Whangarei Marina

Baseline survey for non-indigenous marine species (Research Project ZBS 2000/04)

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Executive Summary

This report describes the results of a November 2002 survey to provide a baseline inventory of native, non- indigenous and cryptogenic marine species within the Whangarei Town Basin Marina.

- The survey is part of a nationwide investigation of native and non-native marine biodiversity in 13 international shipping ports and three marinas of first entry for yachts entering New Zealand from overseas.

- Sampling methods used in these surveys were based on protocols developed by the Australian Centre for Research on Introduced Marine Pests (CRIMP) for baseline surveys of non-indigenous species in ports. Modifications were made to the CRIMP protocols for use in New Zealand port conditions.

- A wide range of sampling techniques was used to collect marine organisms from habitats within the Whangarei Town Basin 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, starfish and shrimp traps.

- The distribution of sampling effort in the Whangarei Marina was designed to maximise the chances of detecting non-indigenous species and 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.

- A total of 56 species or higher taxa was identified from the Whangarei Town Basin Marina survey. They consisted of 35 native species, nine non-indigenous species, four cryptogenic species (those whose geographic origins are uncertain) and eight species indeterminata (taxa for which there is insufficient taxonomic or systematic information available to allow identification to species level).

- One species - a non-indigenous species of amphipod, *Melita matilda* - collected from the Whangarei Marina had not previously been described from New Zealand waters.

- The nine non-indigenous organisms described from the Whangarei Marina included representatives of four phyla. The non-indigenous species detected (ordered alphabetically by phylum, class, order, family, genus and species) were: (Annelida) *Ficopomatus enigmatus* and *Polydora cornuta*, (Bryozoa) *Bugula neritina* and *Conopeum seurati*, (Crustacea) *Monocorophium acherusicum*, *Paracorophium brisbanensis* and *Melita matilda*, (Mollusca) *Musculista senhousia* and *Theora lubrica.*

- None of the non-indigenous species detected from the Whangarei Town Basin Marina are on the New Zealand register of unwanted organisms. Resting cysts of the cryptogenic toxin-producing dinoflagellates, *Gymnodinium catenatum* and *Alexandrium* cf. *catenella* were recorded in sediment samples taken from the marina. Both species are on the Australian ABWMAC list of unwanted marine pests.

- Most non-indigenous species located in the Marina are likely to have been introduced to New Zealand accidentally by international shipping. Approximately 56 % (five of nine

species) of NIS in the Whangarei Marina are likely to have been introduced in hull fouling assemblages, 11 % via ballast water and 33 % could have been introduced by either ballast water or hull fouling vectors.

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

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 trans-continental 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, 1999, AMOG Consulting 2002, Coutts *et al.* 2003). These shipping transport mechanisms have enabled hundreds 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, Leppäkoski *et al.* 2002).

Biosecurity[1] is important to all New Zealanders. New Zealand's geographic isolation makes it particularly vulnerable to marine introductions because more than 95 % of its trade in commodities is transported by shipping, with several thousand international vessels arriving and departing from more than 13 ports and recreational boat marinas of first entry (Inglis 2001). The country's geographic remoteness also means that its marine biota and ecosystems have evolved in relative isolation from other coastal ecosystems. New Zealand's marine biota is as unique and distinctive as its terrestrial biota, with large numbers of native marine species occurring nowhere else in the world.

The numbers, identity, distribution and impacts of non-indigenous species in New Zealand's marine environments are poorly known. A recent review of existing records suggested that by 1998, at least 148 species had been deliberately or accidentally introduced to New Zealand's coastal waters, with around 90 % of these establishing permanent populations (Cranfield *et al.* 1998). 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) encouraging 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 baseline surveys. These surveys aimed to determine the identity, prevalence and distribution of native, cryptogenic and non-indigenous species in New Zealand's major shipping ports and other high risk points of entry. 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 (Fig. 1). Marine biosecurity functions are now vested in Biosecurity New Zealand.

[1] Biosecurity is the management of risks posed by introduced species to environmental, economic, social, and cultural values.

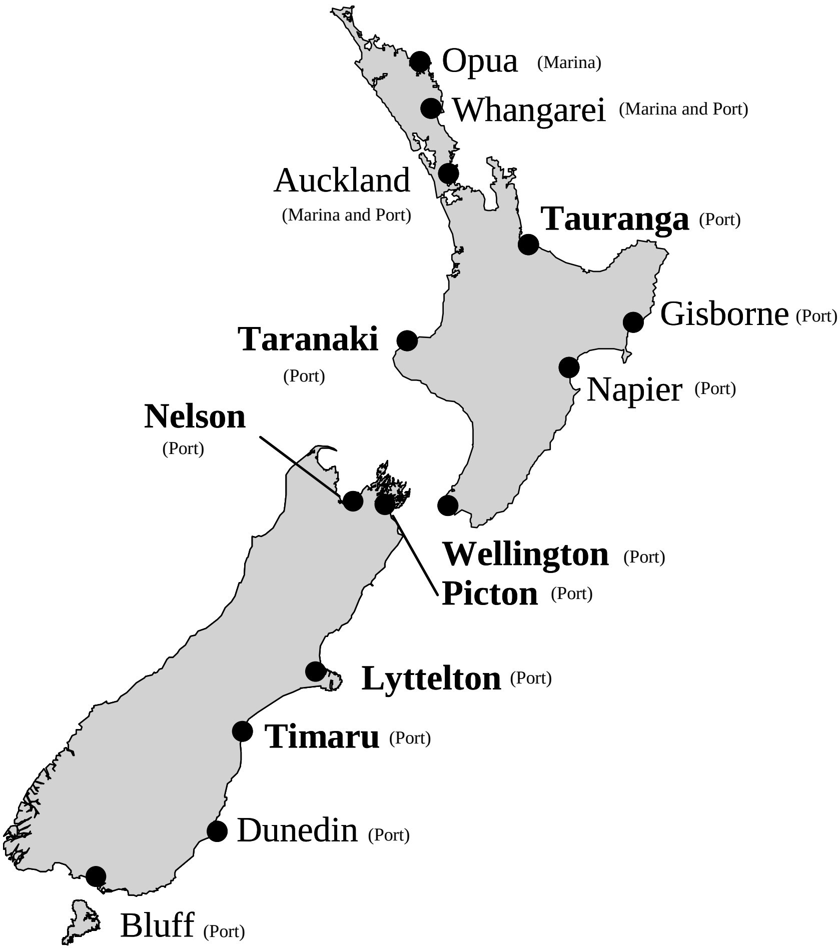

Figure 1: Commercial shipping ports in New Zealand where baseline non-indigenous species surveys have been conducted. Group 1 ports surveyed in the summer of 2001/2002 are indicated in bold and group 2 ports surveyed in the summer of 2002/2003 are indicated in plain font. Marinas were also surveyed for NIS in Auckland, Opua and Whangarei in 2002/2003.

The port surveys have two principal objectives:

i. To provide a baseline assessment of native, non-indigenous and cryptogenic[2] species, and
ii. To determine the distribution and relative abundance of a limited number of target species in shipping ports and other high risk points of entry for non-indigenous marine species.

The surveys will form a baseline for future monitoring of new incursions by non-indigenous marine species in port environments nationwide, and will assist international risk profiling of problem species through the sharing of information with other shipping nations and ports.

This report summarises the results of the Whangarei Marina survey and provides an inventory of species detected in the Marina. It identifies and categorises native, introduced ("non-indigenous") and cryptogenic species. Organisms that could not be identified to species level are also listed as species indeterminata.

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

DESCRIPTION OF THE WHANGAREI MARINA

Whangarei Harbour is a large drowned river estuary situated in Northland on the east coast of the North Auckland peninsula (Fig. 1). Whangarei Town Basin Marina (35°44'S, 174°21'E) is located on the Hatea River approximately 3 km northwest of Port Whangarei in the upper northwest of the Whangarei harbour (Fig. 2). The marina consists of the Town Basin area with approximately 70 pontoon berths, and additional pile and wharf berths in the main channel area immediately upstream with room for around 120 vessels. Kissing Point Marina located approximately 2 km downstream (100 pole berths with up to 18 m in vessel length in development), and Riverside Marina, located approximately 1.5 km downstream (30 berths with up to 18 m in vessel length) were not included in this survey.

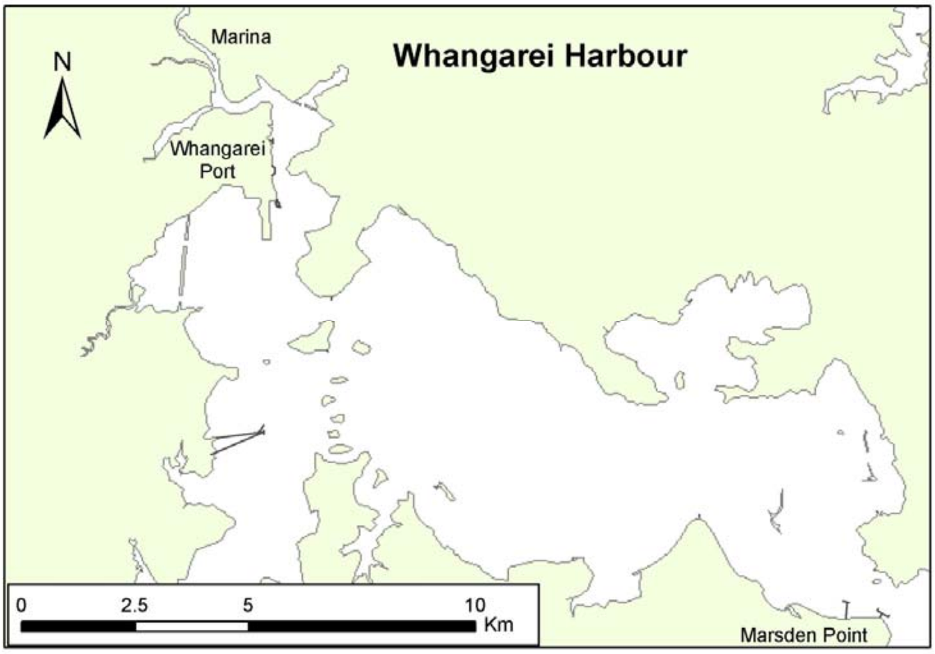

Figure 2: Whangarei Harbour map

MARINA OPERATION AND SHIPPING MOVEMENTS

The Town Basin area (Fig. 3) was first opened with pile moorings in September 1924. In the early 1980's, the quayside of the basin was extensively developed with rock faces, shoreline walkways and commercial shoreline development (cafes, shops etc.), and the marina developed with a mixture of concrete and fibreglass floating pontoons. The town basin and upstream pile-mooring area of the Whangarei Marina currently have berths for approximately 180-190 vessels, with 18 m being the maximum length of vessel that can be accommodated (see Table 1 for details). The diameter of the marina from bank to bank at high tide is 80 m. No commercial cargo is unloaded in the marina. The six local fishing boats resident here take on ice and unload their catch at the commercial area of the main Whangarei Port. Vessels using the marina include local launches and yachts, with international sailing vessels becoming seasonally abundant from November to May each year (e.g. 30-40 boats per month). According to the marina operators, the size of recreational vessels visiting the facility is increasing. The majority of international sailing vessels entering the marina have initially passed through customs in the Opua Marina, approximately 80 km further north.

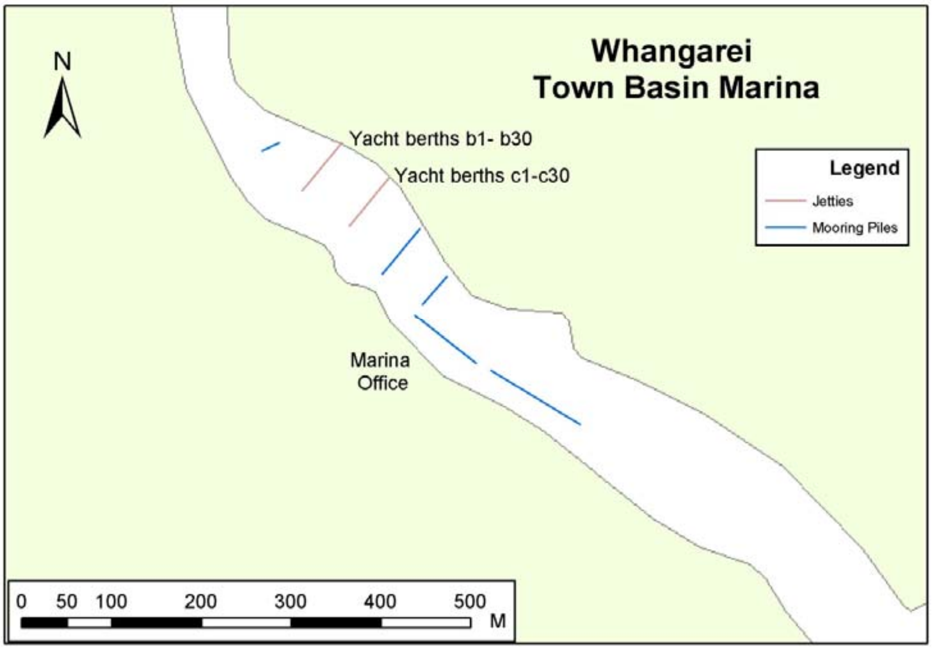

Figure 3: Whangarei Marina map[3]

Vessels are expected to comply with the Voluntary Controls on the Discharge of Ballast Water in New Zealand (http://www.fish.govt.nz/sustainability/biosecurity); vessels are requested to exchange ballast water in mid-ocean (away from coastal influences) en route to New Zealand and discharge only the exchanged water while in port. However, as most of the international sailing vessels entering the marina have little stored sea-water on board and initially passed through Opua Marina and its associated customs operation, discharge of international ballast water is not expected to occur here from these vessels.

In terms of future developments, a developer has recently purchased 85 ha on Port Road, with plans to develop a "marine precinct" on the land with deep water access, travel lift and extra berths for recreational vessels and super yachts. In addition to this proposal, 2 new marinas (Parua Bay and Marsden) are proposed for development in Whangarei Harbour, taking the current berthage in the harbour from 324 to 724 (www.whangareimarine.co.nz/news.html).

Maintenance dredging of the lower Whangarei harbour channel is infrequent, and methods for spoil disposal vary. Dredging of the Town Basin, in the past undertaken once every seven years and averaging around 45,000 m^3 each time, has more recently been undertaken annually, using a barge-mounted hydraulic digger with disposal on-land at Kissing Point (www.nrc.govt.nz/planning/documents/rcp22.pdf). The depth in the marina and dredged channel is approximately 2 m below chart datum. The width of the channel leading to the marina is approximately 30 m at high tide.

PHYSICAL ENVIRONMENT OF WHANGAREI HARBOUR

Whangarei Harbour consists of a drowned river valley system, some 24 kilometres in length. It is a large estuarine system, 100 km^2 in extent, with a diverse range of habitats and associated species, including 54 km^2 of intertidal flats, 14 km^2 of mangroves and 2 km^2 of saltmarsh. The main harbour channel enters from the open coast between Marsden Point and Lort Point, with water depths of 15–31 m. The seafloor of the harbour entrance and middle

[3] Note that an official plan drawing of the marina was not available at the time the reports were prepared. This map has been constructed on the observed layout of the marina and following discussions with the marina managers.

harbour are dominated by coarse sands and muddy sands. The middle harbour is 4–5 km wide, with the main channel on the northern side, and extensive intertidal flats to the south. The channel divides near Onerahi, with one arm going north along the Hatea River channel, and the other going southeast into the Portland arm. The Town Basin Marina is situated in the Hatea River Channel. This area contains numerous areas of shallow intertidal habitat with mud and sandy-mud sediments and mangrove (*Avicennia marina*) stands. At low tide extensive flats are exposed in this area and often only the channels retain water. From the 1920's to the 1970's a major source of mud into the upper harbour was waste material from the Portland cement works which were directly discharged into the Portland arm of the upper harbour. The lower (south-eastern end) of the harbour is generally deeper, with wider channels and small areas of intertidal flats. Sediments in this area of the harbour are mainly fine-medium sands that have been deposited via the harbour entrance. Mean grain size decreases up-harbour and away from the main channels, reflecting a decrease in dispersal energy and current velocities (Millar, 1980). High water turbidity levels (from suspended sediments) are considered characteristic of the upper harbour areas.

