusting bryozoan capable of forming single or multiple layer colonies. The colonies range from dark red-brown to black, with a thin bright red margin. *Watersipora* arcuata has no spines, avicularia (defensive structures) or ovicells (reproductive structures). The aperture of the zooid is black, with a semicircular distal margin and a concave proximal margin - a key distinguishing feature of this species.

Watersipora arcuata is native along the east coast of Central and North America (Figure 29). It has been introduced to the Japan and China Seas, Australia and New Zealand (Figure 29). *Watersipora arcuata* is an important marine fouling species found in ports and harbours. It is mostly found on vessel hulls, pilings and pontoons, but also attaches to rocks and seaweeds, typically around the low water mark. *Watersipora arcuata* is an abundant fouling organism and is resistant to a range of antifouling paints. It can, therefore, spread rapidly on vessel hulls (Table 12) and provide an area for other species to settle upon. This, in turn, has an impact on vessel maintenance and speed, as many more organisms are able to foul the hull.

In New Zealand, *W. arcuata* was first recorded from Waitemata Harbour in the mid-1950s (Table 12), where it subsequently spread to become a dominant component of intertidal fouling assemblages. It has also been recorded from Whangarei, Tauranga and the Bay of Islands (Gordon and Mawatari 1992). *W. arcuata* was recorded in the initial baseline survey of Taranaki (Inglis *et al*. 2006j) and in the second survey of Gulf Harbour Marina, Napier (Inglis *et al.* in press) and in this survey of the Viaduct Harbour (Table 12; Table 14).

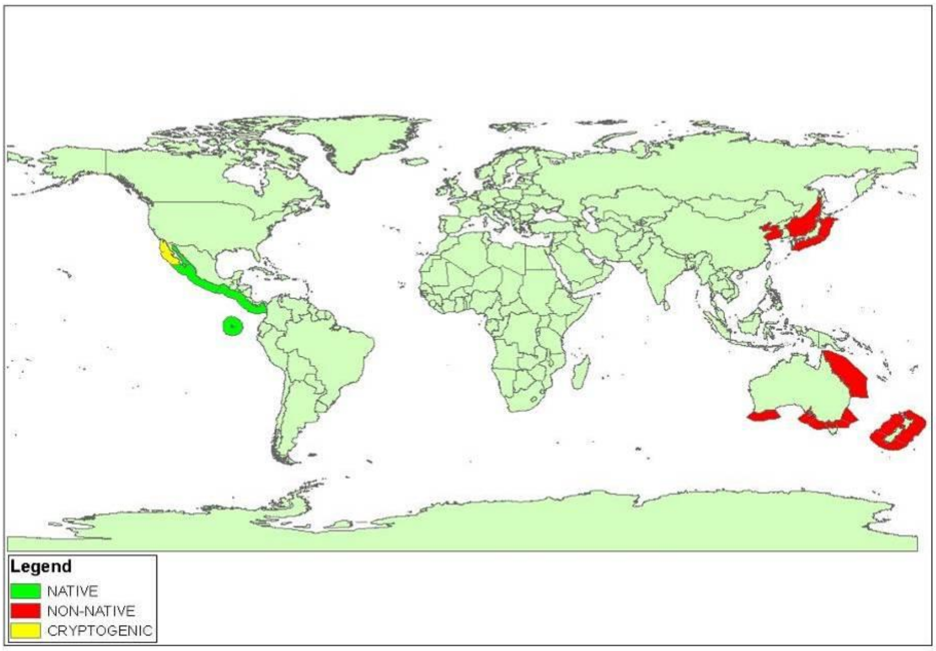

Figure 29: Global distribution of *Watersipora arcuata*

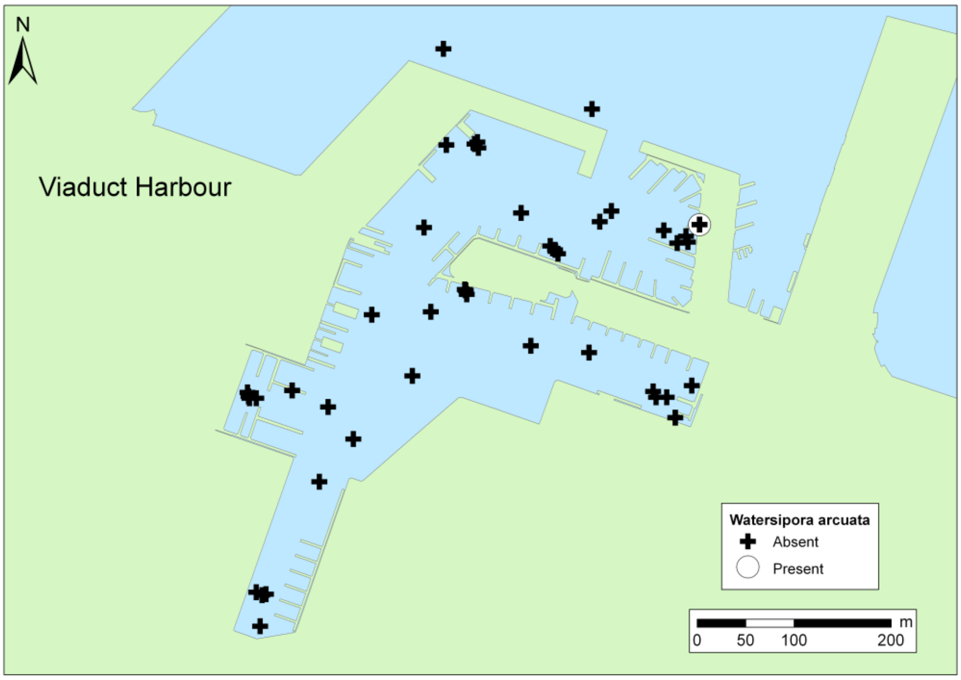

Figure 30: *Watersipora arcuata* distribution in the initial survey of Viaduct Harbour Marina

Tricellaria catalinensis (Robertson, 1905)

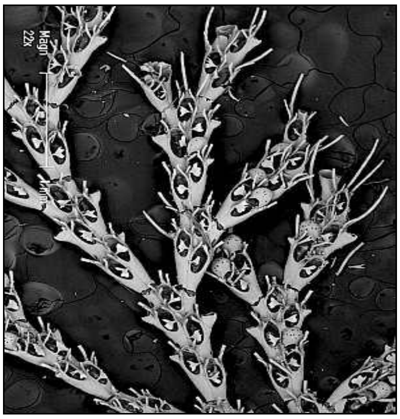

Image: Bock (2004)

Tricellaria catalinensis is an erect bryozoan composed of unilaminar branches branching dichotomously with anchoring rhizoids. Colonies are cream to buff coloured (Dyrynda *et al*. 2000).

The type locality of *T. catalinensis* is Venice, Italy. An assessment of samples and literature from various global regions by Dyrynda *et al*. (2000) suggests that Atlantic and Adriatic *T. catalinensis* correspond with a morphospecies known to be invasive in New Zealand, and cryptogenic in Pacific North America, Japan and Australia. The morphospecies in question has usually been referred to as *T. occidentalis* (Trask, 1857) and, in at least one instance, as *T. porteri* (MacGillivray, 1889) (see Dyrynda *et al*. 2000). A more precise identification of its source region is not possible due to its widespread Pacific distribution and the possibility of anthropogenic dispersal there in historical times (Dyrynda *et al*. 2000).

Tricellaria catalinensis is found within ports and marinas, and on natural shores. It is able to tolerate a range of salinities (i.e., 20-35 ppt) and inhabit brackish waters (Dyrynda *et al*. 2000). It is usually found within the infralittoral fringe, favouring strong currents and brackish salinities, and is well represented within fouling assemblages colonizing a wide range of anthropogenic and natural substrata. *Tricellaria catalinensis* is a filter feeder.

Tricellaria catalinensis was listed (as *T. occidentalis*) as a medium priority domestic pest in Australia by Hayes *et al*. (2005). They ranked it 17th of 53 species in its impact potential (Hayes *et al*. 2005a). *Tricellaria catalinensis* is a prolific fouling species with a high reproductive output. It has documented impacts on the abundance of native bryozoan species; for example, the invasion of *T. catalinensis* in Laguna di Venezia (Italy) resulted in a sharp decline in the abundance of native bryozoans whose populations had been stable prior to its introduction(Occhipinti Ambrogi 2000). It is known to foul mussel byssal threads (Occhipinti Ambrogi 2000). In Japan, it is known to be a vigorous colonizer of set nets and boat hulls (Dyrynda *et al*. 2000). The most likely pathway for introduction to a new location is through attachment to ships, pathways for dispersal within New Zealand include attachment to navigation buoys and marina floats, through translocations of fish or shellfish, through fishery products, packing or substrate and naturally through planktonic dispersal and rafting of adults on biogenic substrata.

T. catalinensis was first documented in New Zealand in 1964 (as *T. occidentalis*, (Gordon and Mawatari 1992)). It has been recorded from Whangarei, Auckland, Tauranga, Gisborne, Napier, Porirua Harbour, Tarakohe, Pelorus Sound, Nelson and Lyttelton (Gordon and Mawatari 1992). During the initial port baseline surveys, it was recorded from Whangarei

(Marsden Point), Gisborne, New Plymouth and Lyttelton (all during Survey 1), from the second survey of the ports of Picton and Gisbrone, the survey of Westhaven Marina, (Inglis *et al*. 2006e; Inglis *et al*. 2006f; Inglis *et al*. 2006j, m; Inglis *et al*. 2006p) and in this survey of the Viaduct Harbour Marina (
Figure 32; Table 12; Table 14).

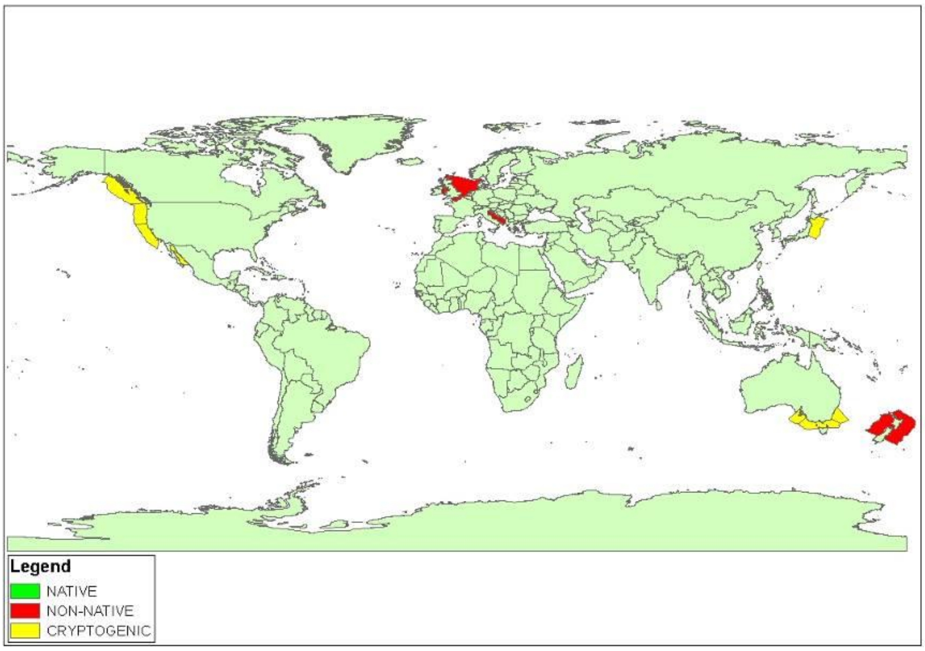

Figure 31: Global distribution of *Tricellaria catalinensis*

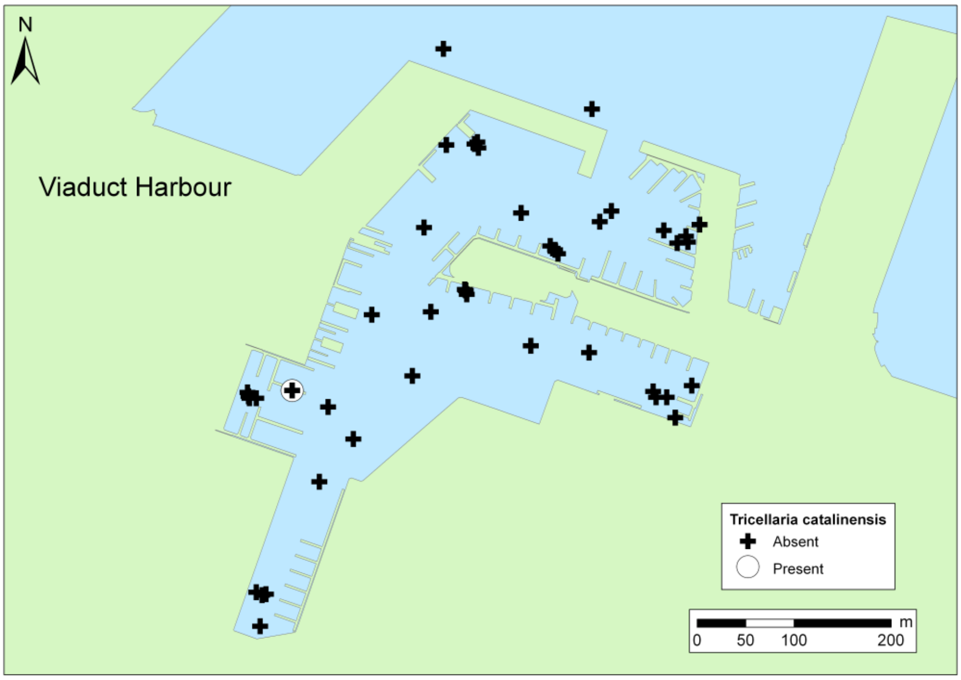

Figure 32: *Tricellaria catalinensis* distribution in the initial survey of Viaduct Harbour Marina

Bowerbankia gracilis (Leidy, 1855)

Image: (Hill 2001)

Bowerbankia gracilis is a pale yellow to tan-coloured encrusting bryzoan. Zooids are almost transparent, cylindrical and disjunct (Gordon and Mawatari 1992). Zooids are up to 0.62 mm long when retracted and 1.04 mm long when extended and can be found singulary or clustered in dense groups of various size and age (Gordon and Mawatari 1992). The stolon is considerably narrower than the zooid. The polypide and body wall is flexible. *B. gracilis* is found in the low intertidal to shallow subtidal depths and in estuaries.

As well as fouling on structures, *B. gracilis* can settle on cultivated species and consequently have a deleterious impact on the aquaculture industry (Soule 1977). Additionally, this species has the potential to out-compete native species and disrupt species assemblages.

The type locality of *B. gracilis* is Point Judith, Rhode Island (Gordon and Mawatari 1992). It has a wide global distribution and has been recorded from Europe, Britain, Greenland, eastern United States, Washington State to Mexico, South Africa, India, Japan, South Australia (Figure 33). *B. gracilis* is regarded as established in New Zealand and has been recorded in Goat Island Bay, Leigh marine Harbour, Onehunga, Port of Napier, Oaonui, Tataraimaka, Totaranui, Oban (Gordon 1986). *B. gracilis* was not found in any initial baseline port surveys but has been recorded in the second baseline survey of Gisborne, Opua, Whangarei (Marina and Port), Napier, Gulf Harbour Marina Westhaven (Inglis *et al.* in press) and in this survey of the Viaduct Harbour Marina (Table 12; Table 14).

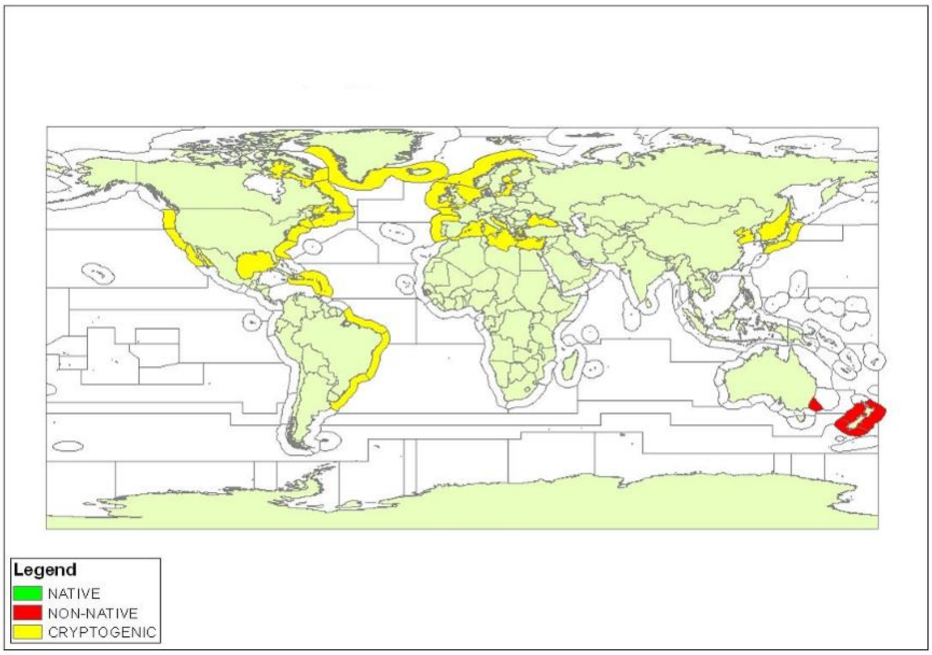

Figure 33: Global distribution of *Bowerbankia gracilis*

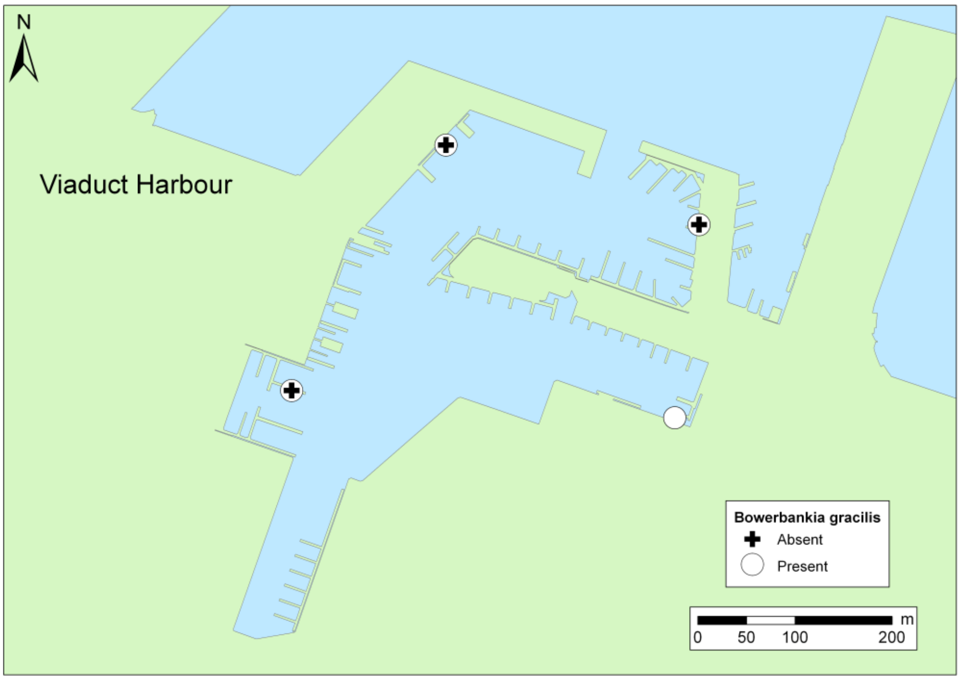

Figure 34: *Bowerbankia gracilis* distribution in the initial survey of Viaduct Harbour Marina

***Zoobotryon verticillatum* (Delle Chiaje, 1828)**

Image and information: Gordon and Matawari (1992)

Zoobotryon verticillatum is a bryozoan that grows into large, bushy colonies often 20-30cm in diameter. They often appear like thin, stringy, gelatinous noodles. The young colonies are usually transparent, while older and larger ones have a dirty white appearance. In contrast to most other bryozoans, calcium carbonate is absent in exoskeletons of this species. *Zoobotryon verticillatum* is a subtidal species and mostly occurs on hard surfaces such as rocks, pontoons, pilings or, boat hulls, or as an epibiont on shells or carapaces.

The type locality of *Z. verticillatum* is Naples, Italy, although the species is now widely distributed in tropical and subtropical seas, including the Caribbean, Indian Ocean, north-west and north-east Pacific, Hawaii, New Caledonia and Australia (Gordon and Mawatari 1992); Figure 35). It has been present in New Zealand, in the Waitemata and Manukau Harbours, since at least the 1960's (Gordon and Matawari, 1992). Under optimal conditions *Z. verticillatum* can form large aggregations that can clog fishing nets and potentially exclude other sessile organisms. Large bushes are formed only when water warms to 22°C and above, although the colonies can overwinter during colder periods. Elevated temperature and salinity has been suggested to enhance outbreaks of this bryozoan. In the initial port surveys *Z. verticillatum* only occurred in the Gulf Harbour Marina (Inglis *et al*. 2006b). During the repeat surveys it was also found at the Port of Tauranga (Inglis *et al*. 2006r), Gulf Harbour, Westhaven Marina (Inglis *et al.* in press) and in this survey of Viaduct Harbour Marina (Table 12; Table 14).

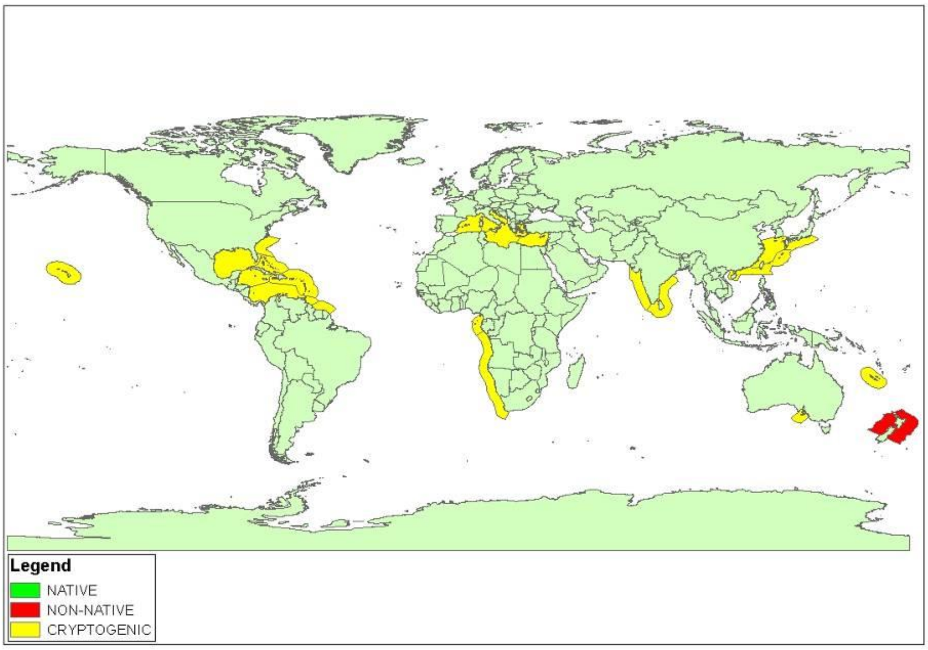

Figure 35: Global distribution of *Zoobotryon verticillatum*

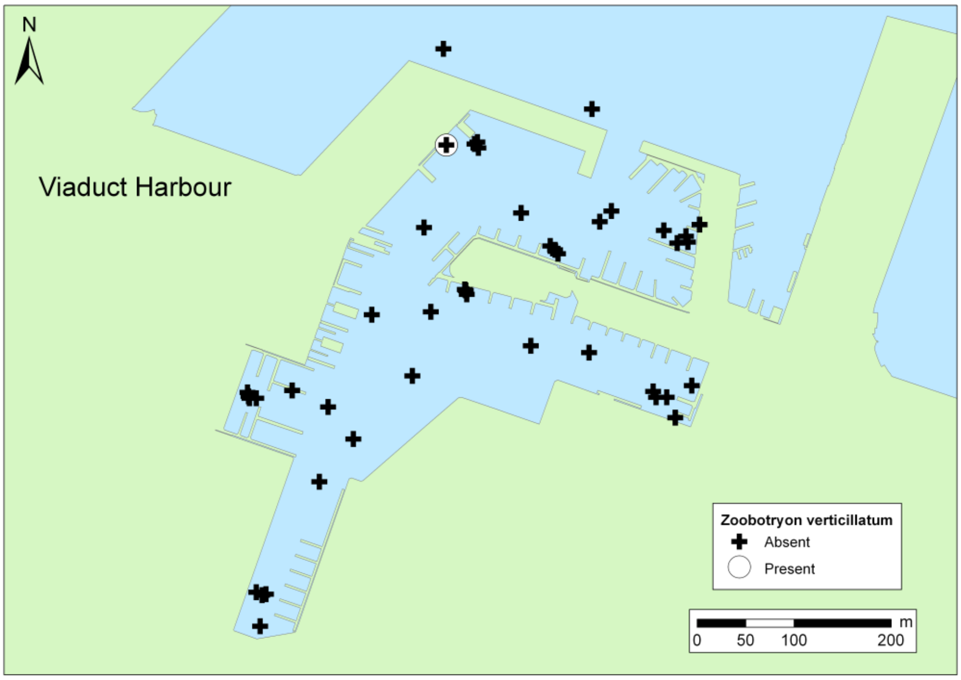

Figure 36: *Zoobotryon verticillatum* distribution in initial survey of Viaduct Harbour Marina

Buskia socialis **(Hincks, 1887)**

No image available.

Buskia socialis is an uncalcified, encrusting bryozoan with erect branches that can grow up to 3.2 cm long. Zooids are colourless, have a stomach gizzard and are around 0.60-0.79 mm long and 0.15-0.17 mm wide when partially retracted. Zooids are borne in two series along the encrusting stolon which is about 1.13 mm in diameter.

The type locality for *B. socialis* is the Adriatic coast and is has been recorded in the Mediterranean and Adriatic Seas, the Red Sea and Brazil (Figure 37). *B. socialis* was first recorded in New Zealand on live mussels (*Perna canaliculus*) in 3 m of water at North Cove, Kawau Island, Hauraki Gulf in May 1977 (Gordon and Mawatari 1992) and has since been recorded in the second basline survey of Napier (Figure 38), in the resurvey of Whangarei Harbour Whangarei and in this survey of Viaduct Harbour Marina (Table 12; Table 14).

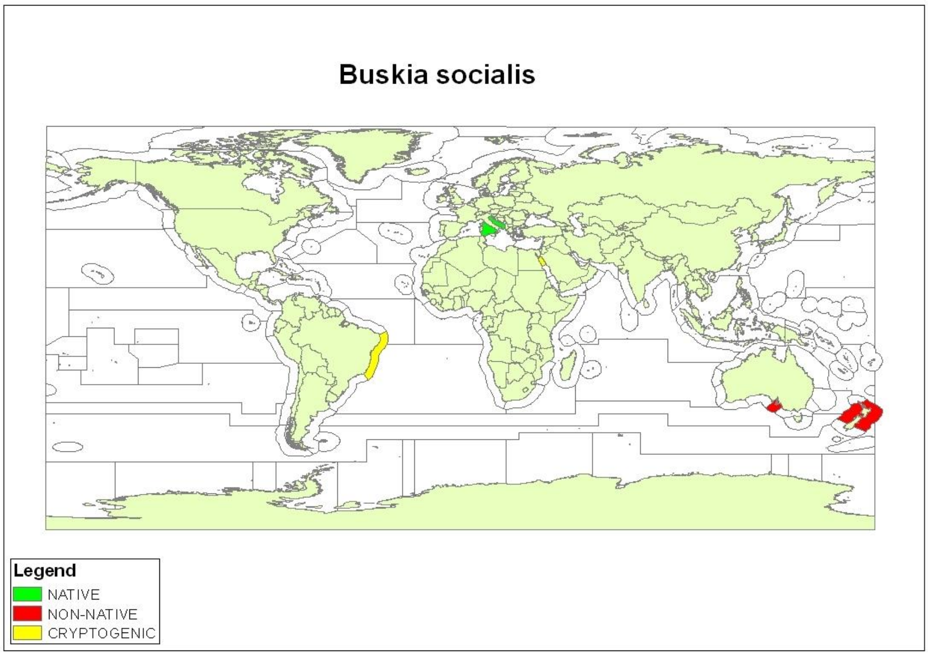

Figure 37: Global distribution of *Buskia socialis*

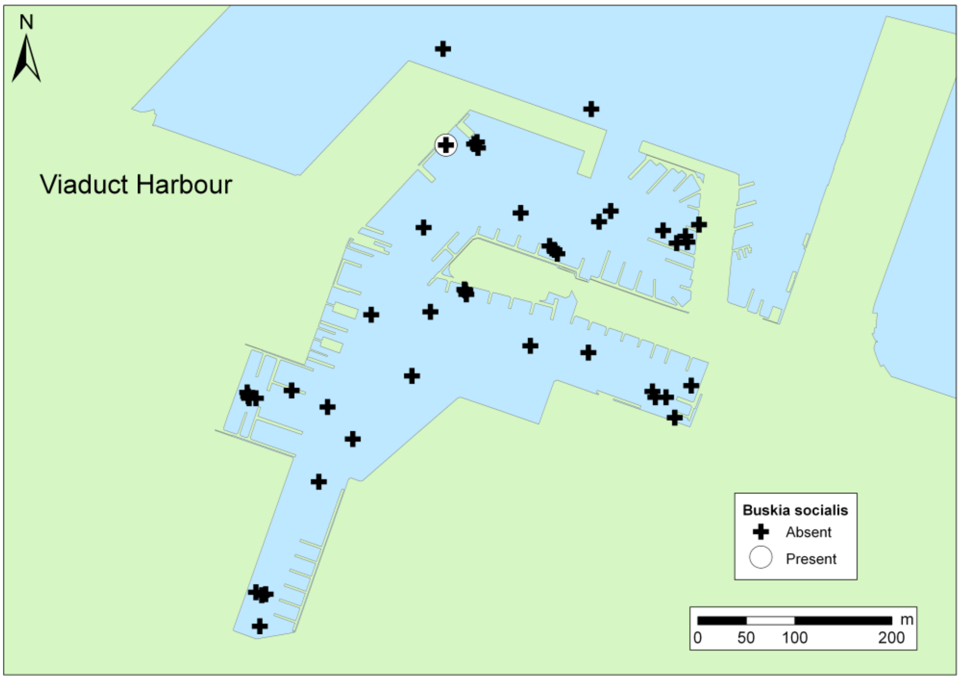

Figure 38: ***Buskia socialis*** **distribution in the intial survey of Viaduct Harbour Marina**

Ascidiella aspersa (Mueler, 1776)

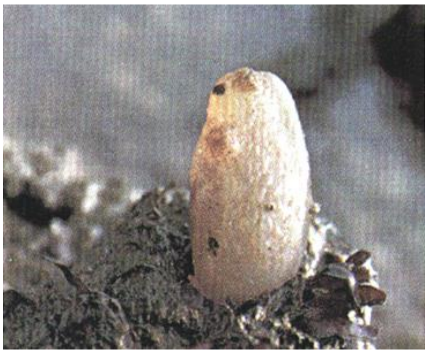

Image and information: NIMPIS (2002a)

Ascidiella aspersa is a solitary ascidian that is native to northwest Europe, the British Isles, the Mediterranean Sea and the northwest African coasts (

Figure 39). It has been introduced to India, Australia and New Zealand, and is cryptogenic to the east coast of the USA. *Ascidiella aspersa* attaches to the substratum by its entire left side and grows up to 130 mm in length. The inhalant (branchial) siphon is positioned at the top of the body and is conical in shape. The exhalent (atrial) siphon is positioned around one third of the way down the body and both siphons are ridged. The body wall (test) is firm and is transparent with numerous papillae scattered over the surface. Small amounts of pink or orange may be visible inside the siphons. *Ascidiella aspersa* is found from intertidal to shallow subtidal waters to 50m depth attached to clay, stones, rocks, algae and wharf piles, where it can be the dominant fouling species. In the southern hemisphere, populations are particularly abundant in the inner-reaches of estuaries and harbours in protected or semi-enclosed marine embayments. Although it is a solitary ascidian (i.e. not colonial) it is often found in dense clumps. It has no known documented impacts.

During the initial baseline surveys it was recorded from Gisborne, Napier and the Gulf Harbour Marina (Table 14; (Inglis *et al*. 2006b, e, g)). These are likely to be extensions to the range of this species in New Zealand (M. Page, pers. comm.), as published records of its occurrence in New Zealand are for Christchurch, Portobello and Stewart Island (Vervoort and Watson 2003). During the second baseline surveys *A. aspersa* was recorded from the Port of Lyttelton (Inglis *et al*. 2006o), Bluff, Gulf Harbour Marina, Westhaven Marina (Inglis *et al.* in press) and during this survey of the Viaduct Harbour Marina (Table 12; Table 14).

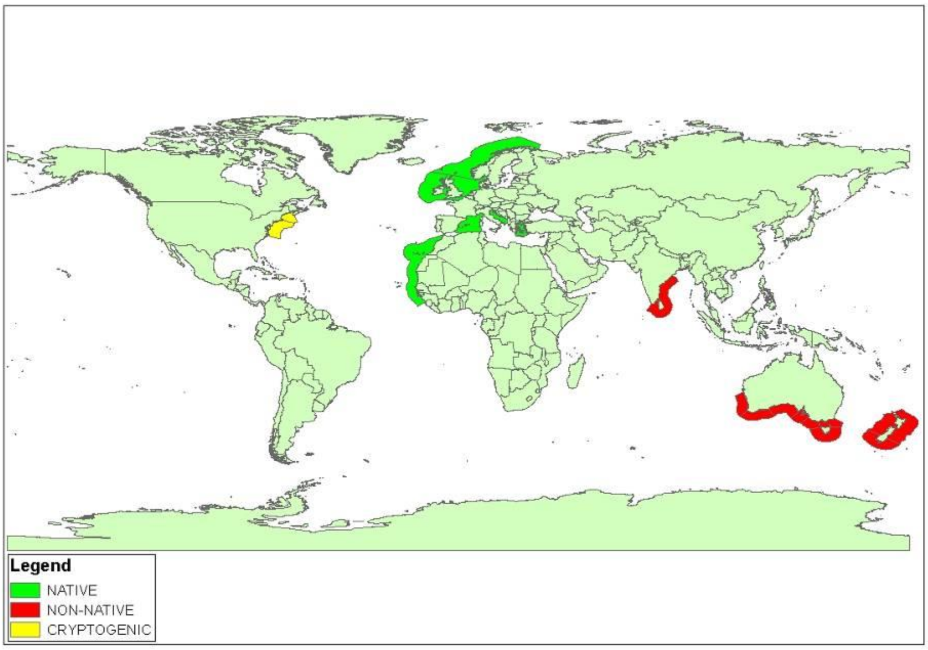

Figure 39: Global distribution of *Ascidiella aspersa*

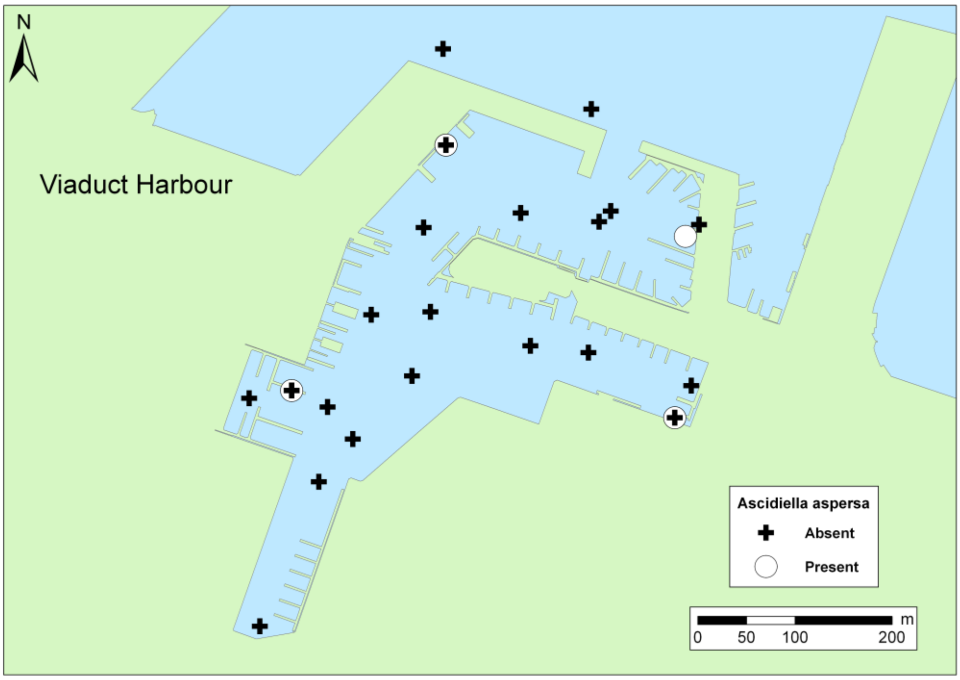

Figure 40: *Ascidiella aspersa* distribution in the initial survey of the Viaduct Harbour Marina

***Diplosoma listerianum* (Milne-Edwards, 1841)**

Image: (Picton 2007)

Diplosoma listerianum is a transparent, gelatinous, ascidian which forms sheets of colonies on algae up to 4 mm thick and 50 mm wide. The zooids are small, colourless and scattered densely throughout the sheet. Each zooid has a small inhalant pore and there are a few larger exhalant openings, but these openings are not conspicuously pigmented. There is a conspicuous pattern of small yellow pigment bodies in the surface layer which can be seen on close inspection (Picton 2007).