Whangarei Harbour has a mean tidal range of 1.7 m (neap tides) to 2.3 m (spring tides). The residence times calculated for water masses in Whangarei Harbour range from 24 days in winter to 120 days in summer. Residence times typically decrease with increasing freshwater input into the harbour, although freshwater input is generally low due to the small size of the surrounding catchment (Millar, 1980). Salinity increases toward the harbour entrance with only small vertical variations, and the greatest salinity variations occur near the Port area. High freshwater input, however, causes a salt-wedge structure in the Port of Whangarei area and causes the lower harbour to become partially mixed. During summer most of the harbour is well mixed, while in winter the lower harbour is well mixed and the upper harbour is partially mixed. Average salinities, measured at 15 stations in the upper harbour, vary from $19^{o}/_{oo}$ to 30 $^{o}/_{oo}$, but surface salinities can drop to 0 $^{o}/_{oo}$ during periods of heavy rain (Northland Regional Council, unpubl. data). Current velocities gradually decrease up-harbour from around 1 ms^{-1} at Marsden Point to 0.8 ms^{-1} at Limestone Island (Millar, 1980).

EXISTING BIOLOGICAL INFORMATION

There appear to be few published biological surveys available on the Hatea River and Whangarei Marina.

Webster *et al*. (2000) undertook a study into trace metals in the Hatea River catchment and estuary following public concern regarding wastewater discharges to the inner harbour. The study found elevated levels of trace metals (Cu, Pb, and Zn) in deposited sediments in the river estuary, derived from tributaries draining the more densely-populated western side of the catchment, city stormwater drains, and Cu-bearing antifoulants used in the marina.

Read and Gordon (1991) described nuisance growths of the non-indigenous tubeworm *Ficopomatus enigmaticus* from the Town Basin Marina. *F. enigmaticus* was first observed there in 1967/68 when it formed large, "coral"-like encrustations on wharf piles, pontoons and boats. The tubes of the worm were associated with two other non-indigenous species: a bryozoan, *Conopeum seurati*, and a spionid polychaete, *Polydora cornuta*.

Morrison (2003) described the results of part of a large scale, estuarine fish survey of northern New Zealand (FRST research programme CO1X022 - "Fish usage of estuarine and coastal habitats") that included survey sites in upper Whangarei Harbour. The survey used small beach seines (9-mm mesh) deployed from intertidal flats. The muddier upper areas of Whangarei Harbour tended to support a wider range of fish species than the sandflats of the middle and lower harbour. Catches with the beach seine were dominated by anchovy

(*Engraulis australis*), yellow-eyed mullet (*Aldrichetta forsteri*), exquisite goby (*Favinogobius exquisitus*), sand goby (*F. lentiginosus*), and juveniles of commercially important species, such as sole (*Peltorhampus latus*), flounder (*Rhombosolea plebia* and *R. leporine*) and snapper (*Pagrus auratus*). A number of individuals of the non-indigenous bridled goby (*Arenigobius bifrenatus*) were also captured in the upper harbour during the surveys.

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

In a confidential client report for Northland Regional Council, Cummings and Hatton (2003) reviewed the suitability of several sites identified by the council as potential sites for shellfish reseeding. These included the Takahiwai River, Otaika River, Parua Bay, Blacksmith Bay, Skull Creek, Limestone Island, and Mangapai River. The report reviewed existing information on the intertidal benthic communities (specifically shellfish) and habitat types at the identified sites, and conducted additional quantitative work on these aspects. The review highlighted the importance as habitat for various bivalves according to Mason and Ritchie (1979), Dickie (1984), Poynter and Kessing (2002), and Cryer *et al.* (2003). From various accounts, a number of these sites had experienced declines in their populations of cockles Cummings *et al.* (2004) subsequently initiated a consultative process with the Whangarei Harbour Kaitiaki Roopu, and conducted preliminary reseeding trials with cockles (*Austrovenus stutchburyi*) at several sites.

Survey methods

SURVEY METHOD DEVELOPMENT

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, 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 baseline 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 Whangarei Marina survey. The survey was undertaken between November 11th and 18th, 2002. Most sampling was concentrated on and around the jetty and pile moorings in the Town Basin. A summary of sampling effort within the Whangarei Marina is provided in Tables 3a,b.

DIVER OBSERVATIONS AND COLLECTIONS ON WHARF PILES

Fouling assemblages were sampled on four pilings at each of four sites within the Town Basin Marina. Selected pilings were separated by 10 – 15 m (Gust *et al*. 2001). On each piling, three 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. Because of the shallow depth of the marine, however, only the upper two quadrats could be sampled on most pilings. 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 (Fig. 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. Opportunistic visual searches were also made of breakwalls and rock facings within the marina. Divers swam vertical profiles of the structures and collected specimens that could not be identified reliably in the field.

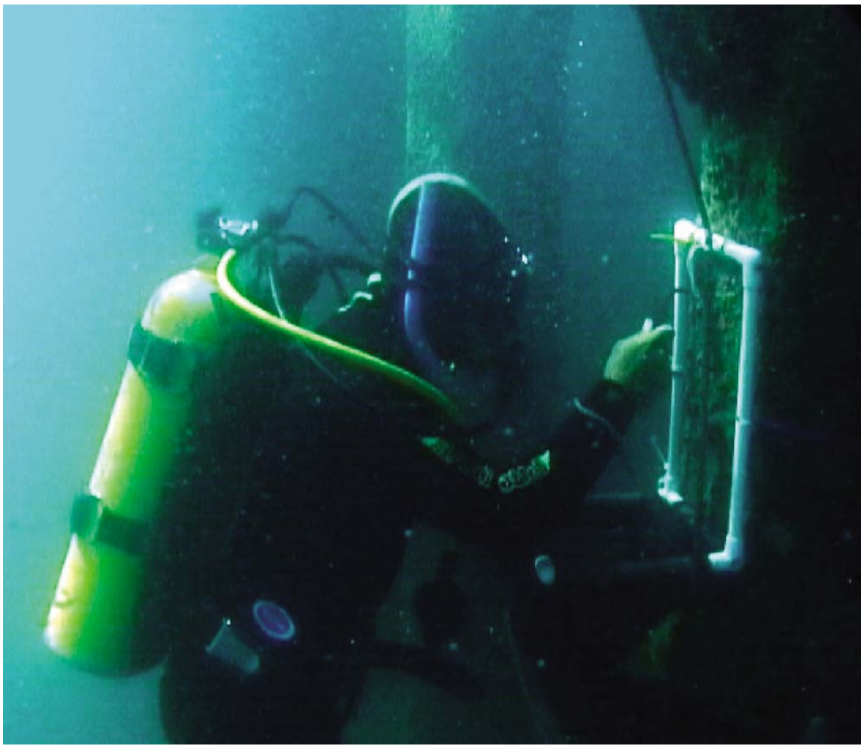

Figure 4: Diver sampling organisms on pier piles.

BENTHIC INFAUNA

Benthic infauna was sampled using a Shipek grab sampler deployed from a researchvessel (Fig. 5). 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 (Fenwick *pers obs*). Three grab samples were taken at haphazard locations at each sample site. 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 x 0.2 m. A short yoke of heavy chain connects the sled to a tow line (Fig. 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 two 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 at each of the four sample sites within the marina, and the entire contents were sorted.

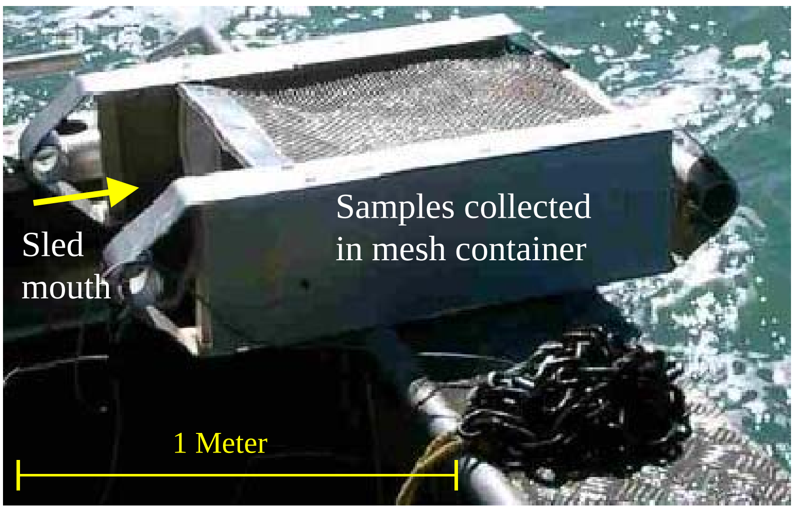

Figure 6: Benthic sled

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 (Fig. 7). The corer consists of a 1 m long x 1 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 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. 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).

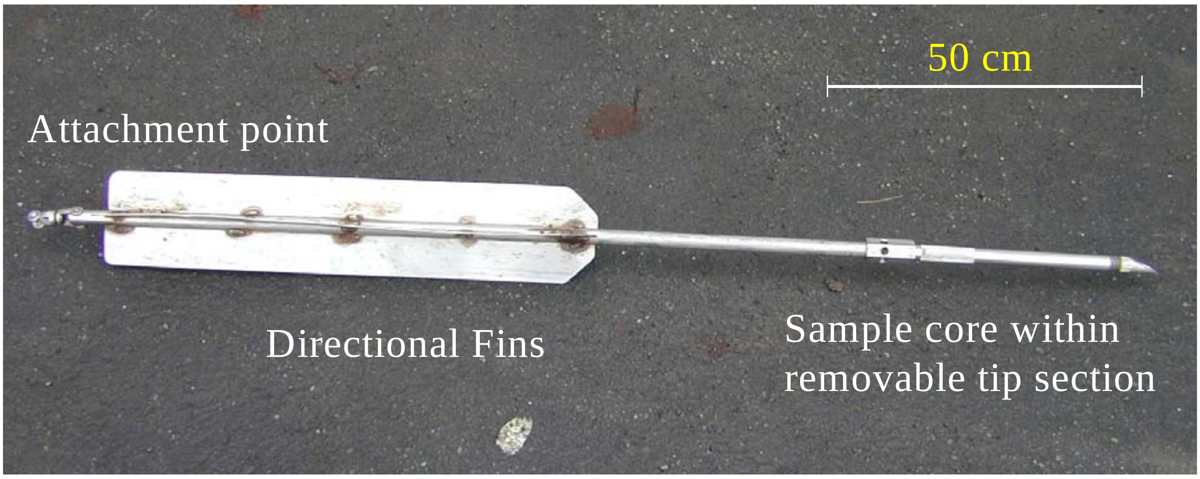

Figure 7: **Javelin corer**

MOBILE EPIBENTHOS

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

Opera house fish 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 (Fig. 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 one 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).

Box traps

Fukui-designed box traps (63 cm x 42 cm x 20 cm) with a 1 cm mesh netting were used to sample mobile crabs and other small epibenthic scavengers (Fig. 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.

Starfish traps

Starfish traps designed by Whayman-Holdsworth were used to catch asteroids and other large benthic scavengers (Fig. 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 starfish 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.

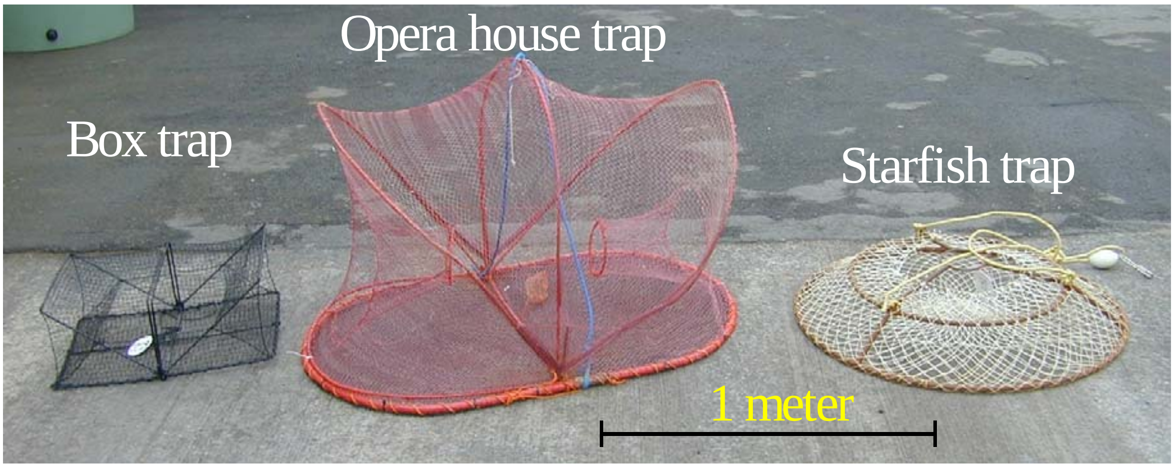

Figure 8: Trap types deployed in the marina.

SAMPLING EFFORT

A summary of sampling effort within the Whangarei Town Basin Marina is provided in Tables 3 a,b. We particularly focused sampling effort on hard substrata (such as pier piles) where invasive species are likely to be found (Hewitt and Martin 2001). The distribution of effort within the marina aimed to maximise spatial coverage and represent the diversity of active mooring sites within the area. Total sampling effort was constrained by the costs of processing and identifying specimens obtained during the survey.

The spatial distribution of sampling effort for each of the sample methods in the Whangarei Marina is indicated in the following figures: diver pile scrapings and javelin cyst coring (Fig. 9), benthic sledding and Shipek grab sampling (Fig. 10), and box, starfish, shrimp and opera house fish trapping (Fig. 11). Sampling effort was varied between ports and marinas on the basis of risk assessments (Inglis 2001) to maximise the search efficiency for NIS nationwide. Sampling effort in each of the thirteen Ports and three marinas surveyed over two summers is summarised in Table 3c.

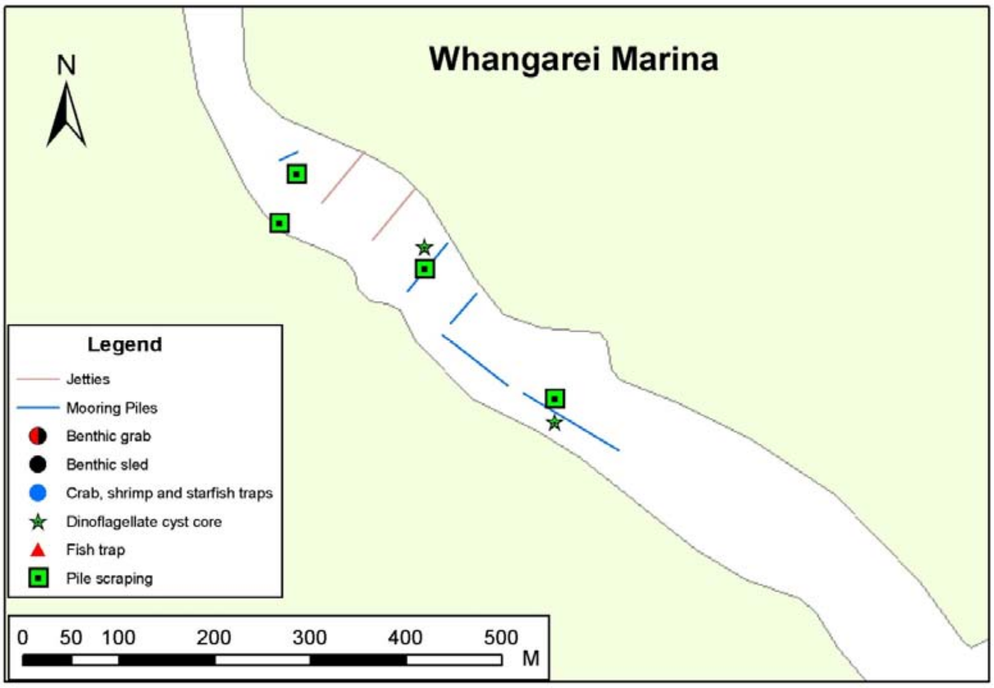

Figure 9: Diver pile scrape sites and dinoflagellate cyst sample sites

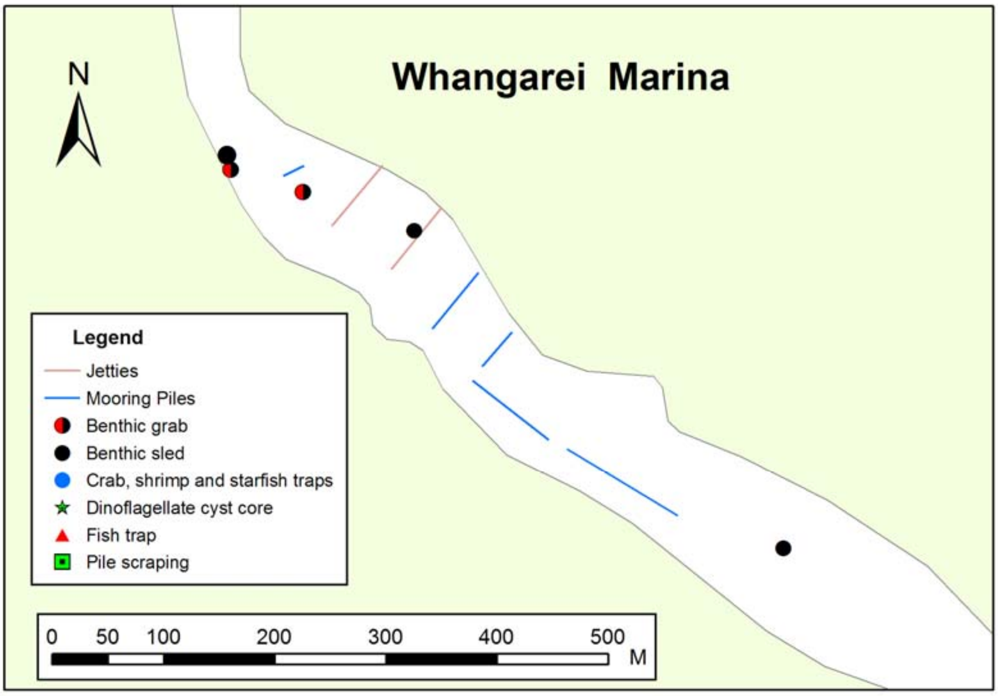

Figure 10: Benthic sled and benthic grab sites.