D. listerianum is common in shallow water through the British Isles and tropical and subtropical seas (Picton 2007) (
Figure 41). In New Zealand *D. listerianum* was recorded as a cryptogenic category 1 taxon in the initial baseline surveys of the ports of Auckland, Gisborne, Dunedin, Napier, Tauranga, New Plymouth, Whangarei and Taharoa (Inglis *et al*. 2006a, d, g, j, k, n). Since changing status to NIS, *D. listerianum* has been recorded in the resurvey of the ports of Lyttelton, Tauranga, Dunedin, Auckland, Bluff, Napier, Whangarei, Westhaven Marina, Gulf Harbour Marina (Inglis et al. 2006o, r), Inglis in press.) and in this survey of the Viaduct Harbour Marina (Table 14).

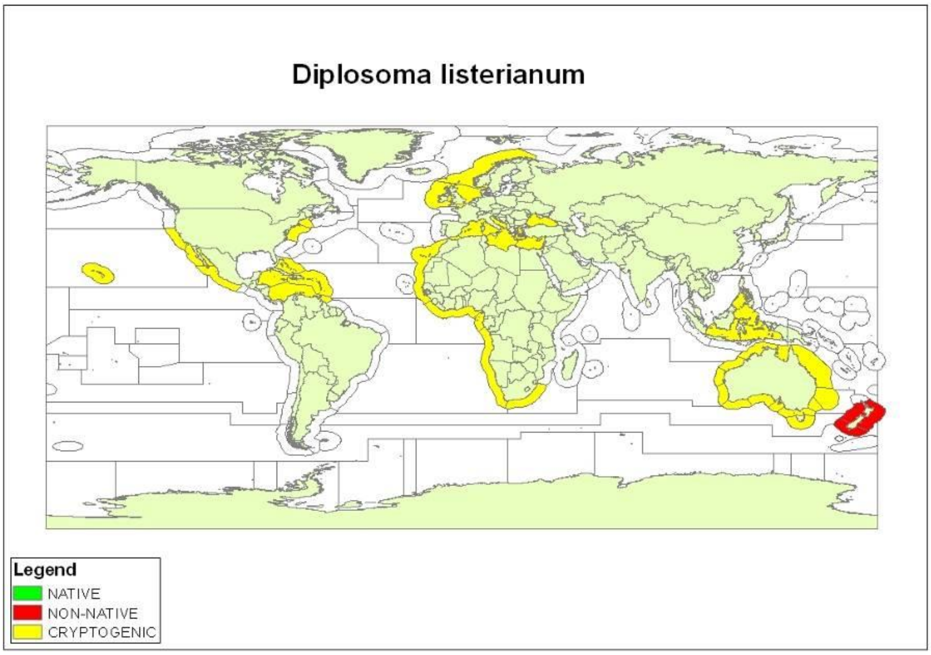

Figure 41: Global distribution of *Diplosoma listerianum*

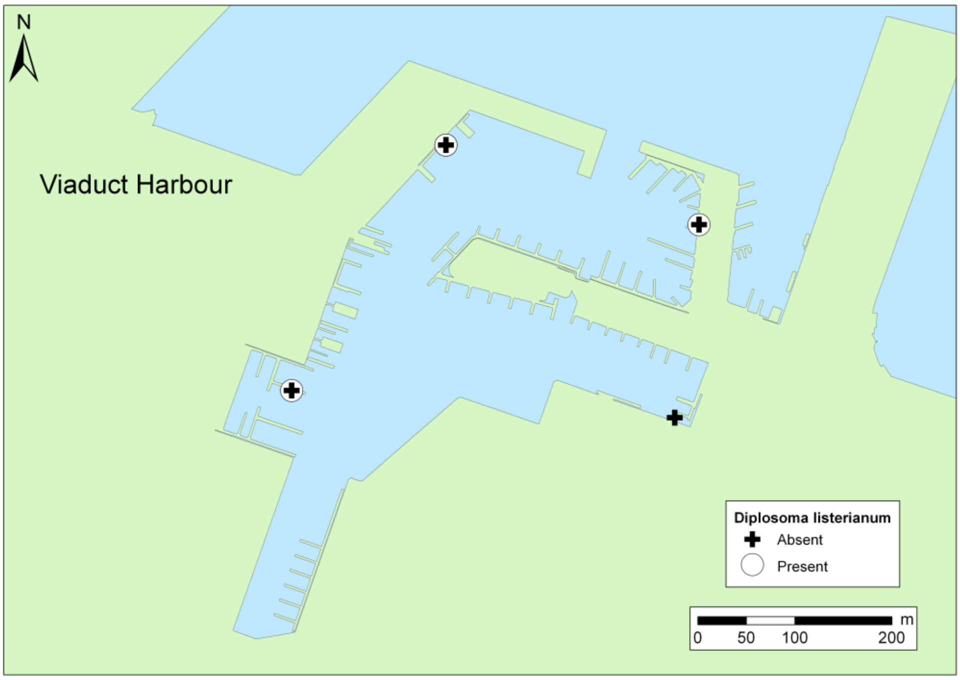

Figure 42: *Diplosoma listerianum* distribution in the initial survey of the Viaduct Harbour Marina.

Botryllus tuberatus (Ritter & Forsyth, 1917)

Image: (DORIS 2008)

Botryllus tuberatus is an encrusting ascidian which forms a thin crust over rocks and other substrates. The individual zooids are of pinhead size and of a pale yellow colour; they are arranged in elliptical patterns. (Hinton 1988). *B. tuberatus* prefers quiet bay waters and has been collected on *Ulva reticulate* (Monniot and Monniot 2001).

The type locality for *B. tuberatus* is California but this is a very common ascidian and is distributed worldwide (Monniot and Monniot 2001). In New Zealand *B. tuberatus* has been recorded in Wellington. In the port baseline surveys *B. tuberatus* has only been recorded from Westhaven Marina (Inglis *et al*. in press) and from this survey of Viaduct Harbour Marina (Table 12; Table 14).

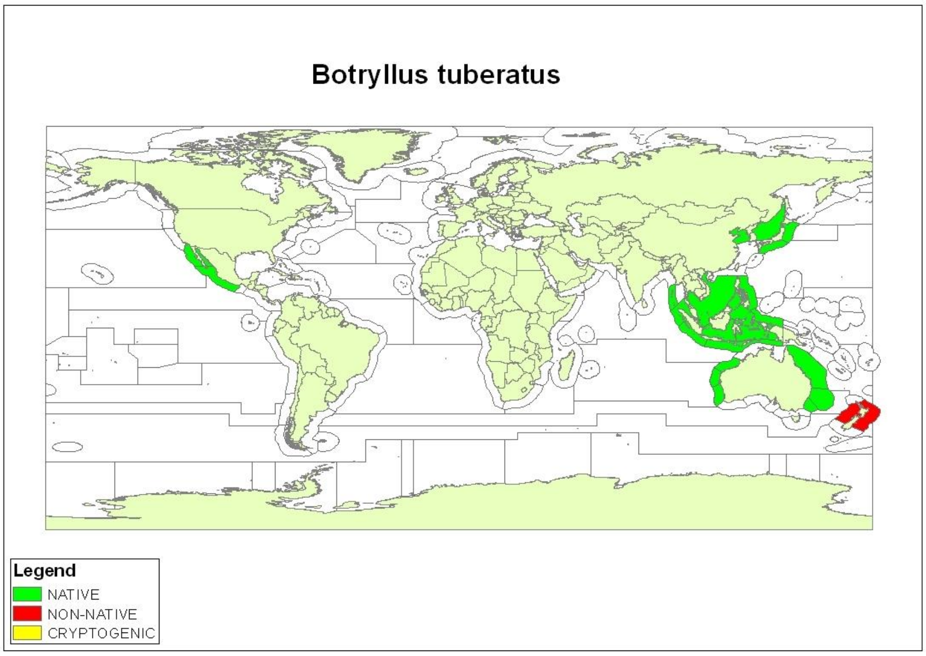

Figure 43: Global distribution of *Botryllus tuberatus*

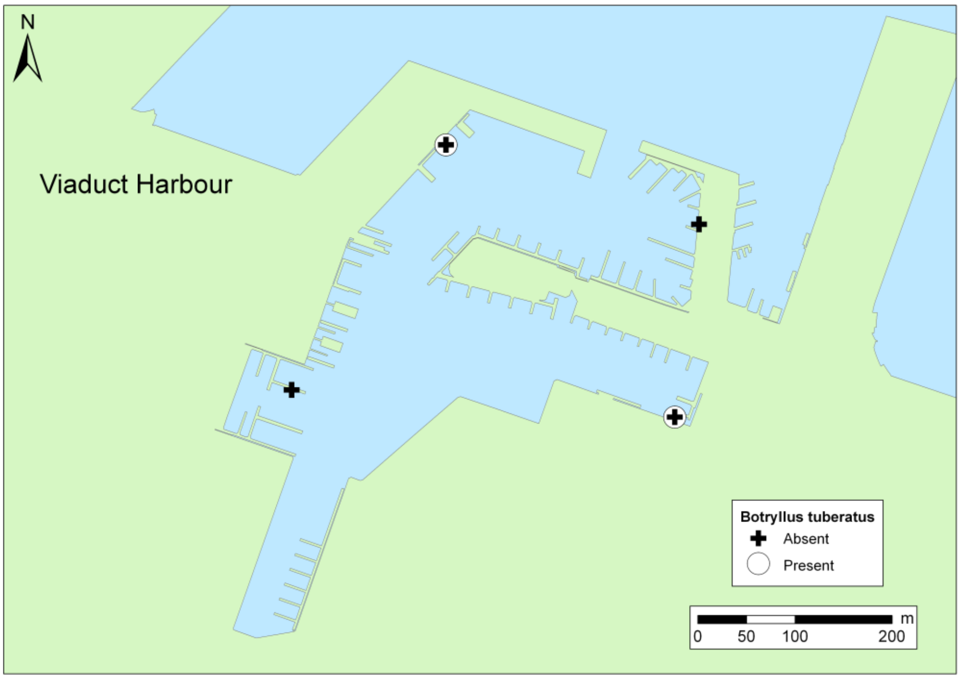

Figure 44: ***Botryllus tuberatus*** **distribution in the initial survey of the Viaduct Harbour Mairna.**

***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). 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 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 and Inglis 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 repeat surveys of Auckland, Gulf Harbour Marina, Lyttelton and in the initial survey of Westhaven Marina (Inglis *et al*. 2006o; Inglis *et al.* in press) and this survey of Viaduct Harbour Marina (Table 12; Table 14).

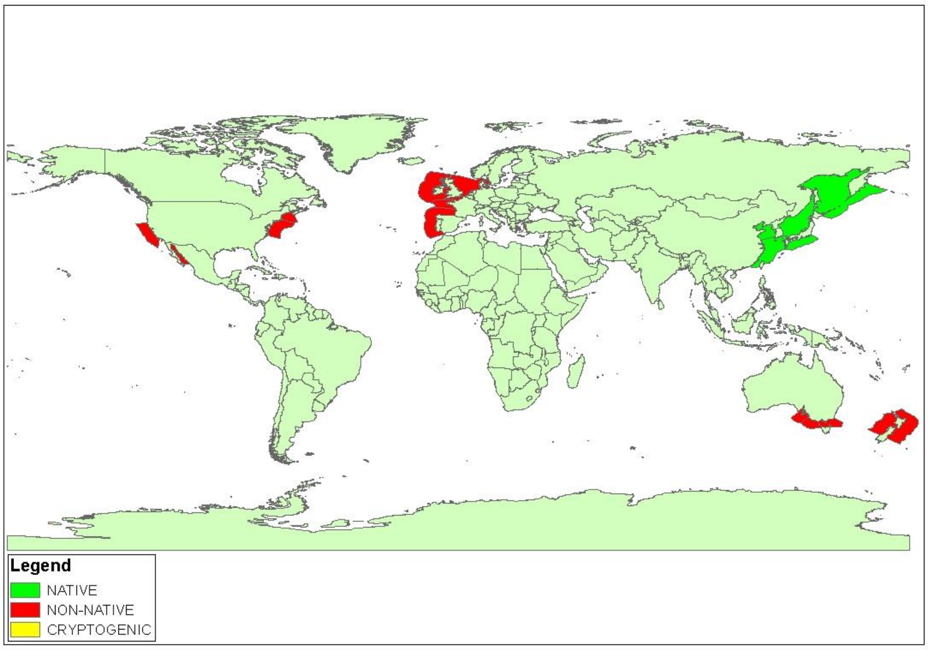

Figure 45: Global distribution of *Styela clava*

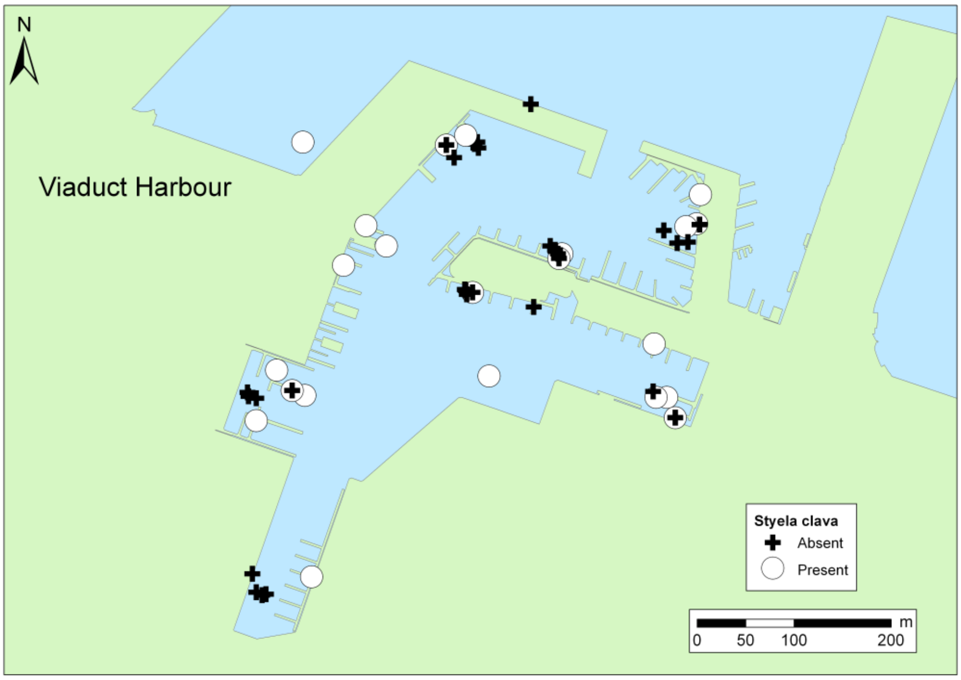

Figure 46: *Styela clava* distribution in the initial survey of Viaduct Habour Marina

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 47). Its impacts on native organisms are unknown.

P. disticha 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 ports of Auckland (Inglis *et al*. 2006a, d). In the second baseline surveys it was reported in Auckland, Dunedin and Bluff, in the surveys of Westhaven Marina, Kaikoura and in this survey of the Viaduct Harbour Marina (Inglis in press; Table 12; Table 14).

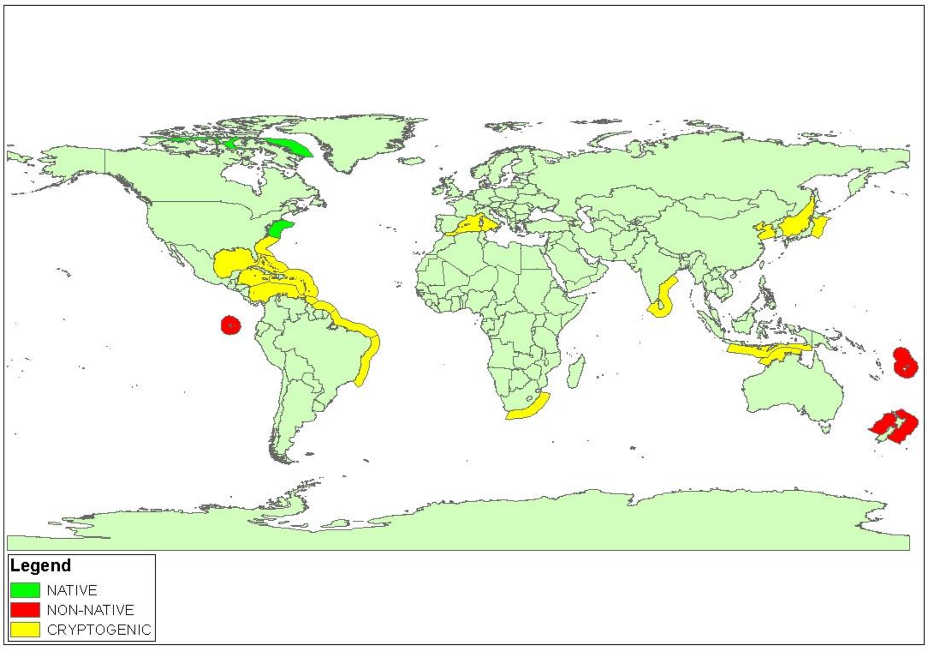

Figure 47: Global distribution of *Pennaria disticha*

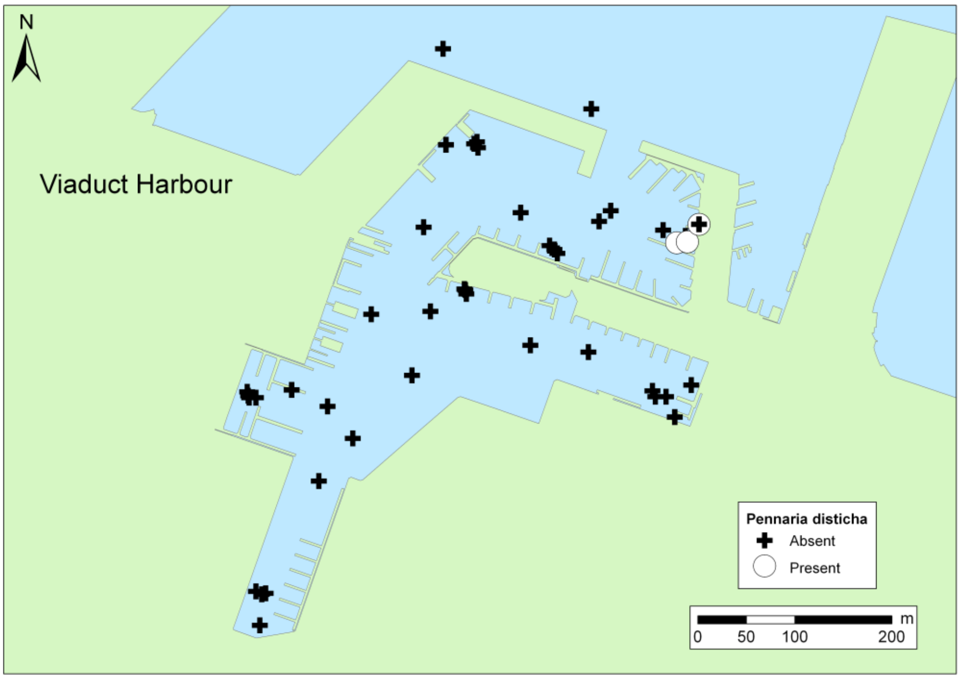

Figure 48: ***Pennaria disticha*** **distribution in the initial survey of the Viaduct Harbour Marina**

Limaria orientalis (Adams & Reeve, 1850)

Image: www.femorale.com.

Limaria orientalis (file shell) is a bivalve in the family Limidae. *L. orientalis* can be a dominant member of benthic assemblages in muddy shell gravels (Hayward 1997). Its impacts in its introduced range are unknown.

L. orientalis is known from Australia and the tropical Indo-Pacific. 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 and Opua Marinas in the initial baseline surveys (Inglis *et al*. 2006b, c), in the repeat surveys of the ports of Auckland and Whangarei and in this survey of the Viaduct Harbour Marina (Table 12; Figure 49; Inglis in press).

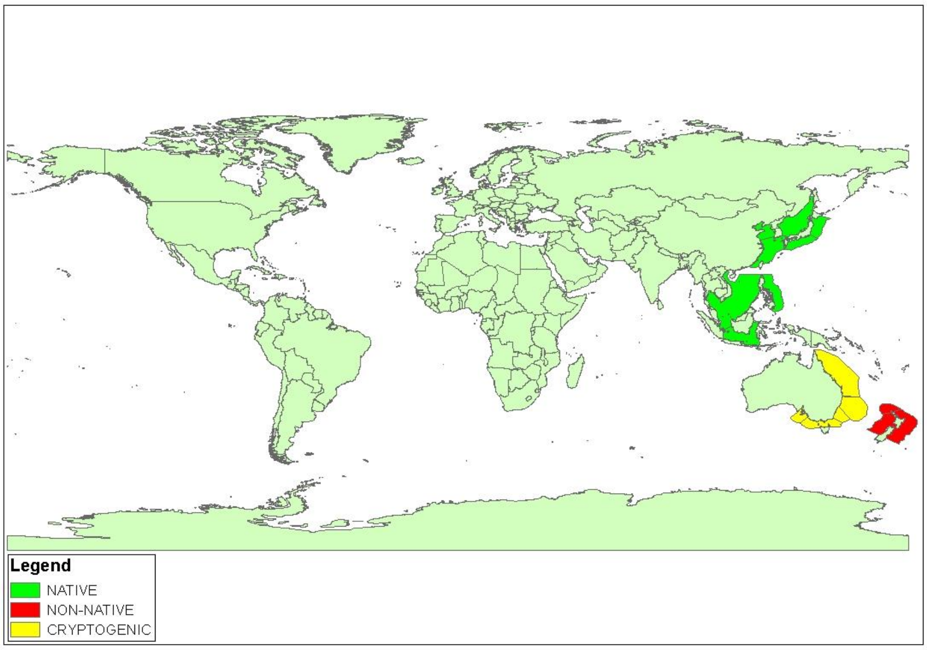

Figure 49: Global distribution of *Limaria orientalis*

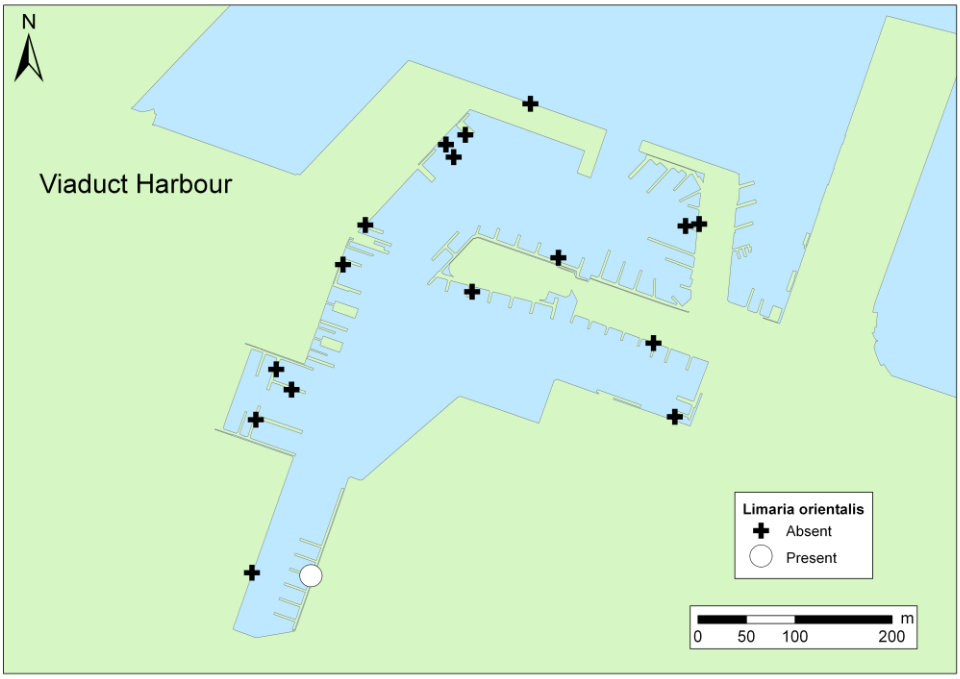

Figure 50: ***Limaria orientalis* distribution in the initial survey of the Viaduct Harbour Mairna**

Theora lubrica (Gould, 1861)

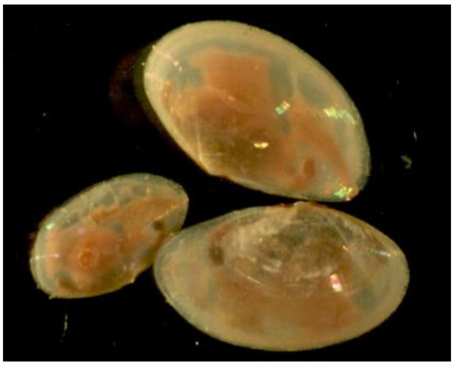

Image and information: NIMPIS (2002e)

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. *Theora 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 51). *Theora 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 12). 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 14). During the initial port baseline surveys, it was recorded from Opua marina, Whangarei port and marina, Gulf Harbour marina, and the ports of Auckland, Napier (

Figure 51), Taranaki, Wellington, Nelson, and Lyttelton (Table 14). During the second baseline surveys, *T. lubrica* was recorded from the ports of Taranaki, Wellington, Picton, Nelson, Lyttelton, Napier (

Figure 52), Opua Marina and Whangarei Port and Marina, Gisborne, Kaipara, Westhaven Marina, Auckland, Gulf Harbour Marina, Port Underwood (Inglis et al. 2006o, p, q; Inglis et al. 2006t; Inglis et al. 2006u), Inglis in press) and in this survey of Viaduct Harbour Marina (Table 12; Table 14).

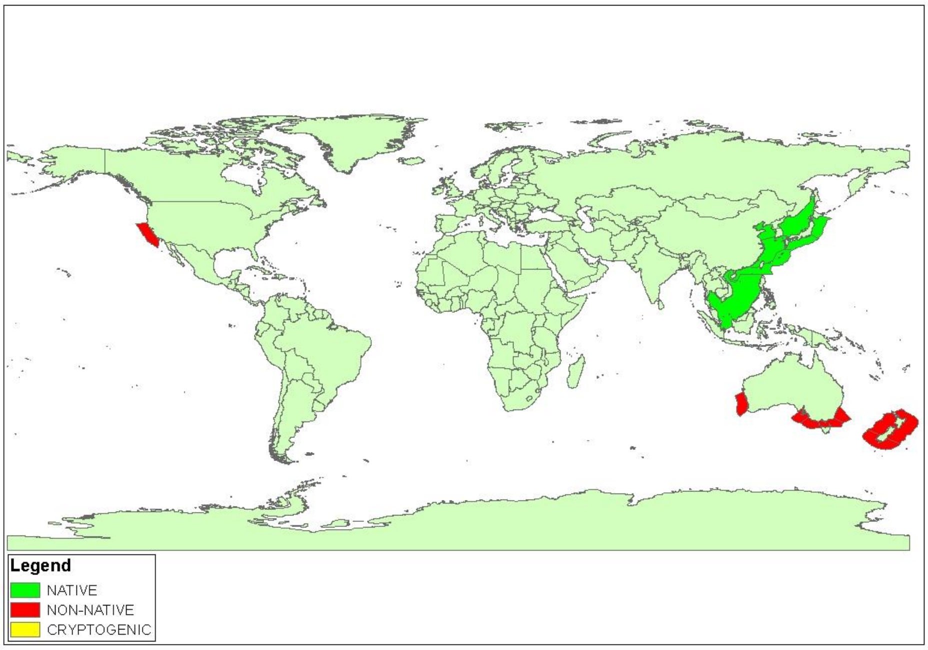

Figure 51: Global distribution of *Theora lubrica*

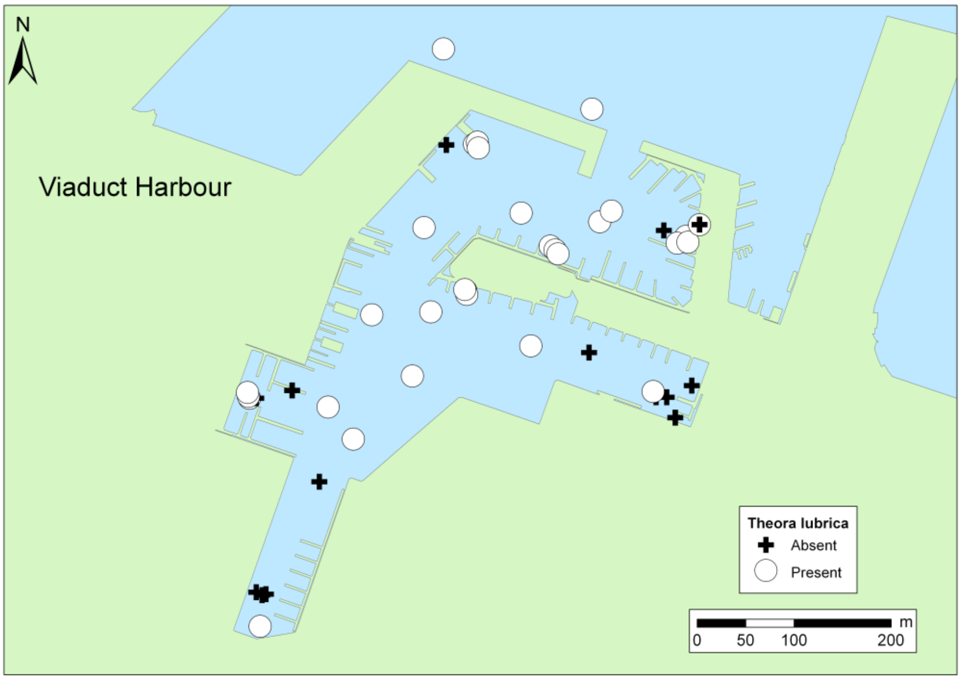

Figure 52: *Theora lubrica* distribution in the initial survey of the Viaduct Harbour Marina

Undaria pinnatifida (Harvey) Suringar, 1873

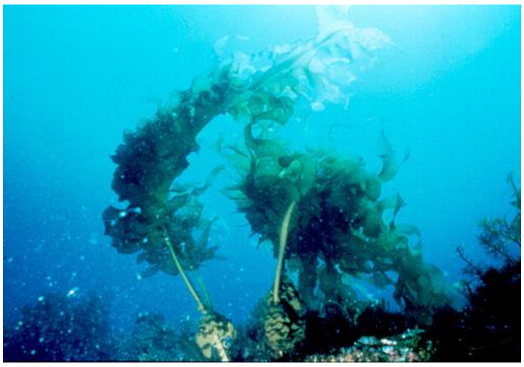

Image: NIMPIS (2002f)
Information: NIMPIS (2002f), Fletcher and Farrell (1999)

Undaria pinnatifida is a brown seaweed that can reach an overall length of 1-3 metres. It is an annual species with two separate life stages; it has a large, "macroscopic" stage, usually present through the late winter to early summer months, and small, "microscopic" stage, present during the colder months. The macroscopic stage is golden-brown in colour, with a lighter coloured stipe with leaf-like extensions at the beginning of the blade and develops a distinctive convoluted structure called the "sporophyll" at the base during the reproductive season. It is this sporophyll that makes *U. pinnatifida* easily distinguishable from native New Zealand kelp species such as *Ecklonia radiata.* It is native to the Japan Sea and the northwest Pacific coasts of Japan and Korea and has been introduced to the Mediterranean and Atlantic coasts of France, Spain and Italy, the south coast of England, southern California, Argentina parts of the coastline of Tasmania and Victoria (Australia), and New Zealand. It is cryptogenic on the coast of China.

Undaria pinnatifida is an opportunistic alga that has the ability to rapidly colonise disturbed or new surfaces. It grows from the intertidal zone down to the subtidal zone to a depth of 15-20 metres, particularly in sheltered reef areas subject to oceanic influence. It does not tend to become established successfully in areas with high wave action, exposure and abundant local vegetation. *U. pinnatifida* is highly invasive, grows rapidly and has the potential to overgrow and exclude native algal species. The effects on the marine communities it invades are not yet well understood, although its presence may alter the food resources of herbivores that would normally consume native species. In areas of Tasmania (Australia) it has become very common, growing in large numbers in areas where sea urchins have depleted stocks of native algae. It can also become a problem for marine farms by increasing labour costs due to fouling problems.

U. pinnatifida is known to occur in a range of ports and marinas throughout eastern New Zealand, from Auckland to Stewart Island and, recently, the Snares Islands (Table 14). With the exception of Bluff, it is considered to be absent from the southern and western coasts of the South Island and most of the western coast of the North Island (Russell *et al*. 2008). During the initial port baseline surveys, it was recorded from the ports of Gisborne, Napier, Wellington, Picton, Lyttelton, Timaru and Dunedin (Table 14). During the second baseline surveys *U. pinnatifida* was recorded from the ports of Taranaki, Gisborne, Wellington, Picton, Nelson, Lyttelton, Waitemata Harbour, Auckland, Tauranga Harbour, Port Underwood, Kaikoura, Timaru, Dunedin, and Bluff and in this survey of Viaduct Harbour Marina (Table 12; Table 14).

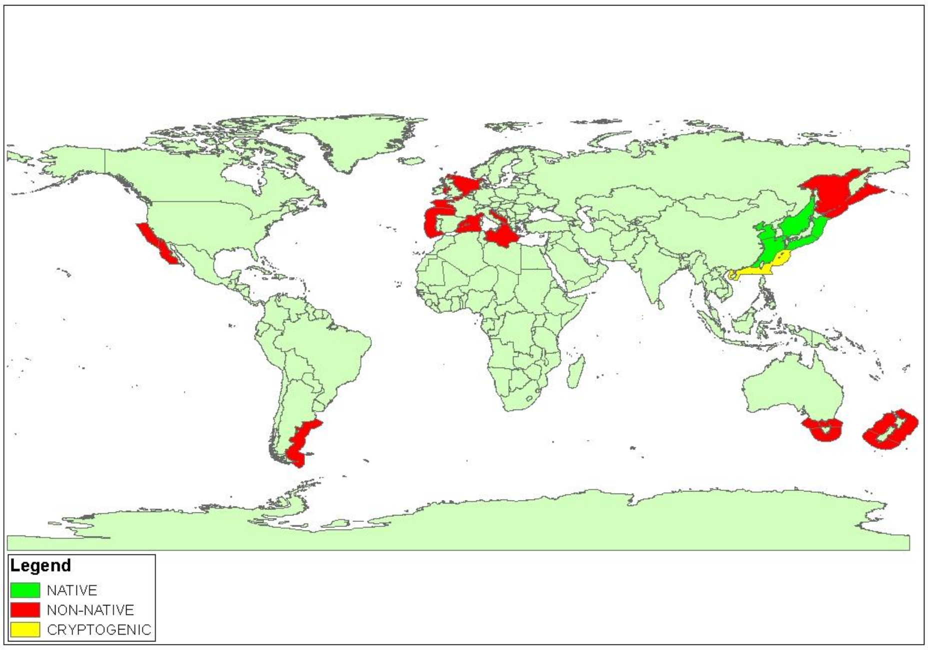

Figure 53: Global distribution of *Undaria pinnatifida*

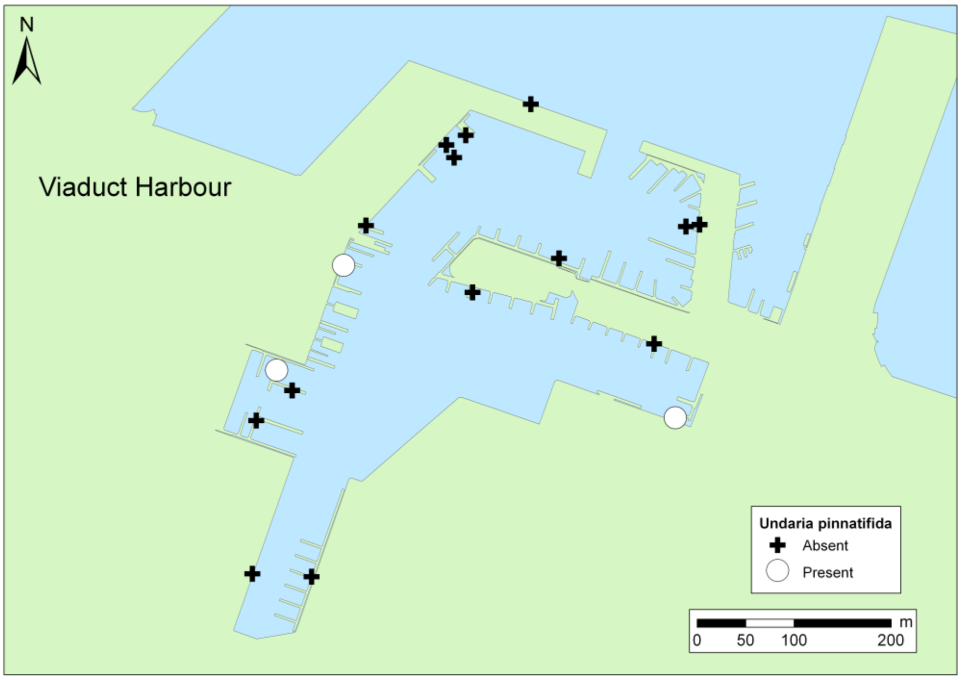

Figure 54: *Undaria pinnatifida* distribution in the initial survey of the Viaduct Harbour Marina

Indeterminate taxa

Thirty organisms from the Viaduct Harbour Marina were classified as indeterminate taxa. If each of these organisms is considered a species of unresolved identity, then together they represent 19.9 % of all species collected from this survey (Figure 15). Indeterminate taxa from the Viaduct Harbour Marina included seven annelids, five crustaceans, four ascidians, two fish, two cnidarians, two dinoflagellates, two brown algae and one bryozoan, one green alga, one mollusc, one Nemertea, one Platyhelminthes and one Sipuncula (Table 13).