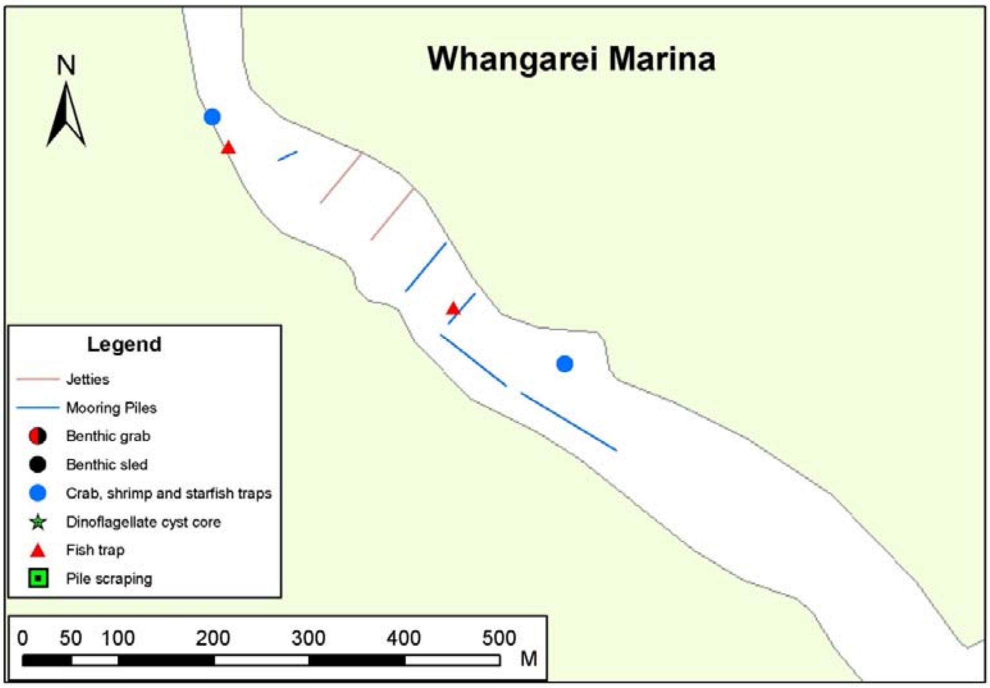

Figure 11: Sites trapped using crab (box), shrimp, starfish and opera house fish traps

SORTING AND IDENTIFICATION OF SPECIMENS

Each sample collected in the diver pile scrapings, benthic sleds, box, starfish and shrimp traps, opera house fish traps, Shipek grabs and javelin cores 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 4. Specimens were subsequently sent to over 25 taxonomic experts (Appendix 1) for identification to species or lowest taxonomic unit (LTU). 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 and marina were compared with the marine species listed on the New Zealand register of unwanted organisms under the Biosecurity Act 1993 (Table 5a) and the marine pest list produced by the Australian Ballast Water Management Advisory Council (Table 5b).

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 reliably determine 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), or because the species has 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. In addition, a fifth category ("species indeterminata") was used for specimens that could not be identified to species-level. Formal definitions for each category are described below.

Native species

Native species are known to be endemic to the New Zealand biogeographical region 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 by Chapman and Carlton (1991, 1994), as exemplified by Cranfield *et al.* (1998).

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

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

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

In this report we distinguish two categories of NIS. "NIS" refers to non-indigenous species previously recorded from New Zealand waters, and "NIS (new)" refers to non-indigenous species first discovered in New Zealand waters during this project.

Cryptogenic species 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 species Category 2:

Species that have recently been discovered but for which there is insufficient systematic of 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.

Species indeterminata

Specimens that could not be reliably identified to species level. 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.

Survey results

A total of only 56 species or higher taxa was identified from the Whangarei Marina survey. This collection consisted of 35 native (Table 6), four cryptogenic (Table 7), nine non-indigenous species (Table 8) and eight species indeterminata (Table 9, Fig. 12). The biota included a diverse array of organisms from eight Phyla (Fig. 13). One species from the Whangarei Marina had not previously been described from New Zealand waters. For general descriptions of the main groups of organisms (Phyla) encountered during this study refer to Appendix 2.

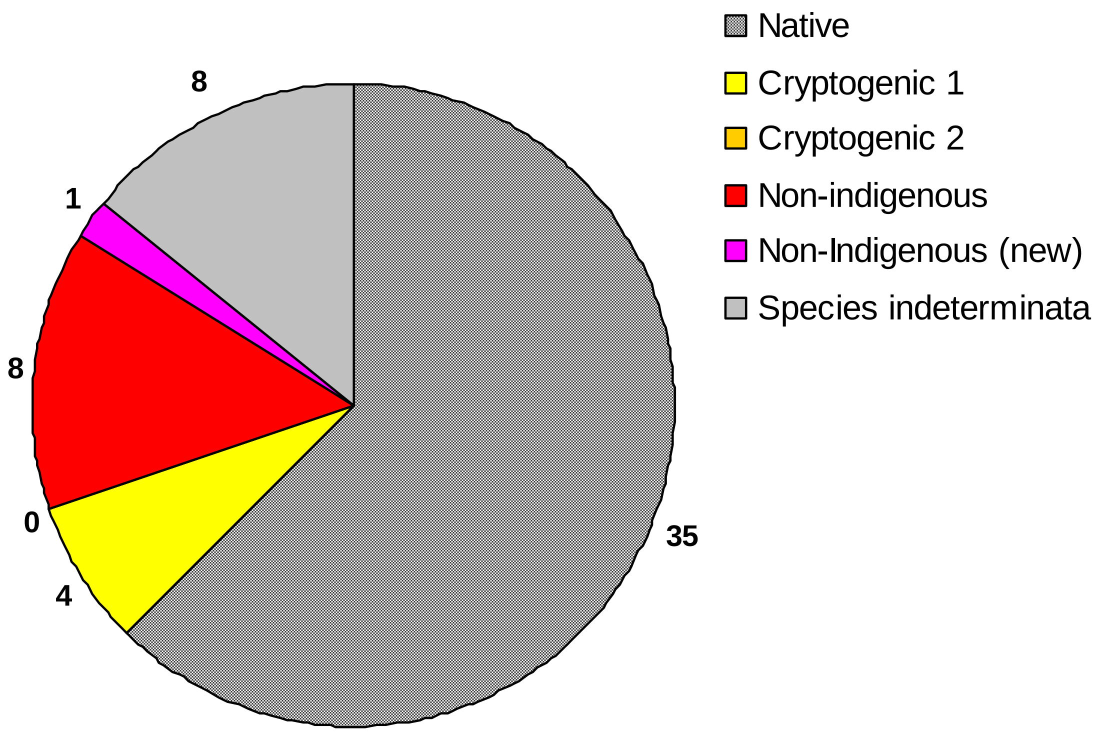

Figure 12: **Diversity of marine species sampled in the Whangarei Marina. Values indicate the number of species in native, cryptogenic, non-indigenous and species indeterminata categories.**

NATIVE SPECIES

A total of 35 native species was identified from the Whangarei Marina. Native species represents 62.5 % of all species identified from this location (Table 6) and included assemblages of annelids (9 species), crustaceans (13 species), molluscs (4 species), and vertebrates (6 species). A number of other less diverse phyla including Pyrrophycophyta and Urochordata were also sampled from the Marina (Table 6).

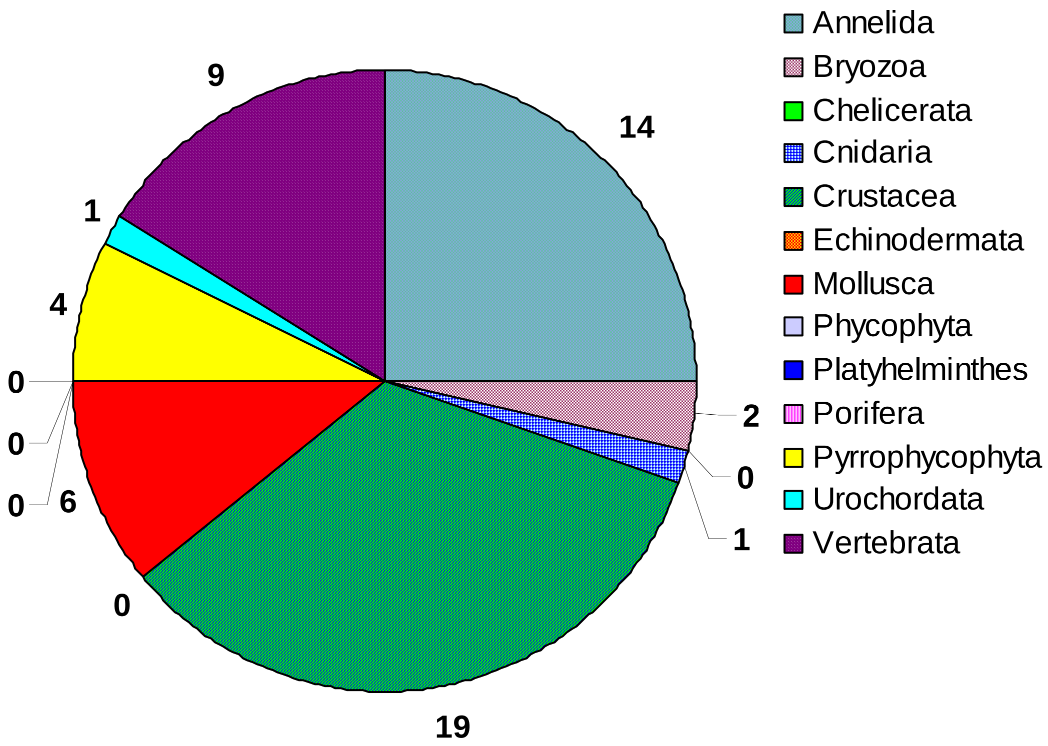

Figure 13: Marine Phyla sampled in the Whangarei Marina. Values indicate the number of species in each of the major taxonomic groups.

CRYPTOGENIC SPECIES

Four cryptogenic species were discovered in the Whangarei Marina. Cryptogenic species represented 7.1 % of all species or higher taxa identified from the marina. The cryptogenic organisms identified were all Category 1 species as defined in Section 2.8 above. These organisms included two crustaceans (a barnacle, *Amphibalanus variagatus*, and a crab, *Pilumnopeus serratifrons*) and the resting cysts of two pyrrophycophyta (*Alexandrium cf. catenella* and *Gymnodinium catenatum*, Table 7). *Pilumnopeus seratifrons* has been present in New Zealand for over 100 years, but is also known from South Australia (Cranfield *et al*. 1998).

NON-INDIGENOUS SPECIES

Nine non-indigenous marine species were recorded from the Whangarei marina (Table 8). They comprised 16.1% of all species identified from this location. One of these species, the amphipod *Melita matilda*, was not previously known from New Zealand. The NIS included two annelids (the tubeworm, *Ficopomatus enigmaticus*, and the spionid *Polydora cornuta*), two bryozoans (*Bugula neritina*, *Conopeum seurati*), three amphipods (*Melita matilda*, *Monocorophium acherusicum*, *Paracorophium brisbanensis*) and two molluscs (*Musculista senhousia* and *Theora lubrica*).

A list of Chapman and Carlton's (1994) criteria (see Section 2.9.2) that were met by the non-indigenous species sampled in this survey is given in Appendix 3. 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 listed in Appendix 1 and from regional databases on non-indigenous marine species in Australia (National Introduced Marine Pest Information System;

http://www.crimp.marine.csiro.au/nimpis) and the USA (National Exotic Marine and Estuarine Species Information System; http://invasions.si.edu/nemesis). Distribution maps for each NIS in the marina are composites of multiple replicate samples. 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 phyla in the same order as Table 8.

***Ficopomatus enigmaticus* (Fauvel, 1923)**

Image and information:
Joint Nature Conservation Committee (available online at: http://www.jncc.gov.uk/page-1700);
Hewitt *et al.* (1999)

Ficopomatus enigmaticus is a serpulid polychaete. The worm lives within a white calcareous tube, and aggregation of tubes can lead to the formation of serpulid "reefs". *F. enigmaticus* has a very high tolerance to low salinities and requires water with fluctuating salinities to reproduce and spawn. It is a temperate-subtropical species that inhabits estuaries and lagoons. In the right conditions it is capable of forming massive aggregations of tubes. In Argentina's Mar Chiquita Coastal Lagoon, large masses of *F. enigmaticus* form circular reefs up to 7 m in diameter and 0.5 m deep, scattered over hundreds of hectares (Cohen 2005).

F. enigmaticus occurs in most of the world's oceans but its exact native range is uncertain due to systematic difficulties. The type specimen was described from Canal de Caen on the Atlantic coast of France (Read and Gordon 1991). Populations of *F. enigmaticus* have been reported from the United Kingdom, Denmark, Netherlands, Spain, Mediterranean Sea, Black Sea, Caspian Sea, USA (California and Texas), Uruguay, northern Argentina, South Africa, southern and western Australia, New Zealand, Japan, and Hawaii (Cohen 2005). It first appeared in New Zealand in the 1960s when it formed extensive nuisance growths on vessel hulls and navigational structures in Whangarei Marina (Read and Gordon 1991). It has since been reported from Waitemata Harbour, Tamaki Estuary and Hawkes Bay (Cranfield *et al*. 1998). Large populations of *F. enigmaticus* may remove suspended particulate matter, reduce excess nutrient loads and improve oxygen levels in boat basins or enclosed waters with poor water quality (Eno *et al*. 1997). In Tamaki Estuary *F. enigmaticus* tubes caused severe fouling of cooling water intake pipes at the Otahuhu Power Station.

During the baseline survey *F. enigmaticus* occurred in the Port of Whangarei and on hard surfaces throughout Whangarei Town Basin Marina, where it was present in pile scrapings taken from all four sites that were sampled using this technique (Fig. 14).