Notifiable and unwanted species

Two species recorded from the Port of Lyttelton - the Asian seaweed, *Undaria pinnatifida* and the club-shaped ascidian *Styela clava* are currently listed on the New Zealand Register of Unwanted Organisms (Table 6).

The Australian Consultative Committee on Introduced Marine Pest Emergencies (CCIMPE) has recently endorsed a Trigger List (Table 7) of marine pest species to Austalia (CCIMPE 2006). The brown alga *Undaria pinnatifida*, is listed as established but not widespread in Austalia. *U. pinnatifida* has also been identified as non-indigenous to New Zealand and was recorded from the Viaduct Harbour Marina. Similarly, the non-indigenous nesting mussel, *Musculista senhousia*, the green alga *Codium fragile* spp. *tomentosoides* and the native New Zealand screw shell, *Maoricolpus roseus*, are all known to be present throughout Waitemata Harbour and listed on the CCIMPE Trigger List as "established but not widespread in Austalia". The non-indigenous portunid crab, *Charybdis japonica*, which is present in Waitemata Harbour, but which was not detected in the Viaduct Harbour survey is also on the CCIMPE Trigger List. It is not known to occur 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 Viaduct Harbour Marina. These are listed in descending order of the impact potential ranking attributed to them by Hayes *et al*. (2005a): *Schizoporella errata*, *Undaria pinnatifida, Styela clava, Zoobotryon verticillatum, Watersipora arcuata, Theora lubrica* and *Pseudopolydora paucibranchiata.* None of the 37 priority international pests (ie. those not yet in Australia) identified by Hayes *et al*. (2005a) were detected in the survey of the Viaduct Harbour Marina, but *Charybdis japonica*, which is one of those pests, is known to occur in surrounding environments.

Species not previously recorded in New Zealand

One species recorded from the survey of the Viaduct Harbour Marina - the cryptogenic category 1 shrimp *Lysmata vittata* - is a new record from New Zealand waters.

Range extensions

There were no taxa recorded in the survey of the Viaduct Harbour Marina highlighted by taxonomists to represent extensions to the known range of these species in New Zealand.

Cyst-forming species

Cysts of six species of dinoflagellate were collected during this survey. Four of these are considered native species (Table 10) and the remaining two are indeterminate (Table 13). None of the species recorded are known to produce toxins (Hay *et al*. 2000; Faust and Gulledge 2002; New Zealand Food Safety Authority 2003).

Depth stratification trends

The greatest proportion of NIS, C1 taxa and native taxa occurred in samples from zero to three metres depth, despite only 25.3 % of samples having been collected from that depth class (Figure 55). This is due to the large proportion of taxa, both NIS and C1 (97 %) and native (64 %), that were recorded in pile scrapings, which were conducted only in the top three metres of water. Maximum depths in the Viaduct Harbour basin were generally < 7 m, meaning that quadrat scrapes were limited to 3 m or shallower. Fouling assemblages tended to have the greatest density of species of the habitats sampled.

The lower depths (depth classes >3-6 m, and >6-9 m) were sampled by several other methods (benthic sleds, benthic grabs, and crab, fish and seastar traps, opportunistic visual searches and wharf piling miscellaneous searches) and yielded more native taxa than NIS and C1 taxa (Figure 55). This reflects the high proportion of fouling organisms amongst the NIS and C1 taxa recorded from the port, which are less likely to be recorded by these other methods than by the pile scraping method, which targets fouling organisms.

Of the 29 NIS and C1 taxa recorded, 26 (89.7 %) were collected between 0 and 3 m depth (Figure 55). Twenty of these 26 taxa (76.9 %) were not recorded from deepest samples. The three species that were not collected in samples from the 0-3 m depth were the annelids *Heteromastus filiformis*, *Pseudopolydora paucibranchiata* and *Paralepidonotus ampulliferus.* These were collected in benthic sled and benthic grab samples (

Table 15).

Of the 86 native taxa recorded, 45 (52 %) were recorded from only the 0-3 m depth class, six (7 %) were recorded only from the >3-6 m depth class and 10 (12 %) were recorded only from the >6-9 m depth class (Table 16). 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.

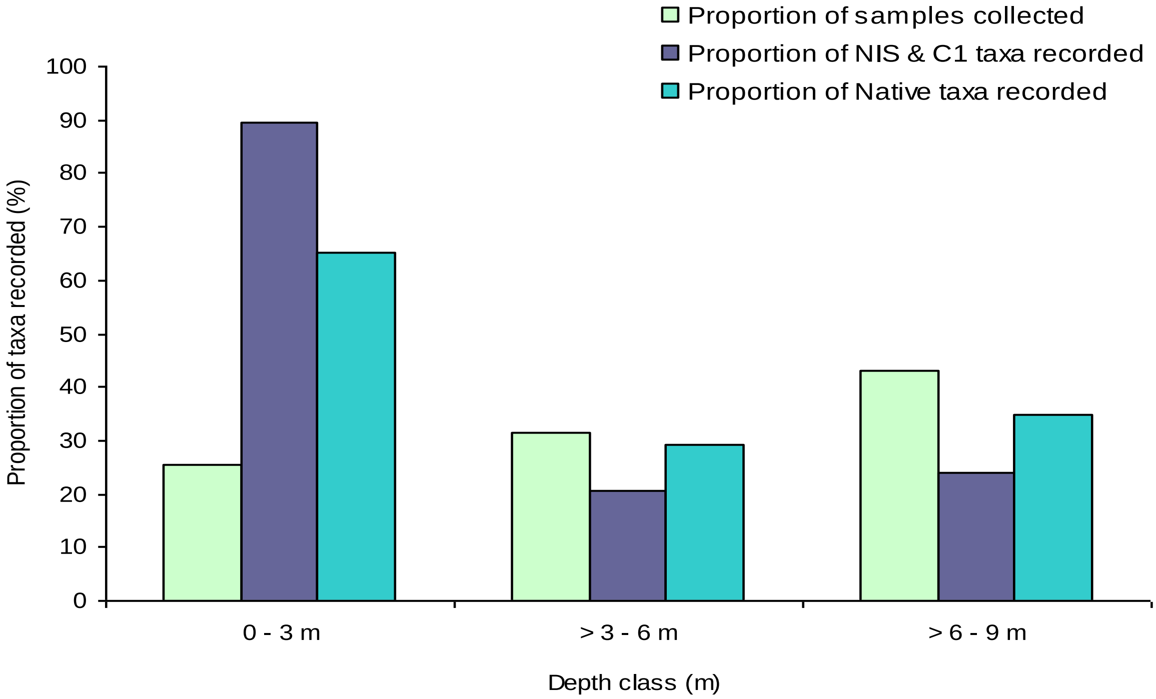

Figure 55: Proportion of taxa recorded from four depth classes during the second survey of the Viaduct Harbour Marina. The proportion of taxa sums to a total of >100% across depth classes, as some taxa were recorded from more than one depth class.

RAREFRACTION CURVES FROM THE INITIAL BASELINE SURVEY OF THE VIADUCT HARBOUR MARINA

Pile scrape samples

Native species

Rarefaction curves for the 48 pile scrape samples taken from the baseline survey of the Viaduct Harbour Marina are presented in

Figure 56. Fifty-four native species were recorded in the survey of the Viaduct Harbour Marina (

Figure 56; Table 17). After 40 quadrats samples the discovery rate of new species was low with less than one new species discovered every three pile scrapes. By 48 samples the observed richness curve was approaching the estimated total richness of 64 species (Chao 2 Bias-corrected mean;

Figure 56). The modest difference between the observed and estimated richness in the first survey (10 species) suggested a relatively complete inventory with a small proportion of uniques (i.e. species recorded in only one sample; 26 %; Table 17) and, therefore, few undetected species.

Cryptogenic category 2 taxa

Too few taxa were recorded in this category for quantitative estimation of taxa richness. Only five cryptogenic category 2 taxa were collected in the survey from the pile scrape (Table 17).

Non-indigenous and Cryptogenic category 1 taxa

The trajectory of the observed richness curve for non-indigenous and cryptogenic category 1 taxa collected in the pile scrape samples showed little indication of reaching a plateau (

Figure 56). This suggests that a number of 'rare' species with patchy distribution were present in the assemblage. Indeed, half of the 24 taxa recorded were uniques (50 %; Table 17). At the rate indicated in Figure 56, a further doubling of survey effort (i.e. ~130 samples) would be needed to capture the estimated species richness of the assemblage (Chao 2 classic estimate = 60 species; Figure 56), although the estimate itself had not completely stabilised indicating that, as more samples were taken, the rate of discovery of unsampled, rare species remained relatively constant. The Chao 2 estimated of species richness was high and unstable and failed to converge with the observed curve suggesting an incomplete inventory of this group and a number of undetected species present.

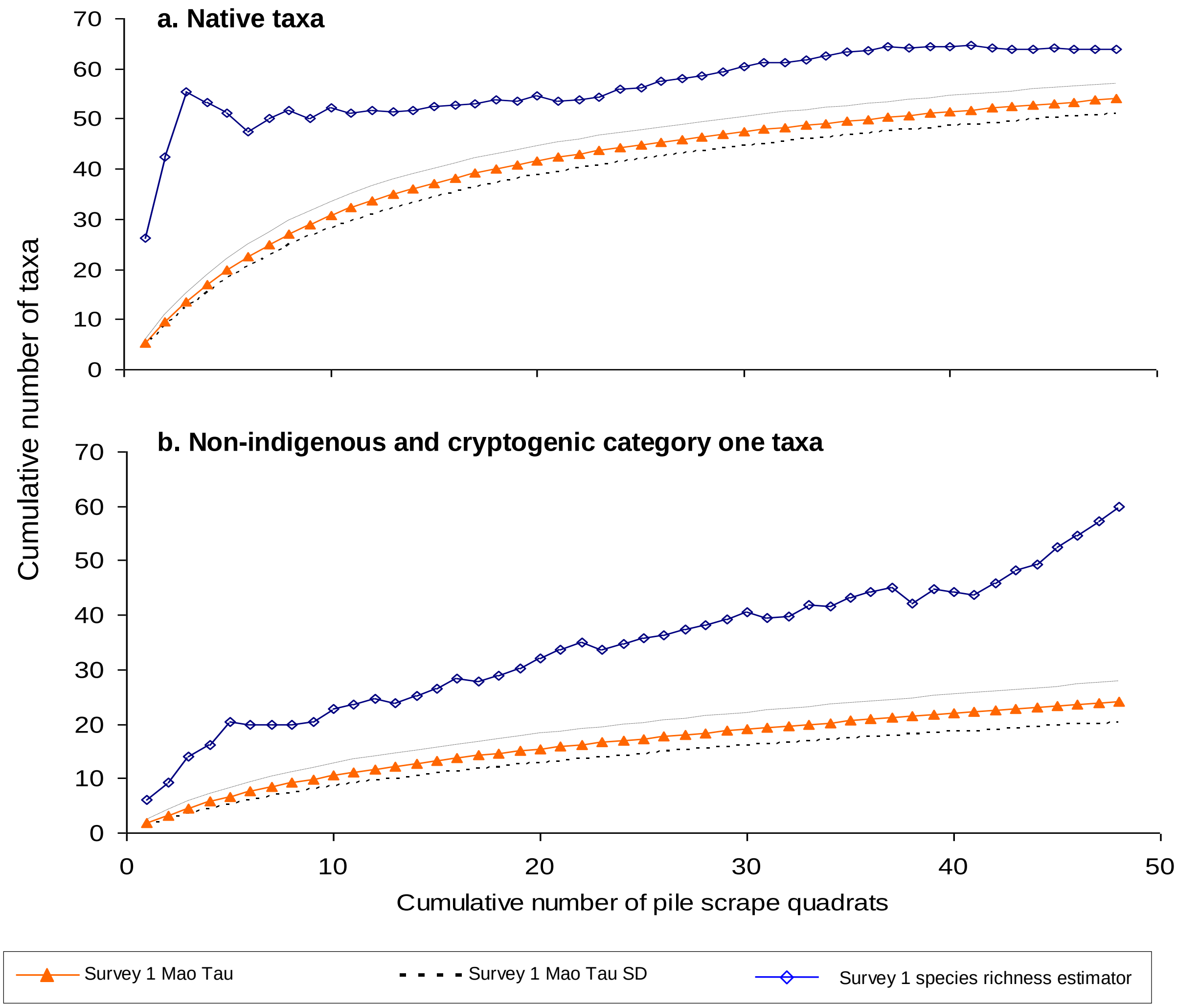

Figure 56: **Mean (± 1 standard deviation (SD)) rarefaction curves (Mao Tau) for native (a) and non-indigenous and cryptogenic category one (b) taxa collected from pile scrape quadrats for this first survey (full triangles, ± SD (dashed lines)). Species richness estimators are also shown (empty diamonds); the Chao 2 classic formula was used for NIS & C1 taxa and the Chao 2 bias-corrected formula was used for the native taxa.**

Benthic sled samples

Samples taken with the benthic sled contained relatively few non-indigenous and cryptogenic category 1 species (four species in total) or cryptogenic category 2 taxa (one taxa; Table 17). For this reason, analysis was done on the pooled species assemblage.

In total, 22 taxa were recorded in the 14 samples collected using the benthic sleds (Table 17). These samples were dominated by uniques (68 %; 15 of 22 taxa; Table 17) resulting in a comparatively large and unstable estimate of total taxa richness (Figure 57). The estimate diverged markedly from the observed taxa (Figure 57) suggesting an incomplete inventory of this group. Although the number of observed taxa increased as more samples were taken, the rate of increase was slow and failed to reach an asymptote suggesting a high proportion of rare and unsampled species within the assemblage. At the rate indicated in Figure 57, a further 32 samples would need to be taken to reach the estimated richness of 66 species (ICE estimate).

Benthic grab samples

Samples taken with the benthic grab contained relatively few non-indigenous and cryptogenic category 1 species (7 species in total) and no cryptogenic category 2 taxa (Table 17). For this reason, analysis was done on the pooled species assemblage.

A total of 22 taxa were recorded in the 21 benthic grab samples taken in in the initial survey of Viaduct Harbour Marina (Table 17). The number of observed taxa continued to increase as more samples were taken, although the rate of increase was low (

Figure 58). Again, the large proportion of uniques recorded (55 %; 12 of 22 taxa; Table 17) resulted in a high and unstable estimate of taxa richness which diverged from the observed species richness. This indicated undersampling of this assemblage. The slow rate of accumulation of species means that sampling effort would need to doubled again (~40 samples in total) to approach the estimated richness (ICE estimate = 42 taxa;

Figure 58).

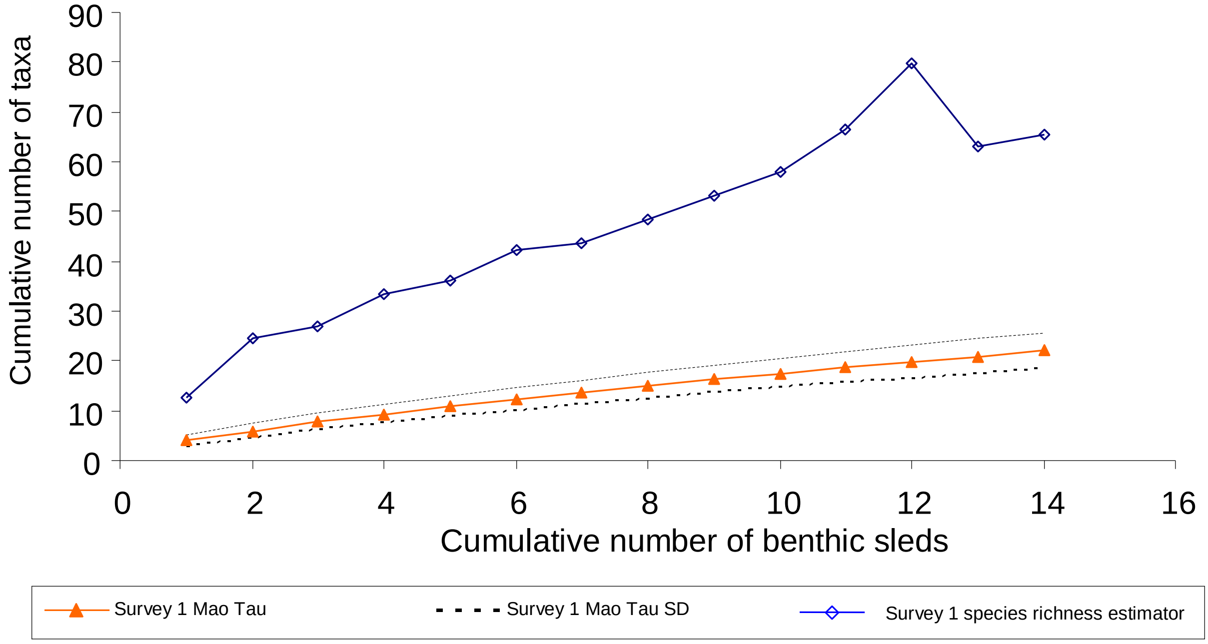

Figure 57: **Mean (± 1 standard deviation (SD)) rarefaction curves (Mao Tau) for native, cryptogenic and non-indigenous taxa combined collected in benthic sled tows during this first survey (full triangles, ± SD (dashed lines)). Species richness estimators are also shown for the first survey (empty diamonds; ICE Mean).**

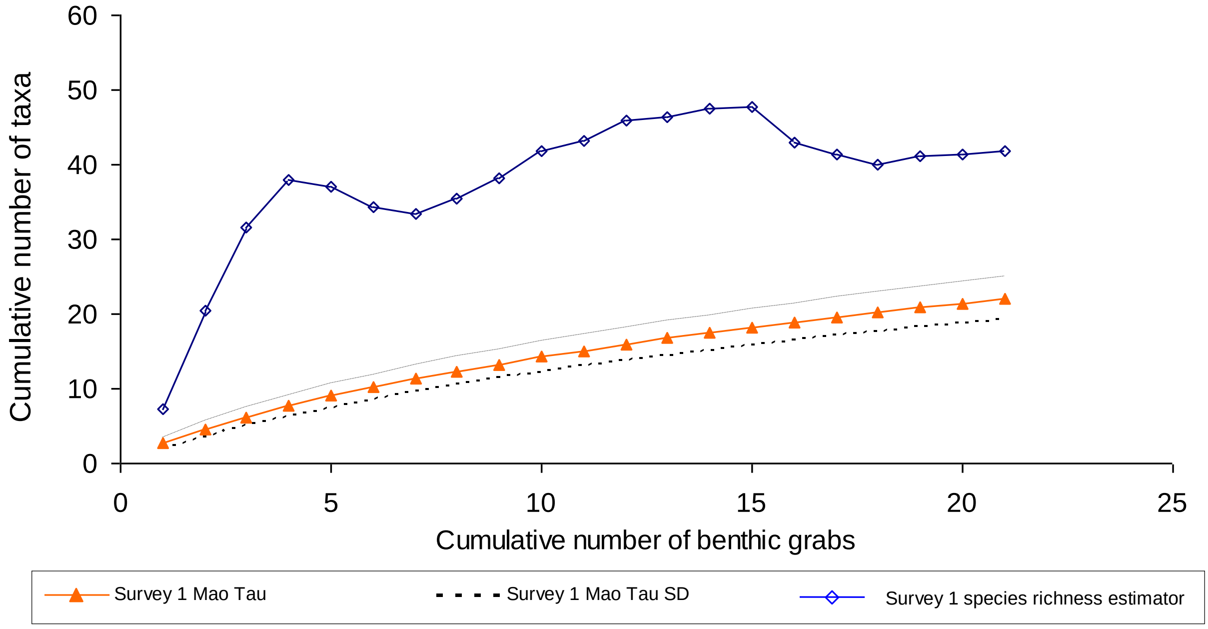

Figure 58: **Mean (± 1 standard deviation (SD)) rarefaction curves (Mao Tau) for native, cryptogenic and non-indigenous taxa combined collected in benthic grabs for the first survey (full triangles, ± SD (dashed lines)). Species richness estimators (ICE formula) are also shown for the first survey (empty diamonds).**

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

The non-indigenous species located in the Viaduct Harbour Marina are thought to have arrived in New Zealand via international shipping. They may have reached the Viaduct Harbour Marina directly from overseas or through domestic spread (natural and/or anthropogenic) from other New Zealand ports. Table 12 indicates the possible vectors for the introduction of each NIS recorded from the Viaduct Harbour Marina during the baseline port surveys. Likely vectors of introduction are largely derived from Cranfield *et al*. (1998) and expert opinion. They suggest that only 1 of the 19 NIS (5 %) probably arrived via ballast water, 10 species (53 %) were most likely to be associated with hull fouling, and eight species (42 %) could have arrived via either of these mechanisms.

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).

The majority of international recreational vessel arrivals to New Zealand come through the South Pacific (around 80%) or Australia (16%; O. Floerl, NIWA, pers. comm., Feb 2007; see "Vessel movements and ballast discharge patterns", above). These vessels commonly arrive from Fiji, Tonga, New Caledonia, Australia (Coffs Harbour, Lord Howe Island, Brisbane, Sydney, Norfolk Island, Bundaberg, Gladstone, Southport, Townsville, Launceston), Cook Islands, Vanuatu, Western Samoa, American Samoa, Niue, French Polynesia and the US Pacific Dependency (Inglis and Floerl 2002). Almost all of these are tropical locations with coastal environments dissimilar to those of New Zealand. However, southern Australian locations, such as Sydney, 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 Viaduct Harbour Marina. Furthermore, five 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*).

Assessment of translocation risk for introduced species found in the port

Modelled data suggest that an average of 273 vessels depart Opua Marina annually and travel to one of 36 ports throughout New Zealand (O. Floerl, NIWA, unpublished data, see "Vessel movements and ballast discharge patterns" above). Picton, Opua, Auckland, Westhaven Marina, Gulf Harbour Marina and Whangarei Town Basin were the next ports of call for the most domestic vessel movements from the Viaduct Harbour Marina. Although many of the non-indigenous species found in the survey of the Viaduct Harbour Marina have been recorded in other locations throughout New Zealand (Table 14), they were not detected in all of the other ports and marinas surveyed. There is, therefore, a risk that species established in the the Viaduct Harbour Marina could be spread to other New Zealand locations.

Of particular note are the two species present in the Viaduct Harbour Marina that are on the New Zealand Register of Unwanted Species: the invasive alga *Undaria pinnatifida* and the club-shaped ascidian, *Styela clava*. *U. pinnatifida* has been present in New Zealand since at least 1987 and has spread through shipping and other vectors to 11 of the 16 ports and marinas surveyed during the baseline surveys (the exceptions being Opua, Whangarei Port and Marina, and Gulf Harbour Marina). Until recently, it was absent from the Ports of Taranaki (New Plymouth) and Tauranga. Mature sporophytes were discovered in the Port of Taranaki during the repeat baseline port survey there in March 2005. Some isolated sporophytes have also been discovered independently on rocky reefs near the Port of Tauranga (Environment Bay of Plenty, pers. comm.), but the alga does not appear to be established in the port itself. Recreational vessels regularly ply between Auckland, Lyttelton and the Port of Tauranga and, to a much lesser extent, ports north of Auckland where *U. pinnatifida* has not yet become established. There is, therefore, a risk that it could be spread to these locations by shipping from the Viaduct Harbour Marina.

Styela clava is considered a significant pest of aquaculture (particularly long-line mussel culture) and there is concern about the potential for it to spread to important mussel growing areas in the Marlborough Sounds and Coromandel.

As Picton (in the Marlborough Sounds) is the most common destination for vessels travelling from the Viaduct Harbour Marina and because *U. pinnatifida* and *S. clava* are fouling organisms, the risk of translocating them is highest for slow-moving vessels, such as yachts and barges, and vessels that have long residence times in port. In the Viaduct Harbour Marina, cargo and 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 survey have only been recorded from the Viaduct Harbour Marina or have relatively restricted distributions nationwide and could, therefore, be spread from the Viaduct Harbour to other locations. These include the annelids *Hydroides elegans* and *Paralepidonotus amphipulliferus*, the bryozoans *Buskia socialis* and *Zoobotryon verticillatum,* and the ascidian *Botryllus tuberatus*.

Management of existing non-indigenous species in the port

Almost half of the NIS detected in this survey appear to be well established in the marina. However, there were eight NIS recorded in this survey that were recorded from only one site (Table 14). Most of these species have, however, been recorded from Waitemata Harbour previously and/or are known from other New Zealand ports.

For most marine NIS, eradication by physical removal or chemical treatment is not yet a cost-effective option. Local population controls are unlikely to be effective for species that are widespread in the Viaduct Harbour Marina. They may be worth considering for the more restricted species noted above, but a more detailed delimitation survey is needed for these species to determine their current distribution and abundance more accurately before any control measures are considered. It is recommended that management activity 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 two unwanted species, *Undaria pinnatifida* and *Styela clava*. MAF Biosecurity NZ led an initial response to the incursion by *Styela clava* into New Zealand. However, in December 2005 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 spread of *S. clava*. 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 the Viaduct Harbour Marina 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 uptaken domestically. Globally, shipping nations are moving toward implementing the International Convention for the Control and Management of Ships Ballast Water & Sediments that was recently adopted by the International Maritime Organisation (IMO). By 2016 all merchant vessels will be required to meet discharge standards for ballast water that are stipulated within the agreement.

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 through biofouling or sea chests by 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. 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 1987; 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 that will 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 species assemblage in the survey of the Viaduct Harbour Marina was characterised by moderate 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 baseline survey, 5 of the 19 non-indigenous species (19 %; *Amphibalanus amphitrite, Bugula stolonifera, Hydroides elegans, Paralepidonotus ampulliferus* and *Vosmaeropsis* cf. *macera*) were each found in just a single sample. Four of these species have been present in New Zealand for at least 30 years, while the date of introduction of *Polydora hoplura* is unknown (Cranfield *et al*. 1998; Kospartov 2008).

As several recent analyses have shown, the large area of habitat available for marine organisms within shipping ports and the logistic 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; 27 % of native species recorded in the Viaduct Harbour Marina 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).

Acknowledgements

We thank the Viaduct Harbour Marina for access to its facilities and assistance during the survey and Westhaven Marina for providing space to accommodate the field laboratory and research vessels. We also thank the field team members for field assistance and the species identification services provided by the taxonomists listed in the Project Team at the start of this report.

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.	
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.	

Term	Definition	Terms with the same or similar meaning
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 Viaduct Harbour Marina

Location	No. of berths	Purpose	Construction	Approximate length of berth (m)	Depth (m below chart datum)
Hobson West Marina	22	Charter boats and large recreational vessels	Floating concrete pontoons/ wooden piles	16-50m	4
Eastern Viaduct Harbour Marina	21	Recreational vessels	Floating concrete pontoons/ wooden piles	25–50m	3
Te Wero	26	Recreational vessels	Floating concrete pontoons/ wooden piles	Max 50m	4
Viaduct Harbour Marine Village	18	Recreational vessels	Floating concrete pontoons/ wooden piles	15-50m	4.7
Viaduct Port	13	Charter and commercial services	Floating concrete pontoons/ wooden piles	24-50m	4.3
Lighter basin Marina and Lighter Quay	20	Recreational vessels	Floating concrete pontoons/ wooden piles	22m	4.3
Waitemata Plaza marina	7	Recreational vessels	Floating concrete pontoons/ wooden piles	15-30m	3

Table 2: 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	
Sedentary /	Quadrat	0.10 m^2 quadrats	Quadrat	0.10 m^2 quadrats	Workshop recommended extra quadrat

	CRIMP Protocol		NIWA Method		
Taxa sampled	**Survey method**	**Sample procedure**	**Survey method**	**Sample procedure**	**Notes**
encrusting biota	scraping	sampled at -0.5 m, -3.0 m and -7.0 m on 3 outer piles per berth	scraping	sampled at -0.5 m, -1.5 m, -3.0 m and -7 m on 2 inner and 2 outer piles per berth	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 Holdsworth seastar traps left overnight)	Few NZ ports have suitable intertidal areas to beach seine.

Table 3. 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 4: Summary of sampling effort in Viaduct Harbour. Exact geographic locations of survey sites are provided in Appendix 2.

	Sampling method										
Site name	**FSHTP**	**CRBTP**	**SHRTP**	**STFTP**	**BGRB**	**BSLD**	**CYST**	**PSC**	**Photo stills & video**	**Qualitative visual searches#**	**Sediment**
Viaduct Harbour Marine village	8	4	2	4	3	4	2	12	54	8	1
Viaduct Port	4	4	2	4	3	2		12	54	9	1
Lighter Basin Marina	4	4	2	4	3	2	2			1	1
Te Wero north	6	4	2	4	3	4				3	1
Te Wero south	4	4	2	4	3	2				3	1
Eastern Viaduct Basin	4	4	2	4	3		2	12	53	5	1
Freemans Bay Breakwall	4	4	2	4		2			55	3	
Hobson West Marina	4	4	2	4	3	2	2	12		6	1
Lighter Quay / wall (viaduct)										1	
Freemans Bay										1	
Hobson Wharf										1	
Viaduct Harbour										1	
Outer Hobson West Marina		3								0	
Total	**38**	**35**	**16**	**32**	**21**	**18**	**8**	**48**	**216**	**42**	**7**

Qualitative visual searches consisted of post-pile scrape, diver transect and above-water searches. For details see the “Diver observations and collections on wharf piles” and “Visual searches” sections above.

Table 5: 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 6: 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 7: 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 8: Physical characteristics of the sites sampled during the survey of Viaduct Harbour Marina. 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)
Eastern Viaduct Basin	8	2.5	29	20.3	0
Freemans Bay Breakwall	8.7	-	-	-	-
Hobson West Marina	8	2.35	27	20.7	2
Lighter Basin Marina	8.5	-	-	-	-
Te Wero South	6.3	-	-	-	-
Viaduct Harbour Marine Village	8	1.85	25	20.5	-
Viaduct Port	5.8	1.85	25	20.5	-
Average across all sites	**7.61**	**2.14**	**26.50**	**20.50**	**1.00**
SE of average across all sites	**0.42**	**0.17**	**0.96**	**0.08**	**1.00**

Table 9: Percentage of five sediment particle sizes at seven sites sampled during the initial baseline survey of the Viaduct Harbour Marina. 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
Te Wero South	0.11	23.13	76.76	0.00	0.00
Hobson West Marina	0.10	15.26	84.65	0.00	0.00
Eastern Viaduct Basin	0.54	41.58	57.88	0.00	0.00
Te Wero North	0.18	28.10	71.71	0.00	0.00
Lighter Basin Marina	0.12	13.57	86.34	0.00	0.00
Viaduct Port	0.04	4.81	70.82	4.13	20.19
Viaduct Harbour Marine Village	0.12	18.59	81.30	0.00	0.00

Table 10: Native species recorded from the Viaduct Harbour Marina.

Phylum, Class	Order	Family	Taxon name
Annelida			
Polychaeta	Eunicida	Lumbrineridae	*Abyssoninoe galatheae*
Polychaeta	Eunicida	Lumbrineridae	*Lumbricalus aotearoae*
Polychaeta	Eunicida	Eunicidae	*Marphysa depressa*
Polychaeta	Phyllodocida	Glyceridae	*Glycera lamelliformis*
Polychaeta	Phyllodocida	Glyceridae	*Glycera benhami*
Polychaeta	Phyllodocida	Nephtyidae	*Aglaophamus verrilli*
Polychaeta	Phyllodocida	Nereididae	*Neanthes kerguelensis*
Polychaeta	Phyllodocida	Nereididae	*Perinereis pseudocamiguina*
Polychaeta	Phyllodocida	Phyllodocidae	*Eulalia microphylla*
Polychaeta	Phyllodocida	Polynoidae	*Harmothoe macrolepidota*
Polychaeta	Phyllodocida	Polynoidae	*Lepidonotus polychromus*
Polychaeta	Phyllodocida	Sigalionidae	*Labiosthenolepis laevis*
Polychaeta	Phyllodocida	Syllidae	*Trypanosyllis zebra*
Polychaeta	Phyllodocida	Goniadidae	*Glycinde trifida*
Polychaeta	Sabellida	Sabellidae	*Megalomma suspiciens*
Polychaeta	Sabellida	Sabellidae	*Pseudopotamilla laciniosa*
Polychaeta	Sabellida	Serpulidae	*Salmacina australis*
Polychaeta	Scolecida	Orbiniidae	*Phylo novazealandiae*
Polychaeta	Scolecida	Cossuridae	*Cossura consimilis*
Polychaeta	Spionida	Spionidae	*Boccardia syrtis*
Polychaeta	Terebellida	Cirratulidae	*Protocirrineris nuchalis*
Polychaeta	Terebellida	Cirratulidae	*Timarete anchylochaetus*
Polychaeta	Terebellida	Flabelligeridae	*Flabelligera affinis*
Polychaeta	Terebellida	Flabelligeridae	*Pherusa parmata*
Polychaeta	Terebellida	Pectinariidae	*Pectinaria australis*
Polychaeta	Terebellida	Terebellidae	*Pseudopista rostrata*
Polychaeta	Terebellida	Acrocirridae	*Acrocirrus trisectus*
Arthropoda			
Malacostraca	Amphipoda	Melitidae	*Melita festiva*
Malacostraca	Amphipoda	Leucothoidae	*Leucothoe trailli*
Malacostraca	Decapoda	Alpheidae	*Alpheus richardsoni*
Malacostraca	Decapoda	Hymenosomatidae	*Halicarcinus cf. varius*
Malacostraca	Decapoda	Hymenosomatidae	*Halicarcinus varius*
Malacostraca	Decapoda	Hymenosomatidae	*Neohymenicus pubescens*
Malacostraca	Decapoda	Majidae	*Notomithrax minor*
Malacostraca	Decapoda	Ocypodidae	*Macrophthalmus hirtipes*
Malacostraca	Decapoda	Palemonidae	*Periclimenes yaldwyni*
Malacostraca	Decapoda	Palemonidae	*Palaemon affinis*
Malacostraca	Decapoda	Pilumnidae	*Pilumnopeus serratifrons*
Malacostraca	Decapoda	Pinnotheridae	*Pinnotheres novaezelandiae*
Malacostraca	Decapoda	Porcellanidae	*Petrolisthes elongatus*
Malacostraca	Decapoda	Porcellanidae	*Petrolisthes novaezelandiae*
Malacostraca	Decapoda	Upogebiidae	*Upogebia hirtifrons*
Malacostraca	Decapoda	Xanthidae	*Pilumnus novaezelandiae*
Malacostraca	Isopoda	Cirolanidae	*Natatolana rossi*
Malacostraca	Isopoda	Cirolanidae	*Cirolana quechso*
Maxillopoda	Sessilia	Archaeobalanidae	*Austrominius modestus*
Maxillopoda	Sessilia	Balanidae	*Balanus trigonus*

Phylum, Class	Order	Family	Taxon name
Bryozoa			
Gymnolaemata	Cheilostomata	Beaniidae	*Beania plurispinosa*
Gymnolaemata	Cheilostomata	Candidae	*Caberea rostrata*
Gymnolaemata	Cheilostomata	Celleporidae	*Celleporina sinuata*
Chlorophyta			
Ulvophyceae	Bryopsidales	Codiaceae	*Codium fragile*
Chordata			
Actinopterygii	Anguilliformes	Anguillidae	*Anguilla dieffenbachii*
Actinopterygii	Mugiliformes	Mugilidae	*Aldrichetta forsteri*
Actinopterygii	Perciformes	Labridae	*Notolabrus celidotus*
Actinopterygii	Perciformes	Sparidae	*Pagrus auratus*
Actinopterygii	Perciformes	Tripterygiidae	*Forsterygion malcolmi*
Actinopterygii	Perciformes	Carangidae	*Pseudocaranx dentex*
Actinopterygii	Perciformes	Carangidae	*Trachurus novaezelandiae*
Ascidiacea	Enterogona	Polyclinidae	*Aplidium phortax*
Ascidiacea	Pleurogona	Molgulidae	*Molgula mortenseni*
Ascidiacea	Pleurogona	Pyuridae	*Pyura rugata*
Ascidiacea	Pleurogona	Pyuridae	*Pyura subuculata*
Ascidiacea	Pleurogona	Styelidae	*Asterocarpa cerea*
Ascidiacea	Pleurogona	Styelidae	*Cnemidocarpa bicornuta*
Ascidiacea	Pleurogona	Styelidae	*Cnemidocarpa nisiotis*
Echinodermata			
Ophiuroidea	Ophiurida	Amphiuridae	*Amphipholis squamata*
Mollusca			
Bivalvia	Myoida	Hiatellidae	*Hiatella arctica*
Bivalvia	Mytiloida	Mytilidae	*Perna canaliculus*
Bivalvia	Mytiloida	Mytilidae	*Xenostrobus pulex*
Bivalvia	Ostreoida	Ostreidae	*Saccostrea glomerata*
Gastropoda	Neotaenioglossa	Calyptraeidae	*Sigapatella novaezelandiae*
Gastropoda	Neotaenioglossa	Calyptraeidae	*Crepidula costata*
Gastropoda	Neotaenioglossa	Turritellidae	*Maoricolpus roseus*
Gastropoda	Vetigastropoda	Fissurellidae	*Tugali suteri*
Gastropoda	Systellomatophora	Onchidiidae	*Onchidella nigricans*
Polyplacophora	Acanthochitonina	Acanthochitonidae	*Acanthochitona zelandica*
Polyplacophora	Acanthochitonina	Acanthochitonidae	*Cryptoconchus porosus*
Polyplacophora	Ischnochitonina	Chitonidae	*Sypharochiton pelliserpentis*
Myzozoa			
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium avellana*
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium conicoides*
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium conicum*
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium punctulatum*
Ochrophyta			
Dictyochophyceae	Dictyochales	Dictyochaceae	*Dictyota dichotoma*
Porifera			
Demospongiae	Haplosclerida	Chalinidae	*Adocia* cf. parietalioides
Demospongiae	Poecilosclerida	Mycalidae	*Mycale (Carmia) tasmani*
Demospongiae	Poecilosclerida	Raspaillidae	*Eurypon hispida*

Table 11: Cryptogenic category 1 (C1) and category 2 (C2) marine taxa recorded from the Viaduct Harbour Marina.