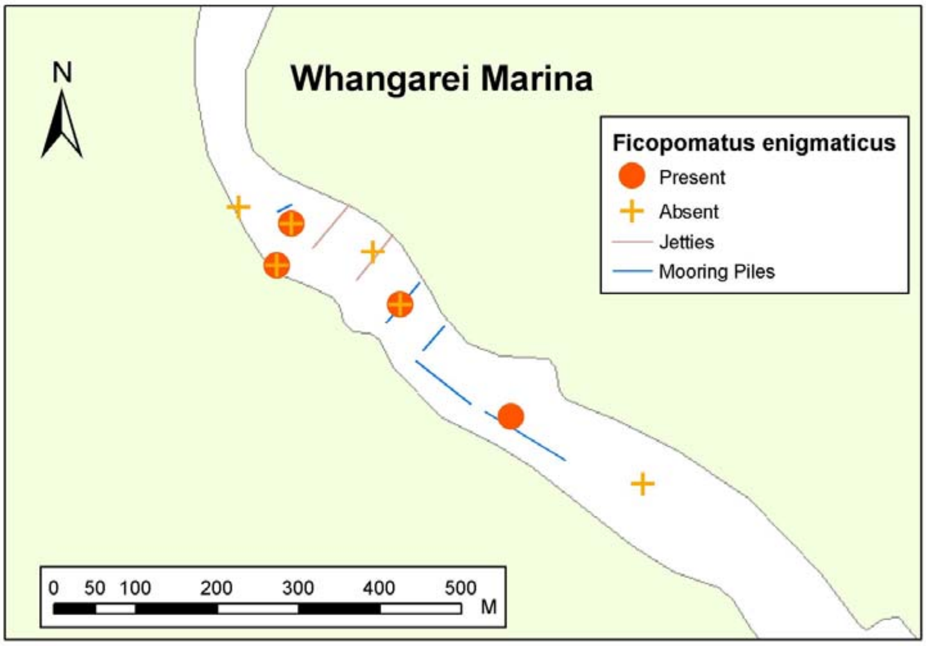

Figure 14: ***Ficopomatus enigmaticus*** **distribution in Whangarei Marina**

Polydora cornuta **(Bosc, 1802)**

No image available.

Polydora cornuta is a polychaete in the family Spionidae. It is native to the east coast of the USA and has been introduced to California and Oregon, probably as a co-introduction with oyster aquaculture imports. *P. cornuta* lives in mud tubes attached to oysters and other bivalves, and is able to live in salinities as low as 5 $^{o}/_{oo}$ (Fuller and O'Connell 2005). It has been present in New Zealand since at least 1972 and has previously been recorded from Whangarei and Waitemata Harbours (Cranfield *et al*. 1998). *P. cornuta* occurred in all four sites from which pile scrapings were taken in Whangarei Marina (Fig. 15).

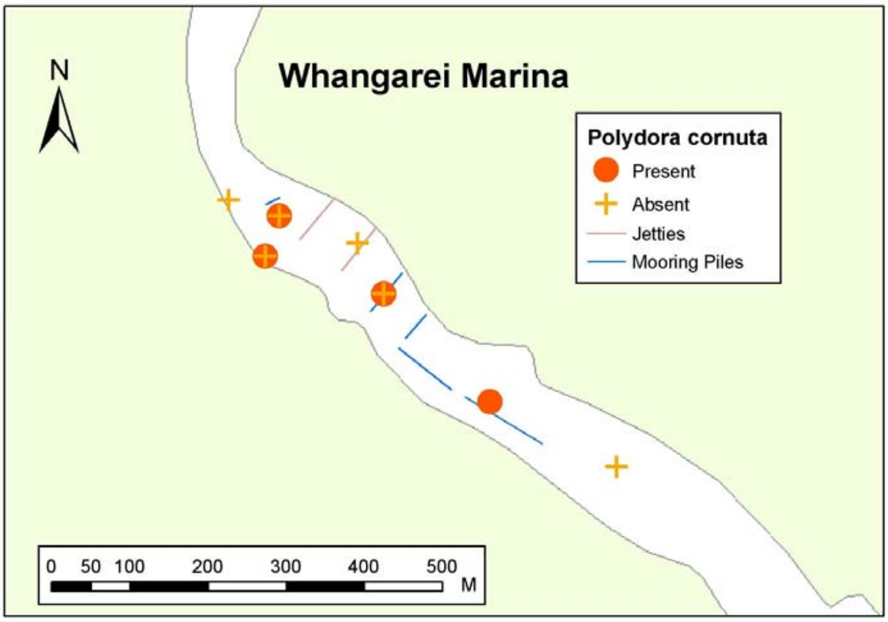

Figure 15: ***Polydora cornuta*** **distribution in Whangarei Marina**

Bugula neritina Linnaeus, 1758

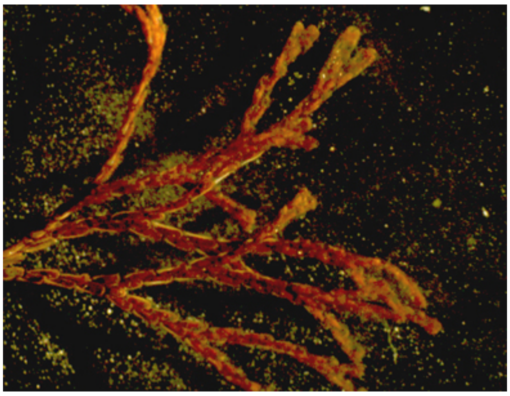

Image and information: NIMPIS (2002a)

Bugula neritina is an erect, bushy, red-purple-brown bryozoan. Branching is dichotomous (in series of two) and zooids alternate in two rows on the branches. Unlike all other species of *Bugula*, *B. neritina* has no avicularia (defensive structures) or spines, but there is a single pointed tip on the outer corner of zooids. Ovicells (reproductive structures) are large, globular and white in colour. They often appear in such high numbers that they resemble small snails or beads. *Bugula neritina* is native to the Mediterranean Sea. It has been introduced to most of North America, Hawaii, India, the Japanese and China Seas, Australia and New Zealand. It is cryptogenic in the British Isles. *Bugula neritina* is one of the most abundant bryozoans in ports and harbours and an important member of the fouling community. The species colonises any available substratum and can form extensive monospecific growths. It grows well on pier piles, vessel hulls, buoys and similar submerged surfaces. It even grows heavily in ships' intake pipes and condenser chambers. In North America, *B. neritina* occurs on rocky reefs and seagrass leaves. In Australia, it occurs primarily on artificial substrata. *B. neritina* occurs in all New Zealand ports (Gordon and Matawari 1992). In Whangarei Town Basin Marina it occurred in benthic grab samples from one of the sites surveyed by this method (Fig. 16).

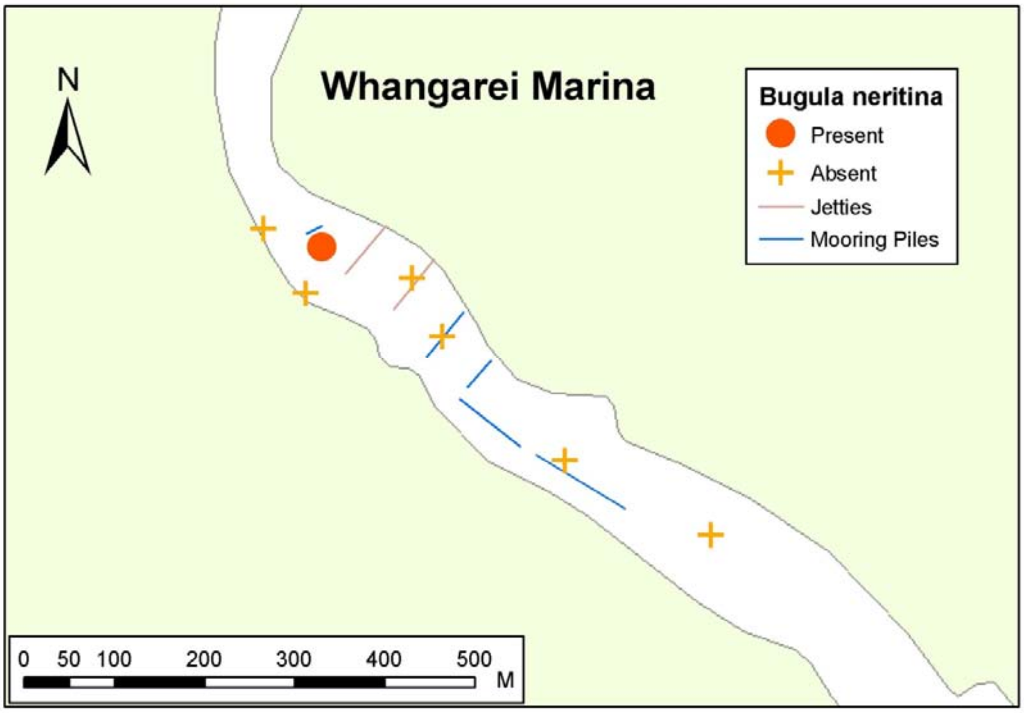

Figure 16: ***Bugula neritina*** **distribution in Whangarei Marina**

***Conopeum seurati* (Canu 1908)**

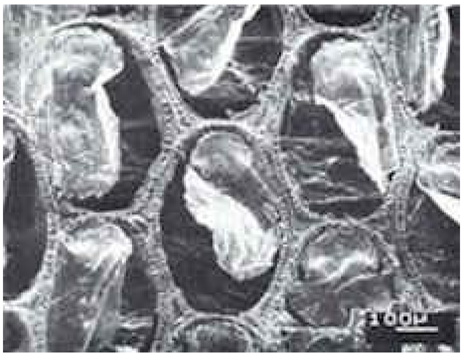

Image and information:
Cranfield *et al.* 1998; Gordon and Matawari 1992; Smithsonian Institution (available at http://www.sms.si.edu/irlspec/Conope_seurat.htm)

Conopeum seurati is an encrusting bryozoan that forms small whitish colonies on seagrasses and other substrata. The zooids are oval in shape and measure approximately 0.55 X 0.33 mm. Each zooid has a single pair of long, distal spines and the lateral spines, if present, are highly variable in number. The lophophore measures approximately 0.621 mm in diameter and bears an average of 15 tentacles. *Conopeum seurati*'s native range includes the Caspian, Azov and Mediterranean Seas. The species has been introduced to New Zealand and Florida's east coast. It has been present in New Zealand since at least 1963. *C. seurati* is a fouling organism that can be found on hard surfaces, marine animals, and plants in estuarine environments. Its impacts on native organisms are unknown.

In New Zealand, *C. seurati* has been recorded from Opua, Whangarei, Auckland, Manukau, Gisborne, Napier, Nelson and Lyttelton. In Whangarei Marina it occurred in pile scrape samples taken from four sites (Fig. 17).

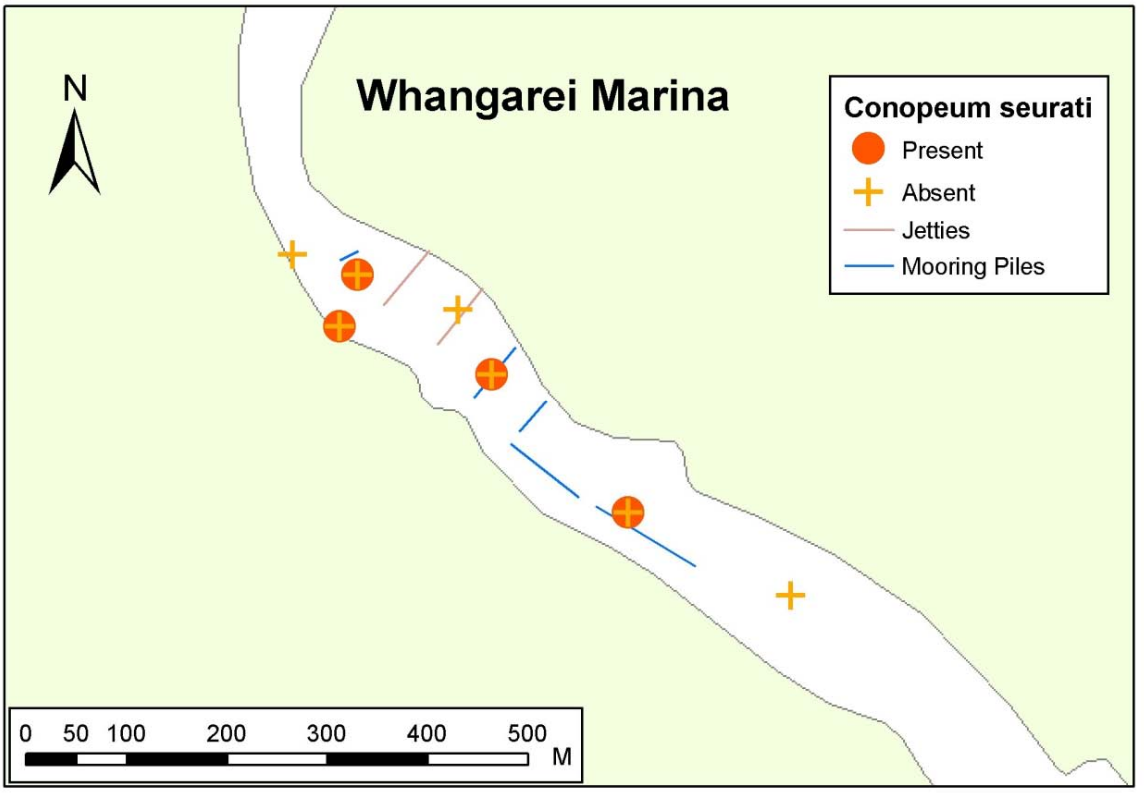

Figure 17: *Conopeum seurati* distribution in Whangarei Marina

***Monocorophium acherusicum* (A. Costa, 1851)**

Image and information: NIMPIS (2002b)

Monocorophium acherusicum is a flat, yellowish-brown amphipod crustacean that lives subtidally amongst assemblages of marine invertebrates and plants or in soft-bottom habitats. It feeds by grazing on bacteria attached to sediment particles or on organic matter suspended in the water column. It is native to the northeast Atlantic, the Mediterranean and the northwest African coast. It has been introduced to Brazil, southeast Africa, India, the Japan and China Seas, Australia and New Zealand. It is cryptogenic in the Baltic Sea, the Caribbean and the east and northwest coasts of the USA. *Monocorophium acherusicum* occurs where silt and detritus accumulate among fouling communities such as algae, ascidians and bryozoans, and man-made installations e.g. wharf pylons, rafts and buoys. It is a tube building species constructing conspicuous, fragile U-shaped tubes of silk, mud and sand particles. It can reach high abundances and can tolerate a wide range of salinities. Pilisuctorid ciliates are parasites on this species in the Black Sea, but it is unknown whether these parasites could transfer to native species and cause negative impacts in New Zealand. During the port baseline surveys, *M. acherusicum* was recorded from the ports of Tauranga, Gisborne, Lyttelton, Timaru, Dunedin and the Whangarei Town Basin Marina. It occurred in pile scrape samples taken from two sites in Whangarei Marina (Fig. 18).

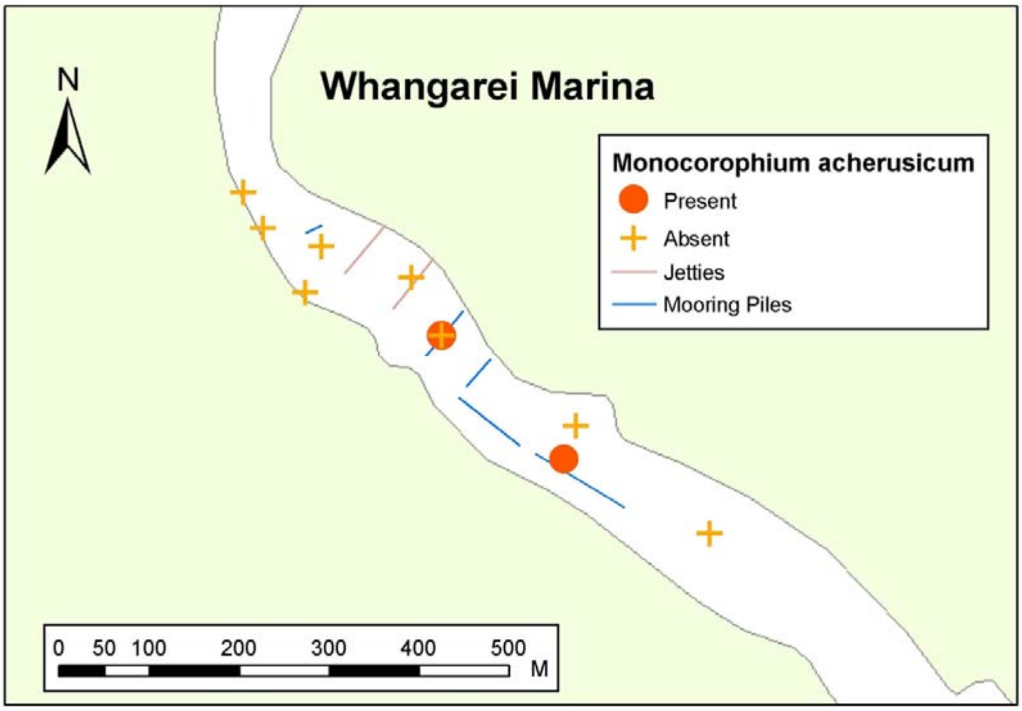

Figure 18: *Monocorophium acherusicum* distribution in Whangarei Marina

Paracorophium brisbanensis **(Chapman, 2002)**
No image available.

Paracorophium brisbanensis is a small amphipod from the family Corophiidae normally found only on the north-east coast of Australia. It was first identified in New Zealand from Tauranga Harbour in 2002 where it inhabits intertidal estuarine sediments (Chapman 2002; Stevens *et al*. 2002). It had not been recorded from any other locations in New Zealand. No information exists on its ecology and impacts in its introduced range. In Whangarei Marina it occurred in pile scrape samples taken from one of the sampled sites (Fig. 19).

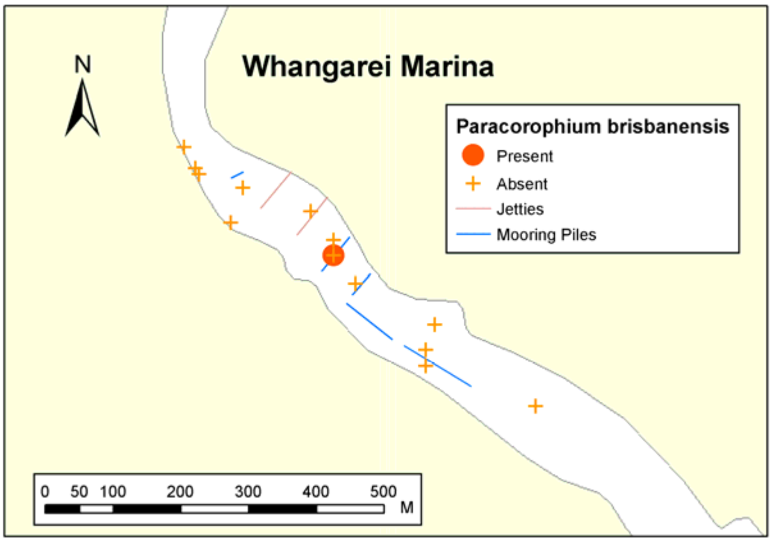

Figure 19: ***Paracorophium brisbanensis*** **distribution in Whangarei Marina**

Melita matilda **(J.L. Barnard, 1972)**
No image available.

Melita matilda is an amphipod in the family Melitidae normally found in south-east and south-west Australia in littoral estuarine environments (Lowry *et al*. 2000). This is the first record of its presence in New Zealand. No information exists on its ecology and likely impacts. In Whangarei Marina *M. matilda* occurred in pile scrape taken from four sample sites (Fig. 20).

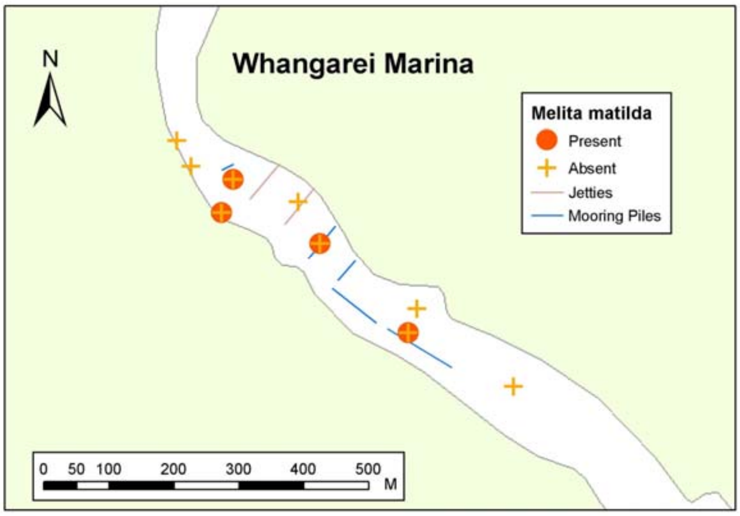

Figure 20: ***Melita matilda*** **distribution in Whangarei Marina**

***Musculista senhousia* (Benson in Cantor, 1842)**

Image and information: NIMPIS (2002c)

Musculista senhousia is a small mussel with a maximum length of around 30 mm. It has a smooth, thin shell that is olive green to brown with dark radial lines or zigzag markings. A well-developed byssus is used to construct a cocoon which protects the shell. This cocoon is made up of byssal threads and sediment. *Musculista senhousia* burrows vertically down into the sand/mud leaving only its posterior end protruding, allowing its siphons access to the water to enable feeding. *Musculista senhousia* has been found from the intertidal to a depth of 20 m and on soft or hard substrata. It prefers to settle in groups on soft substrata, but is capable of fouling wharf pilings and man-made structures. When settled on hard substrata the mussel will not form a protective cocoon. It is a highly adaptive species, and is able to tolerate low salinities. *Musculista senhousia* can dominate benthic communities and potentially exclude native species. It settles in aggregations and is therefore able to reach high densities. The byssal mats formed by the mussel restrict the growth of some species of seagrass, increases sediment deposition and retention, and can thereby alter the abundance and composition of infaunal assemblages.

Musculista senhousia is native to the Japan and north China Seas. It has been introduced to the west coast of the USA, the Mediterranean, Australia and New Zealand. It is cryptogenic in the Red Sea, the eastern Indian Ocean, South China Sea, Indonesia and Papua New Guinea. It has been present in New Zealand since at least 1978 and has spread to a range of estuaries in north-east New Zealand, from the East Cape to Parengarenga Harbour (Cranfield et al 1998). In Whangarei Marina *M. senhousia* was sampled in four discreet locations with specimens collected using pile scrapes, benthic sleds and benthic grabs (Fig. 21).

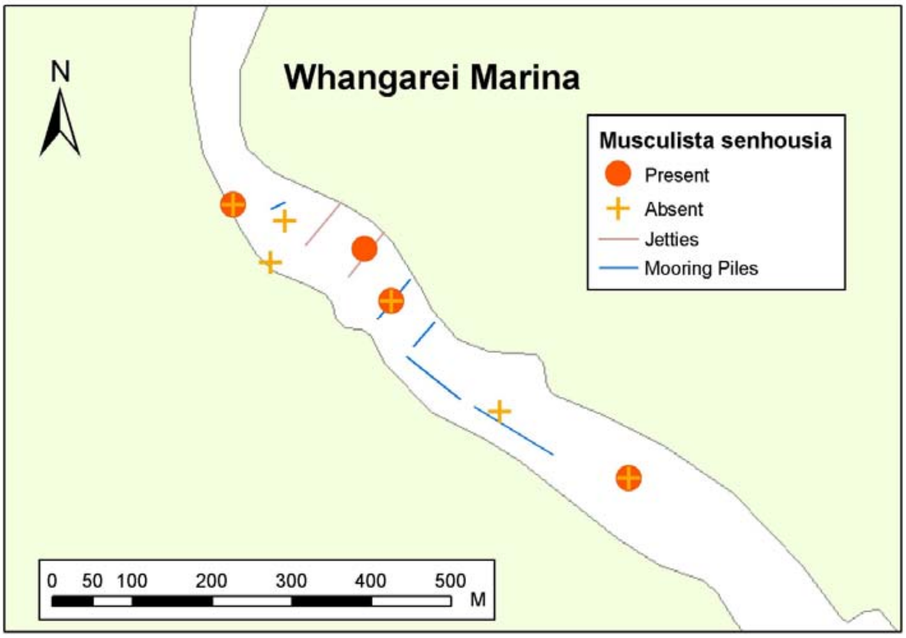

Figure 21: *Musculista senhousia* distribution in Whangarei Marina

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

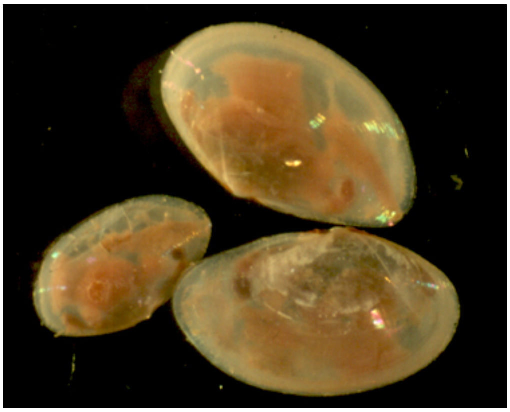

Image and information: NIMPIS (2002d)

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 Japan and China Seas. It has been introduced to the west coast of the USA, Australia and New Zealand. *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. It occurs in estuaries of the north-east coast of the North Island, including the Bay of Islands, Whangarei Harbour, Waitemata Harbour, Wellington and Pelorus Sound. During the port baseline surveys, it was recovered from Opua, Whangarei Port and Marina, Gulf Harbour Marina, Auckland, Gisborne, Napier, Taranaki, Wellington, Nelson, and Lyttelton. *T. lubrica* occurred throughout Whangarei Marina, and was present in three sampled locations using benthic sleds and benthic grabs (Fig. 22).

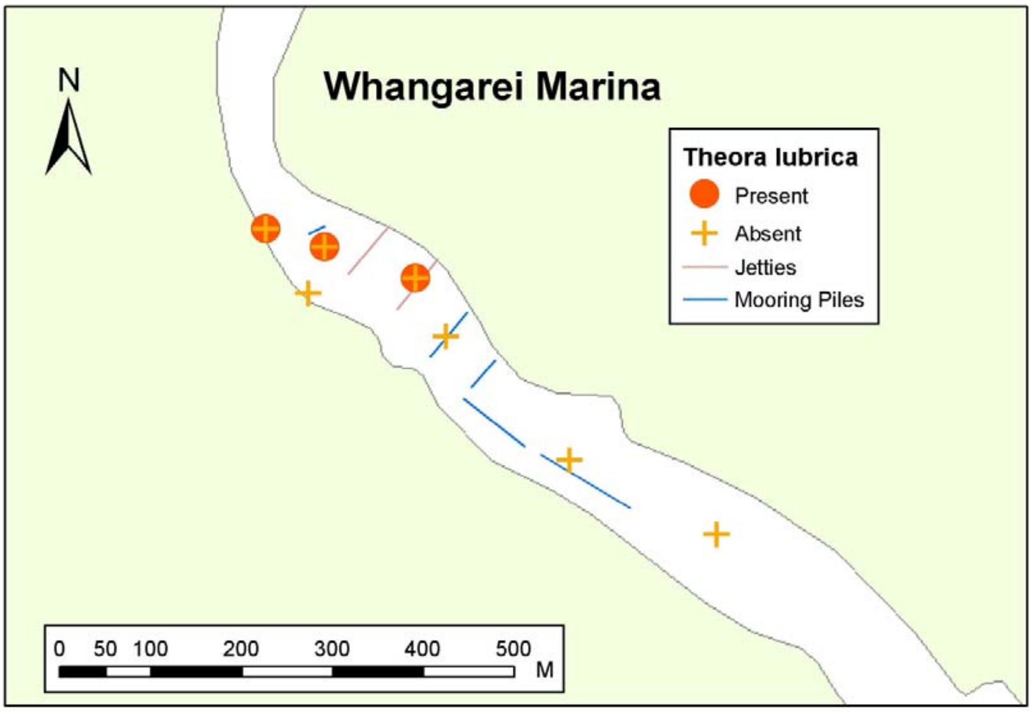

Figure 22: *Theora lubrica* distribution in Whangarei Marina

SPECIES INDETERMINATA

Eight organisms from the Whangarei Marina were classified as species indeterminata. If each of these organisms is considered a species of unresolved identity, then together they represent 14.3 % of all species collected from this survey (Fig. 12). Species indeterminata from Whangarei Marina included three annelids, one crustacean, one cnidarian and three vertebrates (Table 9).

NOTIFIABLE AND UNWANTED SPECIES

Of the non-indigenous species identified from the Whangarei Marina, none is currently listed as an unwanted species on the New Zealand register of unwanted organisms (Table 5a). However, three species found in the marina are listed on the ABWMAC Australian list of marine pest species (Table 5b). These are the non-indigenous species of bivalve, *Musculista senhousia*, and two Category 1 cryptogenic dinoflagellates: *Gymnodinium catenatum*, and *Alexandrium* cf. *catenella*.

PREVIOUSLY UNDESCRIBED SPECIES IN NEW ZEALAND

One species from the Whangarei Marina is previously undescribed from New Zealand waters. This was the amphipod, *Melita matilda*, a species native to Australia (Table 8).

CYST-FORMING SPECIES

Resting cysts of two species of native dinoflagellate cysts were collected during this survey. They are indicated as members of the Pyrrophycophyta in Table 6. Two cryptogenic (Category 1) dinoflagellate species were also collected from the Marina (Table 7). Both *Gymnodinium catenatum* and *Alexandrium* cf. *catenella* are listed on the ABWMAC Australian list of marine pest species (Table 5b). Motile forms of each species produce toxins that can cause Paralytic Shellfish Poisoning (PSP) and are a significant public health problem. Blooms of *G. catenatum* and *A. catenella* can cause problems for aquaculture and recreational harvesting of shellfish.

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

The non-indigenous species located in the marina are thought to have arrived in New Zealand via international shipping. Table 8 indicates the possible vectors for the introduction of each NIS. Likely vectors of introduction are largely derived from Cranfield *et al*. (1998) and indicate that approximately 11% (one of the nine NIS) probably arrived via ballast water, 56 % via hull fouling and 33 % could have arrived via either of these mechanisms.

COMPARISON WITH OTHER PORTS

Sixteen locations (13 ports and three marinas) were surveyed during the summers of 2001/2002 and 2002/2003 (Fig. 1). The total number of species identified in these surveys varied from 332 in the Port of Wellington to 56 in Whangarei Marina (Fig. 23a). The number of species recorded in each location reflects sampling effort (Table 3c) and local patterns of marine biodiversity within the ports and marinas. Sampling effort alone (expressed as the total number of registered samples in each port), accounted for significant proportions of variation in the numbers of native (linear regression; $F_{1,14} = 33.14$, $P < 0.001$, $R^2 = 0.703$), Cryptogenic 1 ($F_{1,14} = 5.94$, $P = 0.029$, $R^2 = 0.298$) and Cryptogenic 2 ($F_{1,14} = 7.37$, $P = 0.017$, $R^2 = 0.345$) species recorded in the different locations. However differences in sampling effort did not explain differences in the numbers of NIS found in each port and marina ($F_{1,14} = 0.77$, $P = 0.394$, $R^2 = 0.052$).

The Whangarei Town Basin Marina had very low diversity of marine organisms compared to the other ports and marinas surveyed, even when sampling effort was taken into account. The

Whangarei Marina had smaller than average numbers of native, non-indigenous, Cryptogenic 1 and Cryptogenic 2 species relative to the other ports and marinas surveyed (Fig 24). Largest numbers of NIS were reported from the ports of Lyttelton and Whangarei, but significantly more Cryptogenic 1 species were recorded in Whangarei Port than in other surveyed locations (Fig 24c, Studentised residual = 3.87). As a proportion of the total fauna, however, the Whangarei Marina had the highest percentage composition of non-indigenous species from the sixteen locations surveyed (Fig. 23b). Non-indigenous species represented 16.1% of all identified species in the marina. In comparison, non-indigenous species represented an average 6.6% (S.E. = 0.6) of species found in the other 15 locations surveyed.

In most locations, native organisms represented over 60 % of the total species diversity sampled, with a minimum contribution of 61.0 % in Lyttelton, and a maximum of 68.4 % in Picton (Fig. 23b). In Whangarei Marina, native species represented 62.5% of total diversity, with cryptogenic Category 1 and species indeterminata comprising 7.1% and 14.3 % of the sampled diversity, respectively.