Phylum, Class	Order	Family	Taxon name	Status
Annelida				
Polychaeta	Sabellida	Serpulidae	*Spirobranchus S. polytrema* complex	C2
Polychaeta	Scolecida	Capitellidae	*Heteromastus filiformis*	C1
Arthropoda				
Malacostraca	Decapoda	Hippolytidae	*Lysmata vittata*	C1
Bryozoa				
Gymnolaemata	Cheilostomata	Scrupariidae	*Scruparia ambigua*	C1
Chordata				
Ascidiacea	Enterogona	Rhodosomatidae	*Corella eumyota*	C1
Ascidiacea	Enterogona	Didemnidae	*Didemnum* sp.#	C1
Ascidiacea	Pleurogona	Pyuridae	*Microcosmus squamiger*	C1
Ascidiacea	Pleurogona	Styelidae	*Styela plicata*	C1
Porifera				
Demospongiae	Halichondrida	Halichondriidae	*Halichondria panicea*	C1
Demospongiae	Halichondrida	Halichondriidae	*Halichondria* new sp. 1	C2
Demospongiae	Haplosclerida	Chalinidae	*Haliclona heterofibrosa*	C1
Demospongiae	Haplosclerida	Chalinidae	*Adocia* new sp. 6	C2
Demospongiae	Haplosclerida	Chalinidae	*Haliclona* new sp. 5	C2
Demospongiae	Haplosclerida	Callyspongiidae	*Dactylia* new sp. 1	C2
Demospongiae	Poecilosclerida	Mycalidae	*Mycale* (*Carnia*) new. sp. 4	C2
Demospongiae	Poecilosclerida	Coelosphaeridae	*Lissodendoryx isodictyalis*	C1

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 12: Non-indigenous marine species recorded from the Viaduct Harbour Marina. Likely vectors of introduction are largely derived from Cranfield *et al*. (1998), where H = Hull fouling and B = Ballast water transport. As there is there is limited information on some species, we provide dates of first detection rather than probable dates of introduction.

Phylum, Class	Order	Family	Taxon name	Date of first record or introduction	Method of intro
Annelida					
Polychaeta	Sabellida	Serpulidae	*Hydroides elegans*	Pre-1952	H or B
Polychaeta	Spionida	Spionidae	*Polydora hoplura*	Unknown	H
Polychaeta	Spionida	Spionidae	*Pseudopolydora paucibranchiata*	Pre-1975	H or B
Polychaeta	Phyllodocida	Polynoidae	*Paralepidonotus ampulliferus*	2003	H or B
Bryozoa					
Gymnolaemata	Cheilostomata	Bugulidae	*Bugula stolonifera*	1962	H
Gymnolaemata	Cheilostomata	Schizoporellidae	*Schizoporella errata*	Pre-1960	H
Gymnolaemata	Cheilostomata	Watersiporidae	*Watersipora arcuata*	Pre-1957	H
Gymnolaemata	Cheilostomata	Candidae	*Tricellaria catalinensis*	Pre-1964	H
Gymnolaemata	Ctenostomata	Vesiculariidae	*Bowerbankia gracilis*	Pre-1965	H or B
Gymnolaemata	Ctenostomata	Vesiculariidae	*Zoobotryon verticillatum*	1960	H or B
Gymnolaemata	Ctenostomata	Buskiidae	*Buskia socialis*	Pre-1977	H
Chordata					
Ascidiacea	Enterogona	Ascidiidae	*Ascidiella aspersa*	1900s	H
Ascidiacea	Enterogona	Didemnidae	*Diplosoma listerianum*	Pre-1996	H
Ascidiacea	Pleurogona	Styelidae	*Botryllus tuberatus*	Unknown	H or B
Ascidiacea	Pleurogona	Styelidae	*Styela clava*	November 2004	H
Cnidaria					
Hydrozoa	Hydroida	Pennariidae	*Pennaria disticha*	Pre-1928	H
Mollusca					
Bivalvia	Pterioida	Limidae	*Limaria orientalis*	Pre-1972	H or B
Bivalvia	Veneroida	Semelidae	*Theora lubrica*	1971	B
Ochrophyta					
Phaeophyceae	Laminariales	Alariaceae	*Undaria pinnatifida*	Pre-1987	H or B

Table 13: Indeterminate taxa recorded from the Viaduct Harbour Marina. 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
Annelida			
Polychaeta			Polychaeta
Polychaeta	Phyllodocida	Glyceridae	*Glycera* sp.
Polychaeta	Sabellida	Sabellidae	Sabellidae Indet.
Polychaeta	Sabellida	Serpulidae	*Serpula* sp.
Polychaeta	Spionida	Spionidae	*Boccardia* sp.
Polychaeta	Spionida	Spionidae	*Polydora* sp.
Polychaeta	Terebellida	Cirratulidae	*Aphelochaeta aphelochaeta*-1 *undescribed*
Arthropoda			
Malacostraca	Decapoda	Majidae	*Notomithrax* sp.
Malacostraca	Isopoda		Isopoda
Malacostraca	Isopoda	Expanathuridae	*Expanathuridae*
Maxillopoda			Maxillopoda Indet.
Ostracoda			Ostracoda
Malacostraca	Decapoda	Hippolytidae	*Lysmata vittata*
Bryozoa			
Gymnolaemata	Cheilostomata	Lepraliellidae	*Celleporaria* sp.
Chordata			
Actinopterygii	Perciformes	Gobiidae	*Eviota* sp.
Actinopterygii	Perciformes	Carangidae	*Trachurus* sp.
Ascidiacea	Enterogona	Didemnidae	*Diplosoma* sp.
Ascidiacea	Pleurogona	Pyuridae	*Pyura* sp.
Ascidiacea	Pleurogona	Styelidae	*Botryllus* sp.
Ascidiacea	Stolidobranchia		*Stolidobranchia* Indet.
Cnidaria			
Anthozoa			Anthozoa
Hydrozoa			Hydrozoa
Mollusca			
Bivalvia			Bivalvia
Myzozoa			
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium* sp. 1
Dinophyceae	Peridiniales	Protoperidiniaceae	*Protoperidinium* sp. 2
Ochrophyta			
Phaeophyceae	Fucales	Sargassaceae	*Sargassum* sp.
Phaeophyceae	Laminariales	Alariaceae	*Ecklonia* sp.
Nemertea			
			Nemertea
Platyhelminthes			
			Platyhelminthes
Sipuncula			
			Sipuncula

Table 14: Non-indigenous marine organisms recorded from the Viaduct Harbour Marina 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 Viaduct Marina	Locations detected in the Viaduct Marina	Detected in other locations surveyed in ZBS2000_04, ZBS2005_18 & ZBS 2005_19
Annelida			
Hydroides elegans	PSC	Hobson West Marina, Viaduct Port, Eastern Viaduct Basin	Gulf Harbour Marina, Westhaven Marina, Auckland, Nelson
Paralepidonotus ampulliferus	BGRB	Viaduct Harbour Marine Village, Te Wero South	Whangarei, Auckland, Westhaven Marina
Polydora hoplura	PSC	Eastern Viaduct Basin	Whangarei, Westhaven Marina, Tauranga, Napier, Wellington, Picton, Nelson, Lyttelton, Timaru, Dunedin, Bluff
Pseudopolydora paucibranchiata	BSLD, BGRB	Freemans Bay Breakwall, Viaduct Harbour Marine Village, Te Wero South, Viaduct Port	Whangarei, Gulf Harbour Marina, Westhaven Marina, Gisborne
Bryozoa			
Bowerbankia gracilis	PSC	Viaduct Harbour Marine Village, Hobson West Marina, Viaduct Port, Eastern Viaduct Basin	Opua, Whangarei, Gulf Harbour Marina, Westhaven Marina, Gisborne, Napier, Port Underwood
Buskia socialis	PSC	Viaduct Harbour Marine Village	Whangarei, Napier
Bugula stolonifera	PSC	Viaduct Harbour Marine Village	Opua, Whangarei, Gulf Harbour Marina, Westhaven Marina, Gisborne, Napier
Schizoporella errata	PSC	Eastern Viaduct Basin	Opua, Whangarei, Gulf Harbour Marina, Westhaven Marina, Nelson
Tricellaria catalinensis	PSC	Viaduct Port, Hobson West Marina	Whangarei, Westhaven Marina, Gisborne, Taranaki, Picton, Lyttelton
Watersipora arcuata	PSC	Hobson West Marina	Gulf Harbour Marina, Taranaki, Napier
Zoobotryon verticillatum	PSC	Viaduct Harbour Marine Village	Gulf Harbour Marina, Westhaven Marina, Tauranga

Taxon name	Capture techniques in the Viaduct Marina	Locations detected in the Viaduct Marina	Detected in other locations surveyed in ZBS2000_04, ZBS2005_18 & ZBS 2005_19
Chordata			
Ascidiella aspersa	BSLD, PSC	Hobson West Marina, Viaduct Harbour Marine Village, Viaduct Port, Eastern Viaduct Basin	Gulf Harbour Marina, Westhaven Marina, Gisborne, Napier, Port Underwood, Lyttelton, Dunedin, Bluff.
Botryllus tuberatus	PSC	Viaduct Harbour Marine Village, Eastern Viaduct Basin	Westhaven Marina
Diplosoma listerianum	PSC	Viaduct Harbour Marine Village, Hobson West Marina, Viaduct Port	Whangarei, Gulf Harbour Marina, Westhaven Marina, Auckland, Tauranga, Gisborne, Napier, Taharoa, Taranaki, Lyttelton, Dunedin, Bluff
Styela clava	PSCM, VISS, PSC, BGRB	Viaduct, Viaduct harbour marine village, Viaduct port, Viaduct port, Viaduct port, Viaduct hobson west, Te Wero North (viaduct), Te Wero South (viaduct), Viaduct Harbour Marine Village, Freemans Bay Breakwall	Gulf Harbour Marina, Westhaven Marina, Auckland
Cnidaria			
Pennaria disticha	BGRB, PSC	Hobson West Marina	Auckland, Westhaven Marina, Kaikoura area, Dunedin, Bluff
Mollusca			
Limaria orientalis	VISS	Viaduct port	Opua, Whangarei, Gulf Harbour Marina, Auckland
Theora lubrica	BSLD, BGRB, PSC	Viaduct Harbour Marine Village, Eastern Viaduct Basin, Freemans Bay Breakwall, Hobson West Marina, Lighter Basin Marina, Te Wero North, Te Wero South, Viaduct Port	Opua, Whangarei, Gulf Harbour Marina, Auckland, Gisborne, Napier, New Plymouth, Wellington, Nelson, Picton, Port Underwood, Kaikoura area, Lyttelton
Ochrophyta			
Undaria pinnatifida	VISS, PSC	Viaduct harbour marine village, Viaduct port	Gisborne, Waitemata Harbour, Napier, New Plymouth, Wellington, Picton, Port Underwood, Nelson, Kaikoura area, Lyttelton, Timaru, Dunedin, Bluff

Table 15: Depth class and method of collection for each NIS and C1 taxons collected during the baseline survey of the Viaduct Harbour Marina. Data are numbers of samples each species occurred in.

Taxon Name	Biosecurity Status	Method *	0 - 3 m	> 3 - 6 m	> 6 - 9 m	Total
Bowerbankia gracilis	NIS	PSC	8			**8**
Bugula stolonifera	NIS	PSC	1			**1**
Corella eumyota	C1	PSC	17			**17**
		BGRB		1		**1**
Microcosmus squamiger	C1	PSC	12			**12**
Schizoporella errata	NIS	PSC	2			**2**
Scruparia ambigua	C1	PSC	1			**1**
Styela plicata	C1	PSC	3			**3**
		BGRB		1		**1**
		VISS	3			**3**
Theora lubrica	NIS	BSLD		11	4	**15**
		PSC	1			**1**
		BGRB		9	5	**14**
Ascidiella aspersa	NIS	BSLD			1	**1**
		PSC	7			**7**
Didemnum sp.	C1	PSC	1			**1**
Diplosoma listerianum	NIS	PSC	5			**5**
Heteromastus filiformis	C1	BSLD			2	**2**
		BGRB		1	1	**2**
Pennaria disticha	NIS	PSC	1			**1**
		BGRB			2	**2**
Polydora hoplura	NIS	PSC	1			**1**
Undaria pinnatifida	NIS	PSC	2			**2**
		VISS	2			**2**
Botryllus tuberatus	NIS	PSC	2			**2**
Buskia socialis	NIS	PSC	3			**3**
Halichondria panicea	C1	PSC	1			**1**
Haliclona heterofibrosa	C1	PSC	11			**11**
Hydroides elegans	NIS	PSC	3			**3**
Limaria orientalis	NIS	VISS	1			**1**
Lissodendoryx isodictyalis	C1	PSC	1			**1**
Lysmata vittata	C1	PSC	1			**1**
Paralepidonotus ampulliferus	NIS	BGRB		1	1	**2**
Pseudopolydora paucibranchiata	NIS	BSLD			1	**1**
		BGRB		1		**1**
Styela clava	NIS	PSC	3			**3**
		BGRB			2	**2**
Tricellaria catalinensis	NIS	PSC	1			**1**
Watersipora arcuata	NIS	PSC	1			**1**
Zoobotryon verticillatum	NIS	PSC	3			**3**
Total number of NIS & C1 specimens			**98**	**25**	**19**	**142**
Proportion of all NIS & C1 specimens (%)			**69.0**	**17.6**	**13.4**	**100**
Total number of NIS & C1 taxa			**26**	**6**	**7**	**29**
Proportion of all NIS & C1 taxa (%)			**89.7**	**20.7**	**24.1**	**#**

* 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; VISS = opportunistic visual search..
# The proportion of taxa in each depth class sums to greater than 100%, as some taxa were recorded from more than one depth class

Table 16: Depth class and method of collection for each native species collected during the baseline survey of the Viaduct Harbour Marian. Data are numbers of samples each species occurred in.

Taxon Name	Method *	0 - 3 m	> 3 - 6 m	> 6 - 9 m	Total
Adocia cf. *parietalioides*	BSLD			1	**1**
	PSC	8			**8**
Aglaophamus verrilli	BSLD		1	1	**2**
	BGRB		2	1	**3**
Aldrichetta forsteri	CRBTP			2	**2**
	FSHTP		11	3	**14**
Alpheus richardsoni	BSLD		1	1	**2**
	BGRB		1		**1**
Aplidium phortax	PSC	2			**2**
	VISS	1			**1**
Austrominius modestus	PSC	9			**9**
Balanus trigonus	PSC	10			**10**
Beania plurispinosa	PSC	5			**5**
Cnemidocarpa bicornuta	PSC	6			**6**
Cnemidocarpa nisiotis	PSC	10			**10**
Flabelligera affinis	PSC	2			**2**
Glycera lamelliformis	BSLD		1		**1**
	BGRB		2	4	**6**
Halicarcinus cf. *varius*	PSC	1			**1**
Halicarcinus varius	PSC	2			**2**
Harmothoe macrolepidota	PSC	7			**7**
Labiosthenolepis laevis	BSLD		3	2	**5**
Lepidonotus polychromus	PSC	8			**8**
Lumbricalus aotearoae	BGRB		1		**1**
Macrophthalmus hirtipes	BGRB		1		**1**
Maoricolpus roseus	BSLD			1	**1**
Megalomma suspiciens	PSC	10			**10**
Molgula mortenseni	PSC	1			**1**
Natatolana rossi	SHRTP			2	**2**
Neanthes kerguelensis	PSC	2			**2**
Neohymenicus pubescens	PSC	3			**3**
Notolabrus celidotus	CRBTP		3	7	**10**
	FSHTP		14	7	**21**
Notomithrax minor	PSC	6			**6**
Pagrus auratus	CRBTP		1	4	**5**
	FSHTP		5	1	**6**
Pectinaria australis	BSLD			1	**1**
Periclimenes yaldwyni	PSC	2			**2**
	SHRTP			1	**1**
Perna canaliculus	PSC	1			**1**
Petrolisthes elongatus	PSC	10			**10**
Petrolisthes novaezelandiae	BSLD		1		**1**
	PSC	8			**8**
Phylo novazealandiae	BSLD		9	4	**13**
	BGRB		4	2	**6**
Pilumnopeus serratifrons	PSC	6			**6**
	BGRB		1		**1**
Protocirrineris nuchalis	PSC	4			**4**

Taxon Name	Method *	0 - 3 m	> 3 - 6 m	> 6 - 9 m	Total
Protoperidinium avellana	CYST			3	**3**
Protoperidinium conicoides	CYST			4	**4**
Pseudopista rostrata	PSC	2			**2**
Pyura rugata	PSC	11			**11**
Sigapatella novaezelandiae	PSC	1			**1**
Timarete anchylochaetus	PSC	3			**3**
Upogebia hirtifrons	BGRB			1	**1**
Xenostrobus pulex	PSC	6			**6**
Acanthochitona zelandica	BSLD		1		**1**
	PSC	1			**1**
Acrocirrus trisectus	PSC	1			**1**
Amphipholis squamata	BGRB		1		**1**
Asterocarpa cerea	PSC	1			**1**
Caberea rostrata	PSC	18			**18**
	BGRB			1	**1**
Codium fragile	PSC	1			**1**
	VISS	4			**4**
Cryptoconchus porosus	CRBTP			1	**1**
	PSC	1			**1**
Glycinde trifida	BSLD		1	2	**3**
Leucothoe trailli	PSC	5			**5**
	BGRB			1	**1**
Mycale (Carmia) tasmani	PSC	6			**6**
Perinereis pseudocamiguina	PSC	2			**2**
Pherusa parmata	PSC	6			**6**
Protoperidinium punctulatum	CYST			1	**1**
Sypharochiton pelliserpentis	PSC	4			**4**
Trypanosyllis zebra	PSC	4			**4**
Abyssoninoe galatheae	BSLD			1	**1**
	BGRB		1		**1**
Anguilla dieffenbachii	FSHTP		1		**1**
Boccardia syrtis	BSLD		1		**1**
	BGRB		1	1	**2**
Celleporina sinuata	BSLD			1	**1**
Cirolana quechso	PSC	2			**2**
Cossura consimilis	BSLD		1		**1**
	BGRB		2	2	**4**
Crepidula costata	BSLD		1		**1**
	PSC	8			**8**
Dictyota dichotoma	VISS	2			**2**
Eulalia microphylla	PSC	3			**3**
Eurypon hispida	PSC	1			**1**
Forsterygion malcolmi	FSHTP		1		**1**
Glycera benhami	BGRB		1	1	**2**
Hiatella arctica	PSC	1			**1**
Marphysa depressa	PSC	1			**1**
Melita festiva	BSLD		1		**1**
	PSC	2			**2**
Onchidella nigricans	PSC	5			**5**
Palaemon affinis	FSHTP		1		**1**
Pilumnus novaezelandiae	PSC	5			**5**
Pinnotheres novaezelandiae	PSC	1			**1**

Taxon Name	Method *	0 - 3 m	> 3 - 6 m	> 6 - 9 m	Total
Protoperidinium conicum	CYST			3	**3**
Pseudocaranx dentex	FSHTP			1	**1**
Pseudopotamilla laciniosa	PSC	8			**8**
Pyura subuculata	PSC	6			**6**
Saccostrea glomerata	PSC	8			**8**
Salmacina australis	PSC	1			**1**
Trachurus novaezelandiae	FSHTP		4	1	**5**
Tugali suteri	BSLD			1	**1**
	PSC	4			**4**
Total number of native specimens		**259**	**81**	**71**	**411**
Proportion of all native specimens (%)		**63.0**	**19.7**	**17.3**	**100**
Total number of native taxa		**56**	**25**	**30**	**86**
Proportion of all native taxa (%)		**65.1**	**29.1**	**34.9**	**#**

* 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; VISS = opportunistic visual search.