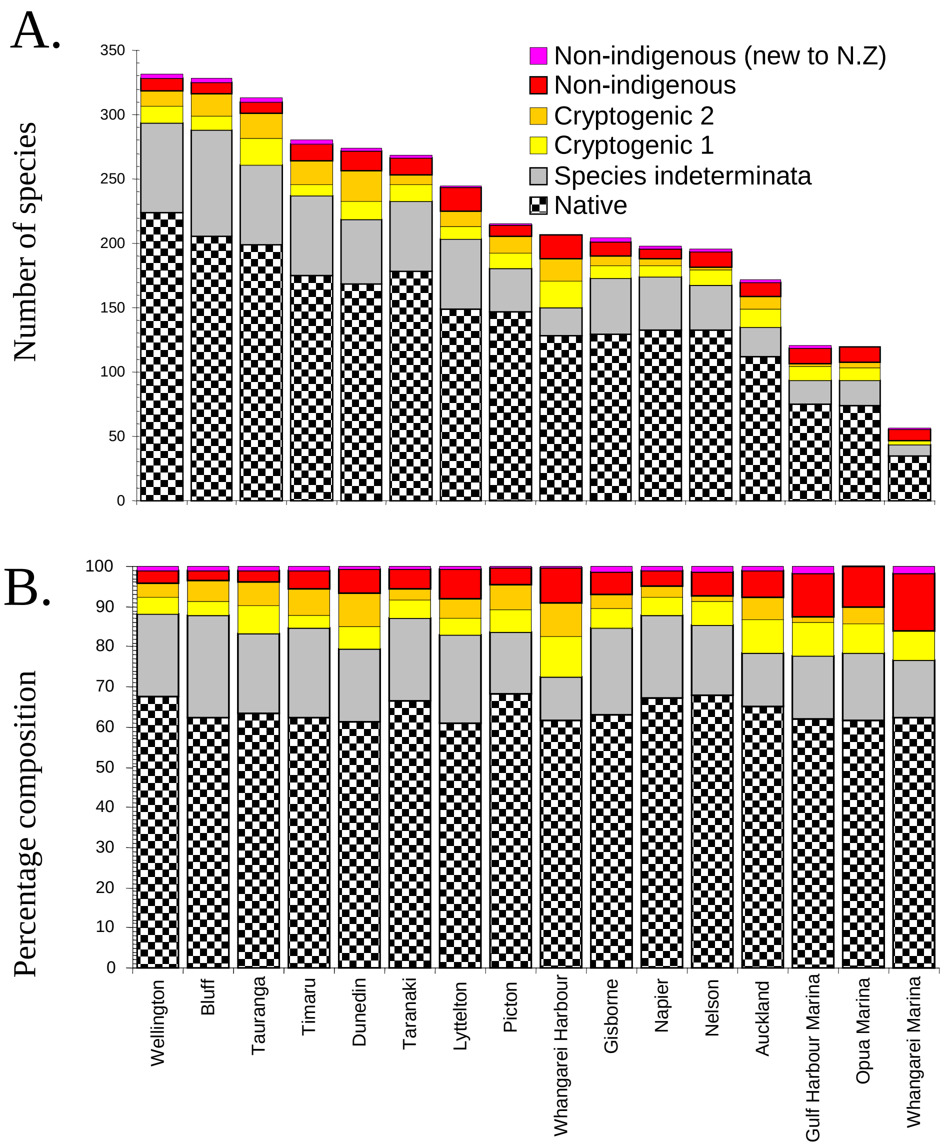

Figure 23: **Differences in (a) the number of species, and (b) the relative proportions of non-indigenous, cryptogenic, species indeterminata and native categories among the sixteen locations sampled over the summers of 2001 – 2002, and 2002-2003. Locations are presented in order of decreasing species diversity sampled.**

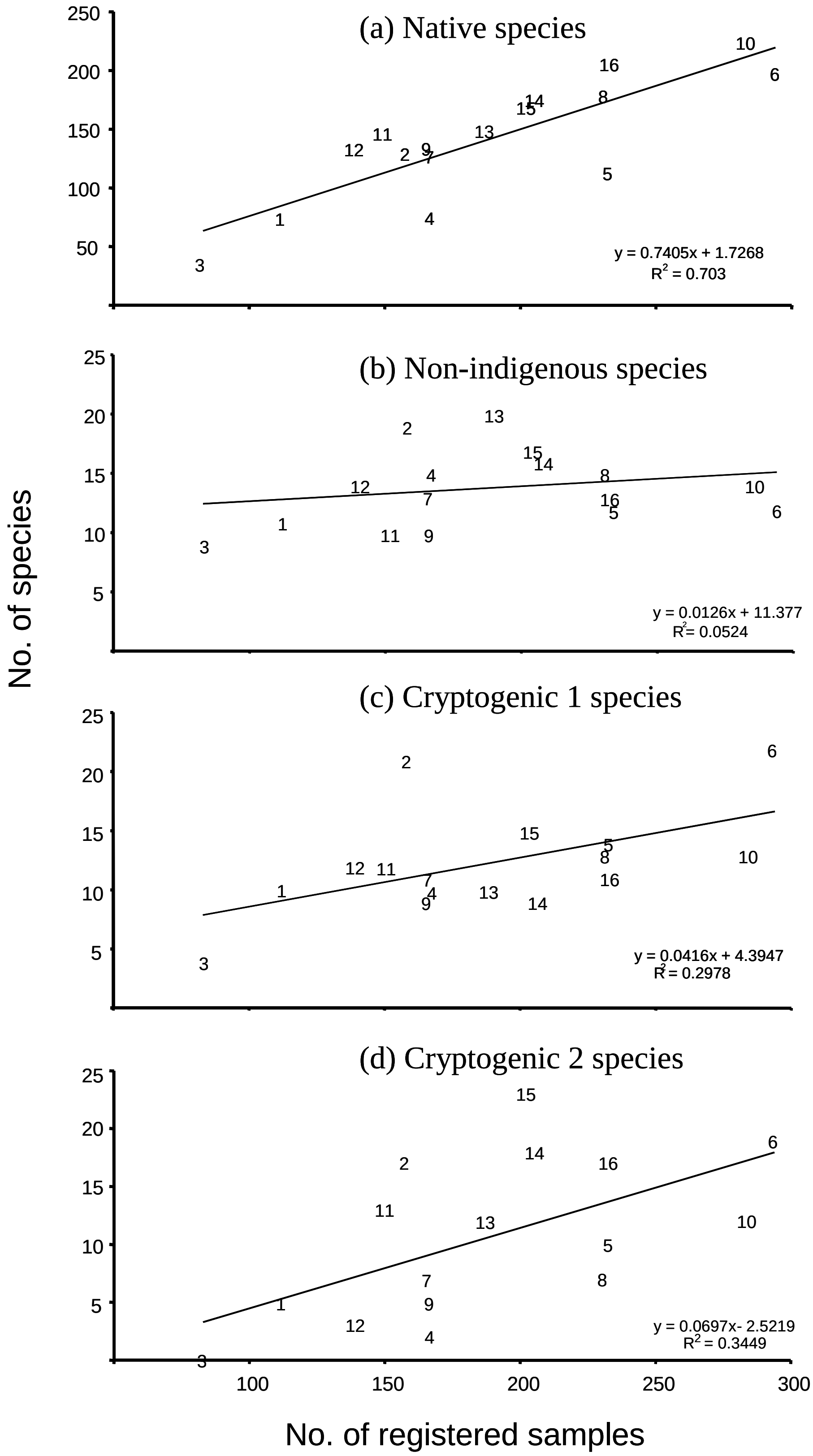

Figure 24. Linear regression equations relating numbers of species detected to sample effort at the 16 locations surveyed nation-wide. Location codes are as follows; 1 = Opua Marina, 2 = Whangarei Port, 3 = Whangarei Marina, 4 = Gulf Harbour Marina, 5 = Auckland Port, 6 = Tauranga Port, 7 = Gisborne Port, 8 = Taranaki Port, 9 = Napier Port, 10 = Wellington Port, 11 = Picton Port, 12 = Nelson Port, 13 = Lyttelton Port, 14 = Timaru Port, 15 = Dunedin Port, 16 = Bluff Port

Assessment of the risk of new introductions to the marina

Many NIS introduced to New Zealand ports, through hull fouling, ships' sea chests, or ballast water discharge, probably 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 north-west Pacific, and southern Australia (Cranfield *et al*. 1998).

Pleasure boating is a very popular activity in New Zealand, and there are more than 30 marinas that offer mooring facilities to sailing yachts and cabin cruisers of up to 50m in length. New Zealand is also a popular destination for international yachts. These yachts arrive throughout the year, but predominantly (94 % of all annual arrivals) between October and December. Whangarei receives between 40 and 80 international yacht arrivals annually and, after Auckland and Opua, is the third major arrival port for international yachts in New Zealand (New Zealand Customs Service, personal communication). The majority of international yachts entering New Zealand through Whangarei come from Tonga, Fiji, Australia and New Caledonia (NIWA, unpublished data 2002-2004). Whangarei Marina also receives a large number of international yachts that entered New Zealand through Opua Marina (80 km north of Whangarei). In total, the Whangarei Marina receives 250 – 300 international yachts every year. It provides mooring space for 280 boats and, on average, 90 % of these are occupied at all times (NIWA, unpubl. data).

Recreational yachts generally do not carry ballast water. Fouling of hull surfaces or internal structures (e.g. piping) is therefore the only likely vector for species introductions into the Whangarei Marina via recreational yachts. Hull fouling on recreational vessels is recognised as an important method of NIS transfer (Floerl 2002; Floerl *et al*. 2005) and it appears that at least one of the NIS recorded in Whangarei Marina – the tubeworm *Ficopomatus enigmaticus* – is the result of a direct introduction by an international yacht (Read and Gordon 1991).

Because of its location in the Hatea River, the Town Basin Marina experiences variable salinity, that can be < 5 $^{o}/_{oo}$ during periods of heavy rain. This may be a reason for the comparatively low diversity of marine organisms recorded in the marina during this survey. Notably, many of the NIS recorded in the marina (e.g. *B. neritina*, *F. enigmaticus*, *Polydora cornuta*, *Monocorophium acherusicum*, *Theora lubrica* and *Musculista senhousia* have broad salinity tolerance and are capable of surviving in very low salinities (see Section 3.3). Only three of these species (*B. neritina, F. enigmaticus*, and *T. lubrica*) were also recorded from the upper harbour wharves of the Port of Whangarei during this survey (although *M. senhousia* is also known to occur there) and only one (*B. neritina*) was present at the Marsden Point terminals in the lower harbour. Indeed, there was comparatively limited overlap of species at these three locations in Whangarei Harbour, presumably reflecting the different environmental conditions experienced at each. For example, of the 25 NIS recorded from Whangarei Harbour during the port baseline surveys, 6 occurred only in samples from the Town Basin Marina, 5 occurred only in samples from wharves in the upper harbour section of the port, and 7 occurred only in samples from wharves at Marsden Point. It appears, therefore, that different suites of NIS inhabit the three different nodes for international shipping in the harbour and that the differences in the assemblages correspond with broad scale changes in environmental conditions and habitat. Only species capable of withstanding periods of reduced salinity are likely to be able to establish within the Town Basin Marina. Nevertheless, some of the most notorious aquatic invaders, including the fouling mussels *Limnoperna fortunei* (Dunter) and *Mytilopsis leucophaeata* (Conrad, 1831), are capable of inhabiting brackish water environments (Ricciardi 1998, Therriault *et al.* 2004).

Assessment of translocation risk for introduced species found in the marina

Recreational vessels departing from the Whangarei Marina travel to a wide range of locations around both of New Zealands main islands. For example, 16 international yachts that had arrived in Whangarei from overseas in 2003 subsequently visited Opua, Tutukaka, the Pook Knight Islands, Auckland, Great Barrier Islands, Gisborne, Napier, New Plymouth, Wellington, Picton, Nelson and Dunedin. Domestic and international yachts that visit the Whangarei Marina directly or indirectly connect it to nearly 100 locations around New Zealand’s coastline (NIWA, unpubl. data). Movements of yachts between Whangarei and other locations have the potential to spread introduced fouling organisms.

Although several of the non-indigenous species found in the Whangarei Marina survey are already widely distributed in ports and marinas around New Zealand, others are not. The amphipods *Paracorophium brisbanensis* and *Melita matilda* were found only in Whangarei Marina and the latter was first described from New Zealand waters during these port surveys. *P. brisbanensis* was previously known only from Tauranga Harbour. Little is currently known about the ecology of either species and there is no information on the risks posed by these amphipods to New Zealand’s native ecosystems and species. Similarly, despite being present in Whangarei Marina for almost 40 years, the tubeworm *F. enigmaticus* has not yet spread widely within New Zealand. Based upon its known environmental tolerances and behaviour in other regions it has been introduced to overseas, Read and Gordon (1991) suggested it could spread to other estuaries with brackish environments throughout northern New Zealand.

Vessels departing from Whangarei Marina after having spent prolonged periods within the marina may pose a significant risk of spreading these species to locations within New Zealand that remain uninfested. The risk of translocation of these amphipods is highest for slow-moving vessels, such as yachts and barges that have long residence times in the marina, that are heavily fouled, and which are travelling to marinas or estuaries that are diluted by freshwater inflows. Vessels that are laid up for significant periods of time in the marina, or which have not had frequent anti-fouling pose increased risk for the spread of these or other fouling species.

Species in the Whangarei Marina that are transferred to the nearby Port of Whangarei, may also be transported to other locations in New Zealand or overseas by larger commercial vessels. The Port of Whangarei is connected directly to the ports of Auckland, Nelson and Tauranga by relatively infrequent coastal shipping, and is indirectly connected to most other domestic ports throughout mainland New Zealand (Dodgshun *et al*. 2004).

Management of existing non-indigenous species in the marina

For most marine NIS eradication by physical removal or chemical treatment is not yet a cost-effective option. Many of the species recorded in Whangarei Marina are widespread in New Zealand waters and local population controls are unlikely to be effective. Management should be directed toward preventing the spread of species from Whangarei Marina to locations where they do not presently occur. This is particularly relevant to harmful or potentially harmful species such as *F. enigmaticus*, the nesting bivalve, *Musculista senhousia*, and the toxic dinoflagellates, *Alexandrium* cf. *catenella* and *Gymnodinium catenatum*, which were detected in the Whangarei Marina during this survey. Cysts of the dinoflagellates may be transported in ballast water, in sediments moved through dredging and harbour works, or with the movement of macroalgae or shellfish as hull-fouling or as relocation of aquaculture stock. Effective management of these species will require better understanding of the frequency of movements by vessels and other vectors of spread from Whangarei Marina to other domestic and international locations. Improving procedures for maintenance and sanitation of vessels leaving this marina or the nearby Port of Whangarei may reduce the risk of translocation.

Prevention of new introductions

Interception of unwanted species transported by shipping is best achieved offshore, through control and treatment of vessels destined for Whangarei from high-risk locations elsewhere in New Zealand or overseas. Under the Biosecurity Act 1993, the New Zealand Government has developed an Import Health Standard for ballast water that requires large ships to exchange foreign coastal ballast water with oceanic water prior to entering New Zealand, unless exempted on safety grounds. This procedure ("ballast exchange") does not remove all risk, but does reduce the abundance and diversity of coastal species that may be discharged with ballast. Ballast exchange requirements do not currently apply to ballast water that is taken up 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 on vessel hulls and sea-chests. Biosecurity New Zealand has recently embarked on a national survey of hull fouling on vessels entering New Zealand from overseas. The study will characterise risks from this pathway (including high risk source regions and vessel types) and identify predictors of risk that may be used to manage problem vessels. Shipping companies and vessel owners can reduce the risk of transporting NIS in hull fouling or sea chests through regular maintenance and antifouling of their vessels.

Overseas studies 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). The growing number of baseline port surveys internationally and an associated increase in published literature on marine NIS means information is becoming available to allow more robust risk assessments to be carried out for new shipping routes. Such assessments could be conducted on the principal sources of international yachts entering marinas of first entry from overseas. 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 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 being introduced to New Zealand waters by shipping, especially considering the lack of management options for hull fouling introductions. There is a need for continued monitoring of marine NIS 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. Baseline inventories, like this one, facilitate the second and third of these two purposes. They become outdated when new introductions occur and, therefore, should be repeated on a regular basis to ensure they remain current. Hewitt and Martin (2001) recommend an interval of three to five years between repeat surveys.