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

Table 17: Summary statistics for taxon assemblages collected in the Viaduct Harbour Marina using three different methods. 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	No. of taxa	No. (%) of taxa in only one sample
Pile scrape quadrats			
Native	48	54	14 (26 %)
C2	48	5	2 (40 %)
NIS & C1	48	24	12 (50 %)
Benthic sleds			
Native	14	17	12 (71 %)
C2	14	1	1 (100 %)
NIS & C1	14	4	2 (50 %)
Native, C2, NIS & C1 taxa combined	14	22	15 (68 %)
Benthic grabs			
Native	21	15	9 (60 %)
C2	21	0	
NIS & C1	21	7	3 (43 %)
Native, C2, NIS & C1 taxa combined	21	22	12 (55 %)

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

Geographical area	Countries/locations included
Eastern Mediterranean inc Cyprus, Turkey	Turkey
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

Geographical area	Countries/locations included
	Niue Island
	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

Geographical area	Countries/locations included
	Portugal
	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

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
	G	PC	part c.c.
	G	RF	ref
LPG / LNG	L	FP	floating production
	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

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	RX	repair barge
	O	SB	storage barge
	O	SC	sludge carrier
	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

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	AF	anchor handling firefighting tug/supply
	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 Viaduct Harbour Marina baseline survey (NZGD49)

Site	Easting	Northing	Survey Method*	Number of sample units
	2667650	6483085	CRBTP	3
Eastern Viaduct Basin	2667599	6482816	BGRB	1
Eastern Viaduct Basin	2667602	6482810	BGRB	1
Eastern Viaduct Basin	2667613	6482810	BGRB	1
Eastern Viaduct Basin	2667503	6482826	CRBTP	2
Eastern Viaduct Basin	2667596	6482866	CRBTP	2
Eastern Viaduct Basin	2667592	6482809	CYST	1
Eastern Viaduct Basin	2667620	6482812	CYST	1
Eastern Viaduct Basin	2667511	6482824	FSHTP	2
Eastern Viaduct Basin	2667612	6482850	FSHTP	2
Eastern Viaduct Basin	2667622	6482789	PSC	12
Eastern Viaduct Basin	2667613	6482810	SEDIMENT	1
Eastern Viaduct Basin	2667503	6482826	SHRTP	1
Eastern Viaduct Basin	2667596	6482866	SHRTP	1
Eastern Viaduct Basin	2667503	6482826	STFTP	2
Eastern Viaduct Basin	2667596	6482866	STFTP	2
Freemans Bay Breakwall	2667383	6483169	BSLD	1
Freemans Bay Breakwall	2667536	6483107	BSLD	1
Freemans Bay Breakwall	2667439	6483125	CRBTP	2
Freemans Bay Breakwall	2667470	6483114	CRBTP	2
Freemans Bay Breakwall	2667392	6483142	FSHTP	2
Freemans Bay Breakwall	2667525	6483093	FSHTP	2
Freemans Bay Breakwall	2667439	6483125	SHRTP	1
Freemans Bay Breakwall	2667470	6483114	SHRTP	1
Freemans Bay Breakwall	2667439	6483125	STFTP	2
Freemans Bay Breakwall	2667470	6483114	STFTP	2
Freemans Bay Breakwall	2667467	6483082	VISS	1
Freemans Bay Breakwall	2667406	6483080	VISS	1
Freemans Bay Breakwall (viaduct)	2667473	6483112	VISS	1
Hobson West Marina	2667610	6482982	BGRB	1
Hobson West Marina	2667624	6482969	BGRB	1
Hobson West Marina	2667635	6482970	BGRB	1
Hobson West Marina	2667556	6483002	BSLD	1
Hobson West Marina	2667633	6482976	BSLD	1
Hobson West Marina	2667602	6483039	CRBTP	2
Hobson West Marina	2667603	6482966	CRBTP	2
Hobson West Marina	2667615	6482970	CYST	1
Hobson West Marina	2667639	6482939	CYST	1
Hobson West Marina	2667594	6482938	FSHTP	2
Hobson West Marina	2667597	6482971	FSHTP	2
Hobson West Marina	2667647	6482988	PSC	12
Hobson West Marina	2667610	6482982	SEDIMENT	1
Hobson West Marina	2667602	6483039	SHRTP	1
Hobson West Marina	2667603	6482966	SHRTP	1
Hobson West Marina	2667602	6483039	STFTP	2
Hobson West Marina	2667603	6482966	STFTP	2
Lighter Basin Marina	2667190	6482609	BGRB	1

Site	Easting	Northing	Survey Method*	Number of sample units
Lighter Basin Marina	2667196	6482606	BGRB	1
Lighter Basin Marina	2667200	6482607	BGRB	1
Lighter Basin Marina	2667194	6482574	BSLD	1
Lighter Basin Marina	2667255	6482723	BSLD	1
Lighter Basin Marina	2667180	6482594	CRBTP	2
Lighter Basin Marina	2667189	6482566	CRBTP	2
Lighter Basin Marina	2667194	6482634	CYST	1
Lighter Basin Marina	2667195	6482625	CYST	1
Lighter Basin Marina	2667186	6482564	FSHTP	2
Lighter Basin Marina	2667202	6482644	FSHTP	2
Lighter Basin Marina	2667190	6482609	SEDIMENT	1
Lighter Basin Marina	2667180	6482594	SHRTP	1
Lighter Basin Marina	2667189	6482566	SHRTP	1
Lighter Basin Marina	2667180	6482594	STFTP	2
Lighter Basin Marina	2667189	6482566	STFTP	2
Lighter Basin Marina	2667198	6482662	VISS	1
Lighter Quay / wall (viaduct)	2667186	6482628	VISS	1
Te Wero North	2667493	6482966	BGRB	1
Te Wero North	2667498	6482962	BGRB	1
Te Wero North	2667501	6482958	BGRB	1
Te Wero North	2667463	6483000	BSLD	1
Te Wero North	2667533	6482856	BSLD	1
Te Wero North	2667544	6482991	BSLD	1
Te Wero North	2667639	6482822	BSLD	1
Te Wero North	2667494	6482952	CRBTP	2
Te Wero North	2667505	6482948	CRBTP	2
Te Wero North	2667404	6482968	FSHTP	2
Te Wero North	2667471	6482972	FSHTP	2
Te Wero North	2667493	6482966	SEDIMENT	1
Te Wero North	2667494	6482952	SHRTP	1
Te Wero North	2667505	6482948	SHRTP	1
Te Wero North	2667494	6482952	STFTP	2
Te Wero North	2667505	6482948	STFTP	2
Te Wero North	2667502	6482953	VISS	1
Te Wero North (viaduct)	2667502	6482953	VISS	1
Te Wero South	2667405	6482921	BGRB	1
Te Wero South	2667406	6482920	BGRB	1
Te Wero South	2667407	6482916	BGRB	1
Te Wero South	2667370	6482898	BSLD	1
Te Wero South	2667473	6482863	BSLD	1
Te Wero South	2667390	6482936	CRBTP	2
Te Wero South	2667396	6482927	CRBTP	2
Te Wero South	2667382	6482921	FSHTP	2
Te Wero South	2667450	6482904	FSHTP	2
Te Wero South	2667406	6482920	SEDIMENT	1
Te Wero South	2667390	6482936	SHRTP	1
Te Wero South	2667396	6482927	SHRTP	1
Te Wero South	2667390	6482936	STFTP	2
Te Wero South	2667396	6482927	STFTP	2
Te Wero South	2667413	6482918	VISS	1
Te Wero South (viaduct)	2667413	6482918	VISS	1

Site	Easting	Northing	Survey Method*	Number of sample units
Viaduct	2667238	6483073	PSCM	1
Viaduct	2667240	6482812	PSCM	1
Viaduct	2667324	6482966	PSCM	1
Viaduct	2667430	6482832	PSCM	1
Viaduct	2667476	6482903	PSCM	1
Viaduct	2667505	6482958	PSCM	1
Viaduct	2667622	6482789	PSCM	1
Viaduct	2667644	6482989	PSCM	1
Viaduct	2667648	6483019	PSCM	1
Viaduct Harbour Marine Village	2667415	6483071	BGRB	1
Viaduct Harbour Marine Village	2667418	6483073	BGRB	1
Viaduct Harbour Marine Village	2667419	6483067	BGRB	1
Viaduct Harbour Marine Village	2667290	6482767	BSLD	1
Viaduct Harbour Marine Village	2667309	6482895	BSLD	1
Viaduct Harbour Marine Village	2667351	6482832	BSLD	1
Viaduct Harbour Marine Village	2667363	6482985	BSLD	1
Viaduct Harbour Marine Village	2667282	6482960	CRBTP	2
Viaduct Harbour Marine Village	2667371	6483042	CRBTP	2
Viaduct Harbour Marine Village	2667313	6482760	CYST	1
Viaduct Harbour Marine Village	2667338	6482760	CYST	1
Viaduct Harbour Marine Village	2667274	6482895	FSHTP	2
Viaduct Harbour Marine Village	2667317	6482959	FSHTP	2
Viaduct Harbour Marine Village	2667346	6483033	FSHTP	2
Viaduct Harbour Marine Village	2667367	6483053	FSHTP	2
Viaduct Harbour Marine Village	2667386	6483070	PSC	12
Viaduct Harbour Marine Village	2667415	6483071	SEDIMENT	1
Viaduct Harbour Marine Village	2667282	6482960	SHRTP	1
Viaduct Harbour Marine Village	2667371	6483042	SHRTP	1
Viaduct Harbour Marine Village	2667282	6482960	STFTP	2
Viaduct Harbour Marine Village	2667371	6483042	STFTP	2
Viaduct harbour marine village	2667280	6482946	VISS	1
Viaduct harbour marine village	2667303	6482987	VISS	1
Viaduct Harbour Marine Village	2667394	6483057	VISS	1
Viaduct hobson west H/W 22-1	2667633	6482986	VISS	1
Viaduct Port	2667181	6482815	BGRB	1
Viaduct Port	2667182	6482811	BGRB	1
Viaduct Port	2667190	6482809	BGRB	1
Viaduct Port	2667183	6482809	BSLD	1
Viaduct Port	2667264	6482800	BSLD	1
Viaduct Port	2667164	6482795	CRBTP	2
Viaduct Port	2667179	6482840	CRBTP	2
Viaduct Port	2667175	6482826	FSHTP	2
Viaduct Port	2667219	6482776	FSHTP	2
Viaduct Port	2667227	6482817	PSC	12
Viaduct Port	2667190	6482809	SEDIMENT	1
Viaduct Port	2667164	6482795	SHRTP	1
Viaduct Port	2667179	6482840	SHRTP	1
Viaduct Port	2667164	6482795	STFTP	2
Viaduct Port	2667179	6482840	STFTP	2
Viduct port	2667190	6482786	VISS	1
Viduct port	2667211	6482838	VISS	1

Site	Easting	Northing	Survey Method*	Number of sample units
Viduct port EV1-EV16	2667600	6482865	VISS	1
Viduct port LB14-LB1	2667247	6482625	VISS	1

*Survey methods: PSC = pile scrape quadrats and diver observations on wharf pilings, BSLD = benthic sled, BGRB = benthic grab, CYST = dinoflagellate cyst core, CRBTP = crab trap, FSHTP = fish trap, 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 'spiny-skinned'). 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 3i: **Results from the wharf piling miscellaneous search samples.**
Appendix 3j: **Results from the opportunistic visual search samples.**

Appendix 4: Chapman and Carlton criteria applicable to each non-indigenous and C1 taxon recorded from the Viaduct Harbour Marina. Chapman and Carlton's (1994) nine criteria (C1 – C9) were assessed for each non-indigenous and cryptogenic category 1 taxon recorded from the Viaduct Harbour Marina. 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										
Heteromastus filiformis	C1	no	no	no	no	no	no	no	yes	no
Hydroides elegans	NIS	yes	yes	yes	yes	yes	yes	yes	yes	yes
Polydora hoplura	NIS	no	no	yes	no	yes	yes	yes	yes	yes
Pseudopolydora paucibranchiata	NIS	yes	no	yes	no	yes	yes	yes	yes	yes
Paralepidonotus ampulliferus	NIS	yes	yes	no	no	no	yes	yes	yes	Yes
Arthropoda										
Lysmata vittata	C1	no	no	no	no	no	no	no	no	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?
Bryozoa										
Bugula stolonifera	NIS	yes	yes	yes	no	yes	yes	yes	yes	yes
Schizoporella errata	NIS	yes	yes	yes	no	no	yes	yes	yes	no
Scruparia ambigua	C1	No. Been in NZ for a long time, known based on Discovery material for decades.	Very difficult to say because inadequate records to know about absences, let along presences. Often co-occurs with *Bugula flabellata* (often attached to it). So if *B. flabellata* spread, it would take *S. ambigua* with it.	Not necessesarily. Can attach to seaweeds. Nothing to preclude drifting throughout southern oceans.	Sometimes, but not entirely, so no. It's an opportunistic epizooite epiphyte.	no	no	Semi-cosmopolitan but not really disjunct.	no	Don't think so.
Watersipora arcuata	NIS	yes	yes	yes	no	yes	yes	yes	yes	yes

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?
Tricellaria catalinensis	NIS	yes	yes	yes	no	yes	yes	no	yes	yes
Bowerbankia gracilis	NIS	yes	yes	yes	no	yes	yes	yes	yes	no
Zoobotryon verticillatum	NIS	yes	yes	no	no	yes	yes*	yes	yes	yes
Buskia socialis	NIS	yes	no	no	no	yes	yes*	yes	yes	no
Chordata										
Ascidiella aspersa	NIS	yes	yes	yes	yes	yes	yes	yes	yes	yes
Botryllus tuberatus	NIS	no	no	no	no	no	no	no	no	no
Corella eumyota	C1	yes	yes	yes	no	yes	no	yes	yes	no
Didemnum sp.	C1	Unable to assess criteria for the genus as a whole.	no	no	no	no	no	no	no	no
Diplosoma listerianum	NIS	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?
Microcosmus squamiger	C1	Uncertain. Has not been properly looked for 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 to support a positive answer	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, it is impossible to answer this question	yes	Uncertain, but is most likely to have arrived in NZ on ships hulls	Don't know
Styela clava	NIS	yes	yes	yes	no	yes	yes	yes	yes	yes
Styela plicata	C1	yes	yes	yes	no	yes	yes	yes	yes	no
Cnidaria										
Pennaria disticha	NIS	yes	no	yes	no	yes	yes	no	no	no
Mollusca										
Limaria orientalis	NIS	yes	yes	yes	no	no	yes	yes	yes	yes
Theora lubrica	NIS	yes	yes	no	no	yes	yes	yes	yes	yes
Porifera										
Halichondria panicea	C1	yes	yes	yes	no	no	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?
Haliclona heterofibrosa	C1	no	Uncertian. Early collections in these locaitons were not at all comprehensive and the species could have been overlooked	Uncertain, but likely. These are particularly common sponges where they occurr around New Zealand	no	no	no	yes	unlikely (short-lived viviparous larvae)	Uncertain. Insufficient information about interocean genetics; most work on so called cosmpolitan species that are similar to these species have been found to be genetically isolated. I would say that they are isolated genetically.

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?
Lissodendoryx isodictyalis	C1	Only a single specimen was described and identified as *L. isodictyalis* by Bergquist & Fromont (1988). The species has never been picked up again in general subtidal surveys in the past 9 years, and it has only been found again in the Gisborne and Whangarei	Since the species was only described from one location initially, it could be said that it has 'spread subsequently' but not in an active way. In fact the numbers of this species have gone down from c. 7 specimens to 1 specimen in the Whangarei second port survey.	It is possible that the species has spread between ports by hull movement, but Gisborne and Whangarei are far apart with Auckland and Tauranga inbetween. The species has not been recorded at either of these ports.	No	Previous literature indicates that *L. isodictyalis* (Carter, 1882) sensu strictu from the type localities of the Gulf of Mexico and Caribbean region has a preferences for sheltered and rather shallow habitats (Wiedenmayer, 1977)	Yes, it is restricted to only two North Island ports	The type location for *L. isodictyalis* (Carter, 1882) was Acapulco, Mexico, Gulf of Mexico, and it was subsequently identified from Connecticut (Hartman, 1958), and the central Caribbean (Simpson, 1968; Wiedenmayer, 1977; Van Soest, 1984). Bergq	Yes	Uncertain. Bergquist & Fromont (1988) seriously considered the possibility that their thin encrusting intertidal sponge from New Zealand was conspecific with the species *L. isodictyalis* (Carter, 1882).

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?
Ochrophyta										
Undaria pinnatifida	NIS	yes	yes	yes	no	yes	yes	yes	yes	yes