The predominance of hull fouling as a likely introduction vector for NIS encountered in the Whangarei Marina (probably responsible for 90% of the NIS introductions) is consistent with previous findings from New Zealand (Cranfield *et al.* 1998), and a range of overseas locations. For instance, Hewitt *et al.* (1999) attributed the introduction of 77 % of the 99 NIS encountered in Port Phillip Bay (Australia) to hull fouling, and only 20 % to ballast water. Similarly, 61 % of the 348 marine and brackish water NIS established in the Hawaiian Islands are thought to have arrived on ships' hulls, but only 5 % in ballast water (Eldredge and Carlton 2002). However, ballast water is thought to be responsible for the introduction of 30 % of the 212 marine NIS established in San Francisco Bay (USA), compared to 34 % for hull fouling (Cohen and Carlton 1995). The high percentages of NIS thought to have been introduced by hull fouling in Australasia may reflect the fact that hull fouling has a far longer history (~200 years) as an introduction vector than ballast water (~40 years) (Hewitt *et al.* 1999). However, the fact that some of New Zealand and Australia's most recent marine NIS introductions (e.g. *Undaria pinnatifida*, *Codium fragile sp. tomentosoides*) have been facilitated by hull fouling suggests that it has remained an important transport mechanism (Cranfield *et al.* 1998; Hewitt *et al.* 1999).

Non-indigenous marine species can have a range of adverse impacts through interactions with native organisms. For instance, NIS can cause ecological impacts through competition, predator-prey interactions, hybridisation, parasitism or toxicity and can modify the physical environment through altering habitat structure (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 NIS 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). Further studies may be warranted to establish the abundance and potential impacts of the non-indigenous species encountered in this port to determine if management actions are necessary or possible.

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Tables

Table 1: Berthage facilities in the Whangarei Marina.

Berth Area	Approximate No. of Berths	Purpose	Construction	Maximum Length of Berth (m)	Depth (m below chart datum)
Town Basin	70	Pontoon berths (A & B) for launches and yachts	Wood/fibreglass/ concrete	20	2.0
Mooring piles and wharves	110	Pile moorings and wharves for launches and yachts	Wood (H6 Marine-grade pine)	20	2.0

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	20um 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 um 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 / encrusting biota	Quadrat scraping	0.10 m2 quadrats sampled at -0.5 m, -3.0 m and -7.0 m on 3 outer piles per berth	Quadrat scraping	0.10 m2 quadrats sampled at -0.5 m, -1.5 m, -3.0 m and -7 m on 2 inner and 2 outer piles per berth	Workshop recommended extra quadrat in high diversity algal zone (-1.5 m) and to sample inner pilings for shade tolerant species

	CRIMP Protocol		NIWA Method		
Taxa sampled	Survey method	Sample procedure	Survey method	Sample procedure	Notes
Sedentary / encrusting biota	Video / photo transect	Video transect of pile/rockwall facing. Still images taken of the three 0.10 m2 quadrats	Video / photo transect	Video transect of pile/rockwall facing. Still images taken of the four 0.10 m2 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 starfish traps	4 traps (2 lines x 2 traps) of left at each site (Whayman Holdworth starfish traps left overnight)	Few NZ ports have suitable intertidal areas to beach seine.

Table 3a: Summary of the Whangarei Marina sampling effort.

Sample method	Number of berths sampled	Number of replicate samples taken
Benthic Sled Tows	3	6
Benthic Grab (Shipek)	2	6
Box traps	2	8
Diver quadrat scraping	4	33
Opera house fish traps	2	8
Starfish traps	2	8
Shrimp traps	2	8
Javelin cores	N/A	6

Table 3b: Pile scraping sampling effort in the Whangarei Marina. Number of replicate quadrats scraped on Outer (unshaded) and Inner (shaded) pier piles at four depths. Pile materials scraped are indicated.

Sample Depth (M)	Outer Piles	Inner Piles
0.5	16 wood	0 (NB [1])
1.5	16 wood	0
3.5	1 wood	0
7	0 (NB [2])	0

(NB [1]) All piles unshaded in this marina due to construction layout.
(NB [2]) No 7m quadrats sampled due to shallow depths in the marina.

Table 3c: Summary of sampling effort in Ports and Marinas surveyed during the austral summers of 2001-2002 (shown in bold type), and 2002-2003 (shown in plain type). The number of shipping berths sampled is indicated, along with the total numbers of samples taken (in brackets).

Survey Location	Benthic sled tows	Benthic grab	Box traps	Diver quadrat scraping	Opera house traps	Starfish traps	Shrimp traps	Javelin cores
Port of Lyttelton	5 (10)	5 (15)	6 (20)	5 (77)	5 (20)	6 (20)	6 (19)	(8)
Port of Nelson	4 (8)	1 (2) *	4 (16)	4 (55)	4 (16)	4 (16)	4 (16)	(8)
Port of Picton	3 (6)	*	3 (18)	3 (53)	3 (16)	3 (24)	3 (24)	(6)
Port of Taranaki	6 (12)	6 (21)	7 (25)	4 (66)	6 (24)	6 (24)	6 (24)	(14)
Port of Tauranga	6 (18)	6 (28)	8 (32)	6 (107)	6 (25)	7 (28)	7 (28)	(8)
Port of Timaru	6 (12)	4 (14)	5 (20)	4 (58)	5 (20)	5 (20)	5 (20)	(8)
Port of Wellington	7 (13)	6 (18)	7 (28)	6 (98)	7 (34)	7 (28)	7 (28)	(6)
Port of Auckland	6 (12)	6 (18)	6 (24)	6 (101)	6 (24)	6 (24)	5 (20)	(10)
Port of Bluff	6 (21)	7 (21)	7 (29)	5 (75)	6 (24)	7 (28)	7 (24)	(12)
Dunedin Harbour	5 (10)	5 (15)	5 (20)	5 (75)	5 (20)	5 (20)	5 (18)	(9)
Port of Gisborne	5 (10)	6 (18)	5 (20)	4 (50)	5 (20)	5 (20)	5 (20)	(8)
Gulf Harbour Marina	N/A (17)	4 (12)	4 (16)	4 (66)	4 (16)	4 (16)	4 (16)	(8)
Port of Napier	5 (10)	5 (15)	5 (18)	4 (59)	5 (20)	5 (18)	5 (18)	(8)
Opua Marina	N/A (10)	4 (12)	4 (12)	4 (46)	4 (8)	4 (8)	4 (8)	(8)
Whangarei Marina	3 (6)	2 (6)	2 (8)	4 (33)	2 (8)	2 (8)	2 (8)	(6)
Whangarei Harbour	4 (9)	4 (12)	4 (16)	4 (65)	4 (16)	4 (16)	4 (16)	(7)

- Shipek grab malfunctioned in the Ports of Nelson and Picton

Table 4: Preservatives used for the major taxonomic groups of organisms collected during the port surveys. [1] indicates photographs were taken before preservation, and [2] indicates they were relaxed in magnesium chloride or menthol prior to preservation.

5 % Formalin solution	10 % Formalin solution	70 % Ethanol solution	Air dried
Phycophyta	Asteroidea	Alcyonacea [2]	Bryozoa
	Brachiopoda	Ascidiacea [1, 2]	
	Crustacea (large)	Crustacea (small)	
	Ctenophora [1]	Holothuria [1, 2]	
	Echinoidea	Mollusca (with shell)	
	Hydrozoa	Mollusca [1, 2] (without shell)	
	Nudibranchia [1]	Platyhelminthes [1]	
	Ophiuroidea	Porifera [1]	
	Polychaeta	Zoantharia [1, 2]	
	Scleractinia		
	Scyphozoa [1, 2]		
	Vertebrata [1] (pisces)		

Table 5a: 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	*Sabella spallanzanii*
Arthropoda	Decapoda	*Carcinus maenas*
Arthropoda	Decapoda	*Eriocheir sinensis*
Echinodermata	Asteroidea	*Asterias amurensis*
Mollusca	Bivalvia	*Potamocorbula amurensis*
Phycophyta	Chlorophyta	*Caulerpa taxifolia*
Phycophyta	Phaeophyceae	*Undaria pinnatifida*

Table 5b: Marine pest species listed on the Australian Ballast Water Management Advisory Council's (ABWMAC) schedule of non-indigenous pest species.

Phylum	Class/Order	Genus and Species
Annelida	Polychaeta	*Sabella spallanzanii*
Arthropoda	Decapoda	*Carcinus maenas*
Echinodermata	Asteroidea	*Asterias amurensis*
Mollusca	Bivalvia	*Corbula gibba*
Mollusca	Bivalvia	*Crassostrea gigas*
Mollusca	Bivalvia	*Musculista senhousia*
Phycophyta	Dinophyceae	*Alexandrium catenella*
Phycophyta	Dinophyceae	*Alexandrium minutum*
Phycophyta	Dinophyceae	*Alexandrium tamarense*
Phycophyta	Dinophyceae	*Gymnodinium catenatum*

Table 6: Native species recorded from the Whangarei Marina survey.

Phylum, Class	Order	Family	Genus and species
Annelida			
Polychaeta	Phyllodocida	Chrysopetalidae	*Chrysopetalum Chrysopetalum-1*
Polychaeta	Phyllodocida	Nereididae	*Nicon aestuariensis*
Polychaeta	Phyllodocida	Nereididae	*Perinereis vallata*
Polychaeta	Phyllodocida	Polynoidae	*Harmothoe macrolepidota*
Polychaeta	Phyllodocida	Polynoidae	*Lepidonotus polychromus*
Polychaeta	Scolecida	Capitellidae	*Capitella capitata*
Polychaeta	Scolecida	Capitellidae	*Heteromastus filiformis*
Polychaeta	Scolecida	Cossuridae	*Cossura consimilis*
Polychaeta	Spionida	Spionidae	*Boccardiella magniovata*
Crustacea			
Cirripedia	Thoracica	Balanidae	*Austrominius modestus*
Malacostraca	Amphipoda	Aoridae	*Haplocheira barbimana*
Malacostraca	Brachyura	Grapsidae	*Cyclograpsus lavauxi*
Malacostraca	Brachyura	Grapsidae	*Helice crassa*
Malacostraca	Brachyura	Grapsidae	*Hemigrapsus crenulatus*
Malacostraca	Brachyura	Hymenosomatidae	*Halicarcinus cookii*
Malacostraca	Brachyura	Hymenosomatidae	*Halicarcinus sp?*
Malacostraca	Brachyura	Ocypodidae	*Macrophthalmus hirtipes*
Malacostraca	Caridea	Crangonidae	*Pontophilus australis*
Malacostraca	Caridea	Palemonidae	*Palaemon affinis*
Malacostraca	Isopoda	Sphaeromatidae	*Exosphaeroma planulum*

Phylum, Class	Order	Family	Genus and species
Malacostraca	Isopoda	Sphaeromatidae	*Pseudosphaeroma campbellensis*
Malacostraca	Isopoda	Sphaeromatidae	*Sphaeroma quoianum*
Mollusca			
Bivalvia	Mytiloida	Mytilidae	*Xenostrobus securis*
Bivalvia	Nuculoida	Nuculidae	*Nucula hartvigiana*
Bivalvia	Veneroida	Veneridae	*Austrovenus stutchburyi*
Gastropoda	Neogastropoda	Buccinidae	*Cominella glandiformis*
Pyrrophycophyta			
Dinophyceae	Peridiniales	Peridiniaceae	*Protoperidinium sp.*
Dinophyceae	Peridiniales	Peridiniaceae	*Scrippsiella trochoidea*
Urochordata			
Ascidiacea	Stolidobranchia	Styelidae	*Molgula herdmani*
Vertebrata			
Actinopterygii	Anguilliformes	Anguillidae	*Anguilla australis*
Actinopterygii	Anguilliformes	Anguillidae	*Anguilla dieffenbachii*
Actinopterygii	Mugiliformes	Mugilidae	*Aldrichetta forsteri*
Actinopterygii	Perciformes	Gobiidae	*Favonigobius exquisitus*
Actinopterygii	Perciformes	Pinguipedidae	*Cheimarrichthys forsteri*
Actinopterygii	Pleuronectiformes	Pleuronectidae	*Rhombosolea leporina*

Table 7. Cryptogenic marine species recorded from the Whangarei Marina survey. Category 1 cryptogenic species (C1); Category 2 cryptogenic species (C2). Refer to section 2.9 for definitions.

Phylum, Class	Order	Family	Genus and species	
Crustacea				
Cirripedia	Thoracica	Balanidae	*Amphibalanus variagatus*	C1
Malacostraca	Brachyura	Xanthidae	*Pilumnopeus serratifrons*	C1
Pyrrophycophyta				
Dinophyceae	Gonyaulacales	Gonyaulaceae	*Alexandrium cf.catenella*	C1
Dinophyceae	Gymnodiniales	Gymnodiniacea	*Gymnodinium catenatum*	C1

Table 8: Non-indigenous marine species recorded from the Whangarei Marina survey. Likely vectors of introduction are largely derived from Cranfield *et al*. (1998), where H = Hull fouling and B = Ballast water transport. Novel NIS not listed in Cranfield *et al*. (1998) or previously encountered by taxonomic experts in New Zealand waters are marked as New Records (NR). For these species and others for which information is scarce, we provide dates of first detection rather than probable dates of introduction.

Phylum, Class	Order	Family	Genus and species	Probable means of introduction	Date of introduction or detection (d)
Annelida					
Polychaeta	Sabellida	Serpulidae	*Ficopomatus enigmaticus*	H or B	1967
Polychaeta	Spionida	Spionidae	*Polydora cornuta*	H or B	Pre-1972
Bryozoa					
Gymnolaemata	Cheilostomata	Bugulidae	*Bugula neritina*	H	1949
Gymnolaemata	Cheilostomata	Electridae	*Conopeum seurati*	H	Pre-1963
Crustacea					
Malacostraca	Amphipoda	Corophiidae	*Monocorophium acherusicum*	H	Pre-1921
Malacostraca	Amphipoda	Corophiidae	*Paracorophium brisbanensis*	H	Unknown [1]
Malacostraca	Amphipoda	Melitidae	*Melita matilda* **(NR)**	H	Nov. 2002 [d]
Mollusca					
Bivalvia	Mytiloida	Mytilidae	*Musculista senhousia*	H or B	1978
Bivalvia	Veneroida	Semelidae	*Theora lubrica*	B	1971

[1] Date of introduction currently unknown but species had been encountered in New Zealand prior to the present survey.

Table 9: Species indeterminata recorded from the Whangarei Marina survey. This group includes: (1) organisms that were damaged or juvenile and lacked crucial morphological characteristics, and (2) taxa for which there is not sufficient taxonomic or systematic information available to allow positive identification to species level.

Phylum, Class	Order	Family	Genus and species
Annelida			
Polychaeta	Phyllodocida	Nereididae	*Ceratonereis Ceratonereis-A*
Polychaeta	Phyllodocida	Nereididae	*Nereididae Indet*
Polychaeta	Sabellida	Sabellidae	*Oriopsis Indet*
Cnidaria			
Anthozoa	Actiniaria	Acontiophoridae	*Mimetridium sp.*
Crustacea			
Malacostraca	Isopoda	Janiridae	*Iais sp.*
Vertebrata			
Actinopterygii	Perciformes	Tripterygiidae	*Tripterygiidae sp.*
Actinopterygii	Perciformes	Trypterigiidae	*Grahamina sp.*
Actinopterygii	Pleuronectiformes	Pleuronectidae	*Rhombosolea sp.*

Table 10: Non-indigenous marine organisms recorded from the Whangarei Marina survey and the techniques used to capture each species. Species distributions are indicated throughout the port and in other locations surveyed in this project around New Zealand.

Non – indigenous species	Capture technique in Whangarei Marina	Locations detected in Whangarei Marina	Detected in other locations surveyed in ZBS2000_04
Ficopomatus enigmaticus	Pile scrape	Mooring Piles See Fig 14	Whangarei Harbour
Polydora cornuta	Pile scrape	Mooring Piles See Fig 15	Opua Marina
Bugula neritina	Benthic grab	Mooring Piles See Fig 16	Auckland, Dunedin, Gisborne, Gulf Harbour Marina, Lyttleton, Napier, Opua Marina, Taranaki, Tauranga, Timaru, Whangarei Harbour
Conopeum seurati	Pile scrape	Mooring Piles See Fig 17	Lyttleton, Nelson
Monocorophium acherusicum	Pile scrape	Mooring Piles See Fig 18	Dunedin, Gisborne, Lyttleton, Tauranga, Timaru
Paracorophium brisbanensis	Pile scrape	Mooring Piles See Fig 19	None
Melita matilda	Pile scrape	Mooring Piles See Fig 20	None
Musculista senhousia	Pile scrape, Benthic grab, Benthic sled	Yacht Berths; Mooring Piles See Fig 21	Opua Marina
Theora lubrica	Benthic grab, Benthic sled	Yacht Berths; Mooring Piles See Fig 22	Auckland, Gisborne, Gulf Harbour Marina, Lyttleton, Napier, Nelson, Opua Marina, Taranaki, Whangarei Harbour, Wellington

Appendices

Appendix 1: Specialists engaged to identify specimens obtained from the New Zealand Port surveys.

Phylum	Class	Specialist	Institution
Annelida	Polychaeta	Geoff Read, Jeff Forman	NIWA Greta Point
Bryozoa	Gymnolaemata	Dennis Gordon	NIWA Greta Point
Chelicerata	Pycnogonida	David Staples	Melbourne Museum, Victoria, Australia
Cnidaria	Anthozoa	Adorian Ardelean	West University of Timisoara, Timisoara, 1900, Romania
Cnidaria	Hydrozoa	Jan Watson	Hydrozoan Research Laboratory, Clifton Springs, Victoria, Australia
Crustacea	Amphipoda	Graham Fenwick	NIWA Christchurch
Crustacea	Cirripedia	Graham Fenwick, Isla Fitridge John Buckeridge[1]	NIWA Christchurch and [1]Auckland University of Technology
Crustacea	Decapoda	Colin McLay[1] Graham Fenwick, Nick Gust	[1]University of Canterbury and NIWA Christchurch
Crustacea	Isopoda	Niel Bruce	NIWA Greta Point
Crustacea	Mysidacea	Fukuoka Kouki	National Science Museum, Tokyo
Echinodermata	Asteroidea	Don McKnight	NIWA Greta Point
Echinodermata	Echinoidea	Don McKnight	NIWA Greta Point
Echinodermata	Holothuroidea	Niki Davey	NIWA Nelson
Echinodermata	Ophiuroidea	Don McKnight, Helen Rottman	NIWA Greta Point
Echiura	Echiuroidea	Geoff Read	NIWA Greta Point
Mollusca	Bivalvia. Cephalopoda, Gastropoda, Polyplacophora	Bruce Marshall	Museum of NZ Te Papa Tongarewa
Nemertea	Anopla, Enopla	Geoff Read	NIWA Greta Point
Phycophyta	Phaeophyceae, Rhodophyceae, Ulvophyceae	Wendy Nelson, Kate Neill	NIWA Greta Point
Platyhelminthes	Turbellaria	Sean Handley	NIWA Nelson
Porifera	Demospongiae, Calcarea	Michelle Kelly-Shanks	NIWA Auckland
Priapula	Priapulidae	Geoff Read	NIWA Greta Point
Pyrrophycophyta	Dinophyceae	Hoe Chang, Rob Stewart	NIWA Greta Point
Urochordata	Ascidiacea	Mike Page, Anna Bradley Patricia Kott[1]	NIWA Nelson and [1]Queensland Museum
Vertebrata	Osteichthyes	Clive Roberts, Andrew Stewart	Museum of NZ Te Papa Tongarewa

Appendix 2: 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. 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 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.

Phylum Chelicerata

Pycnogonids: The pycnogonids, or sea spiders, are a group within the Arthropoda, and 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 mm to many cm and superficially resemble spiders found on land.

Phylum Cnidaria

Hydroids: 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.

Phylum Crustacea

Crustaceans: The crustaceans represent one of the sea's most diverse groups of organisms, well known examples include shrimps, crabs and lobsters. 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.

Phylum Echinodermata

Echinoderms: This phylum contains a range of predominantly motile organisms – sea stars, brittle stars, sea urchins, sea cucumbers, sand dollars, feather stars and sea lilies. Echinoderms feed by filtering small food particles from the water column or by extracting food particles from sediment grains or rock surfaces.

Phylum Mollusca

Molluscs: The molluscs are a highly diverse group of marine animals characterised by the presence of an external or internal shell. This phyla includes the bivalves (organisms with hinged shells e.g. mussels, oysters, etc), gastropods (marine snails, e.g. winkles, limpets, topshells), chitons, sea slugs and sea hares, as well as the cephalopods (squid, cuttlefish and octopus).

Phylum Phycophyta

Algae: These are the marine plants. Several types were encountered during our survey. 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. These include the green algae (Ulvophyceae), red algae (Rhodophyceae) and brown algae (Phaecophyceae). We also encountered microscopic algal species called *dinoflagellates* (phylum Pyrrophycophyta), single-celled algae that live in the water column or within the sediments.

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 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 Pyrrophycophyta

Dinoflagellates: Dinoflagellates are a large group of unicellular algae common in marine plankton. 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 Urochordata

Ascidians: This group of organisms is sometimes referred to as 'sea squirts'. 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.

Phylum Vertebrata

Fishes: Fishes are an extremely diverse group of the verterbrates familiar to most people. Approximately 200 families of fish are represented in New Zealand waters ranging from tropical and subtropical groups in the north to subantarctic groups in the south. Fishes can be classified according to their depth preferences. Fish that live on or near the sea floor are considered demersal while those living in the upper water column are termed pelagics.

Appendix 3: List of Chapman and Carlton's (1994) nine criteria (C1 – C9) for assigning non-indigenous species status that were met by the non-indigenous species sampled in the Whangarei Marina.

Criteria that apply to each species are indicated by (+). Cranfield et al's (1998) analysis was used for species previously known from New Zealand waters. For non-indigenous species that were first detected during the present study, criteria were assigned using advice from the taxonomists that identified them. Refer to footnote for a full description of C1 – C9.

Phylum and species	C1	C2	C3	C4	C5	C6	C7	C8	C9
Annelida									
Ficopomatus enigmaticus	+	+	+		+	+	+	+	+
Polydora cornuta	+	+	+		+	+		+	
Bryozoa									
Bugula neritina	+				+	+	+	+	+
Conopeum seurati	+		+	+	+	+	+	+	+
Crustacea									
Monocorophium acherusicum			+		+	+		+	+
Paracorophium brisbanensis	+		+					+	
Melita matilda	+		+			+		+	+
Mollusca									
Musculista senhousia	+	+	+			+	+	+	+
Theora lubrica	+	+			+	+	+	+	+

Criterion 1: Has the species suddenly appeared locally where it has not been found before?
Criterion 2: Has the species spread subsequently?
Criterion 3: Is the species' distribution associated with human mechanisms of dispersal?
Criterion 4: Is the species associated with, or dependent on, other introduced species?
Criterion 5: Is the species prevalent in, or restricted to, new or artificial environments?
Criterion 6: Is the species' distribution restricted compared to natives?
Criterion 7: Does the species have a disjunct worldwide distribution?
Criterion 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?
Criterion 9: Is the species isolated from the genetically and morphologically most similar species elsewhere in the world?

Appendix 4. Geographic locations of the sample sites in Whangarei Marina

Site	Eastings	Northings	NZ Latitude	NZ Longitude	Survey Method	No. of sample units
TB1	2630531	6607757	-35.72499	174.32460	BGRB	3
TB1	2630531	6607757	-35.72499	174.32460	BSLD	2
TB1	2630509	6607797	-35.72463	174.32435	CRBTP	4
TB1	2630578	6607685	-35.72563	174.32513	CYST	2
TB1	2630526	6607766	-35.72491	174.32454	FSHTP	4
TB1	2630578	6607685	-35.72563	174.32513	PSC	8
TB1	2630509	6607797	-35.72463	174.32435	SHRTP	4
TB1	2630509	6607797	-35.72463	174.32435	STFTP	4
TB2	2630596	6607737	-35.72515	174.32532	BGRB	3
TB2	2630596	6607737	-35.72515	174.32532	PSC	8
TB3	2630696	6607702	-35.72546	174.32643	BSLD	2
TB3	2630879	6607536	-35.72693	174.32849	CRBTP	4
TB3	2630730	6607660	-35.72583	174.32682	CYST	2
TB3	2630762	6607596	-35.72640	174.32718	FSHTP	4
TB3	2630730	6607637	-35.72604	174.32682	PSC	8
TB3	2630879	6607536	-35.72693	174.32849	SHRTP	4
TB3	2630879	6607536	-35.72693	174.32849	STFTP	4
TB4	2631028	6607416	-35.72799	174.33015	BSLD	2
TB4	2630866	6607475	-35.72748	174.32835	CYST	2
TB4	2630866	6607499	-35.72727	174.32835	PSC	9

*Survey methods: PSC = pile scrape, BSLD = benthic sled, BGRB = benthic grab, CYST = dinoflagellate cyst core, CRBTP = crab trap, FSHTP = fish trap, STFTP = starfish trap, SHRTP = shrimp trap.

Appendix 5a. Results from the diver collections and pile scrapings

					Site code	TB1								TB2								TB3								TB4								
					Pile replicate	1		2		3		4		1		2		3		4		1		2		3		4		1		2		3			4	
Class	Orders	Family	Genus	Species	*Status	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	3	1	2
Actinopterygii	Anguilliformes	Anguillidae	*Anguilla*	*australis*	N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Anthozoa	Actiniaria	Acontiophoridae	*Mimetridium*	*sp.*	SI	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ascidiacea	Stolidobranchia	Styelidae	*Molgula*	*herdmani*	N	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
Bivalvia	Mytiloida	Mytilidae	*Xenostrobus*	*securis*	N	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	1	1	0	1	0	1	1	0	0	1	0	0	1	0	0
Bivalvia	Mytiloida	Mytilidae	*Musculista*	*senhousia*	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Crustacea	Brachyura	Grapsidae	*Hemigrapsus*	*crenulatus*	N	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Brachyura	Grapsidae	*Cyclograpsus*	*lavauxi*	N	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Brachyura	Grapsidae	*Helice*	*crassa*	N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Crustacea	Brachyura	Hymenosomatidae	*Halicarcinus*	*cookii*	N	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Brachyura	Xanthidae	*Pilumnopeus*	*serratifrons*	C1	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Crustacea	Caridea	Palemonidae	*Palaemon*	*affinis*	N	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Thoracica	Balanidae	*Austrominius*	*modestus*	N	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Crustacea	Thoracica	Balanidae	*Amphibalanus*	*variagatus*	C1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Neogastropoda	Buccinidae	*Cominella*	*glandiformis*	N	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gymnolaemata	Cheilostomata	Electridae	*Conopeum*	*seurati*	A	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1
Malacostraca	Amphipoda	Aoridae	*Haplocheira*	*barbimana*	N	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Malacostraca	Amphipoda	Corophiidae	*Monocorophium*	*acherusicum*	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	1	0	0	0	1	1
Malacostraca	Amphipoda	Corophiidae	*Paracorophium*	*brisbanensis*	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malacostraca	Amphipoda	Melitidae	*Melita*	*matilda*	A	1	1	0	0	0	1	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	1
Malacostraca	Isopoda	Janiridae	*Iais*	*sp.*	SI	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malacostraca	Isopoda	Sphaeromatidae	*Sphaeroma*	*quoianum*	N	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	1	0	1	0	1	0	1	1	1	1	1	0	0
Malacostraca	Isopoda	Sphaeromatidae	*Exosphaeroma*	*planulum*	N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Malacostraca	Isopoda	Sphaeromatidae	*Pseudosphaeroma*	*campbellensis*	N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Polychaeta	Phyllodocida	Chrysopetalidae	*Chrysopetalum*	*Chrysopetalum-1*	N	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polychaeta	Phyllodocida	Nereididae	*Ceratonereis*	*Ceratonereis-A*	SI	1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	0	0	1	0	1	0	0	0	1	0	0	0	0	1	0	1
Polychaeta	Phyllodocida	Nereididae	*Nereididae*	*Indet*	SI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Polychaeta	Phyllodocida	Nereididae	*Perinereis*	*vallata*	N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Polychaeta	Phyllodocida	Polynoidae	*Harmothoe*	*macrolepidota*	N	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polychaeta	Phyllodocida	Polynoidae	*Lepidonotus*	*polychromus*	N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Polychaeta	Sabellida	Serpulidae	*Ficopomatus*	*enigmaticus*	A	1	1	0	1	0	1	0	1	1	1	0	1	1	1	1	1	0	0	1	1	0	1	0	1	0	1	0	0	0	0	1	0	1
Polychaeta	Scolecida	Capitellidae	*Capitella*	*capitata*	N	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Polychaeta	Spionida	Spionidae	*Polydora*	*cornuta*	A	1	0	0	1	0	1	0	1	0	1	0	1	1	1	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1	0	1
Polychaeta	Spionida	Spionidae	*Boccardiella*	*magniovata*	N	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

*Status: A = non-indigenous (highlighted by shading), C1 = cryptogenic category 1, C2 = cryptogenic category 2, N = native, SI = species indeterminata. See text for details.

Appendix 5b. Results from the benthic grab samples.

					Site code	TB1			TB2		
Class	Order	Family	Genus	Species	*Status	1	2	3	1	2	3
Bivalvia	Mytiloida	Mytilidae	*Musculista*	*senhousia*	A	0	1	0	0	0	0
Bivalvia	Nuculoida	Nuculidae	*Nucula*	*hartvigiana*	N	0	0	0	0	0	1
Bivalvia	Veneroida	Semelidae	*Theora*	*lubrica*	A	0	1	1	0	0	1
Gastropoda	Neogastropoda	Buccinidae	*Cominella*	*glandiformis*	N	0	0	0	0	1	0
Gymnolaemata	Cheilostomata	Bugulidae	*Bugula*	*neritina*	A	0	0	0	1	0	0
Polychaeta	Phyllodocida	Nereididae	*Nicon*	*aestuariensis*	N	0	0	1	1	0	1
Polychaeta	Phyllodocida	Nereididae	*Perinereis*	*vallata*	N	0	1	0	0	0	0
Polychaeta	Scolecida	Capitellidae	*Heteromastus*	*filiformis*	N	0	0	0	0	1	0
Polychaeta	Scolecida	Cossuridae	*Cossura*	*consimilis*	N	1	0	0	0	0	0

*Status: A = non-indigenous (highlighted by shading), N = native, C1 = cryptogenic category 1, C2 = cryptogenic category 2, SI = species indeterminata. See text for details.

Appendix 5c. Results from the benthic sled samples.

					Site code	TB1		TB3		TB4	
Class	Order	Family	Genus	Species	*Status	1	2	1	2	1	2
Actinopterygii	Anguilliformes	Anguillidae	*Anguilla*	*australis*	N	1	0	0	0	0	0
Actinopterygii	Perciformes	Gobiidae	*Favonigobius*	*exquisitus*	N	1	1	0	0	0	0
Actinopterygii	Perciformes	Pinguipedidae	*Cheimarrichthys*	*forsteri*	N	0	1	0	0	0	0
Actinopterygii	Perciformes	Tripterygiidae	*Tripterygiidae*	*sp.*	SI	0	1	0	0	0	0
Actinopterygii	Perciformes	Trypterigiidae	*Grahamina*	*sp.*	N	0	0	1	0	0	0
Actinopterygii	Pleuronectiformes	Pleuronectidae	*Rhombosolea*	*leporina*	N	1	1	0	0	0	0
Actinopterygii	Pleuronectiformes	Pleuronectidae	*Rhombosolea*	*sp.*	SI	0	0	0	0	1	0
Bivalvia	Mytiloida	Mytilidae	*Musculista*	*senhousia*	A	1	1	1	1	0	1
Bivalvia	Nuculoida	Nuculidae	*Nucula*	*hartvigiana*	N	0	0	1	1	1	1
Bivalvia	Veneroida	Semelidae	*Theora*	*lubrica*	A	0	1	0	1	0	0
Bivalvia	Veneroida	Veneridae	*Austrovenus*	*stutchburyi*	N	0	0	1	1	0	0
Crustacea	Brachyura	Hymenosomatidae	*Halicarcinus*	*sp?*	N	1	1	0	0	0	1
Crustacea	Brachyura	Ocypodidae	*Macrophthalmus*	*hirtipes*	N	0	0	1	0	0	1
Crustacea	Brachyura	Xanthidae	*Pilumnopeus*	*serratifrons*	C1	0	0	1	0	0	0
Crustacea	Caridea	Crangonidae	*Pontophilus*	*australis*	N	1	1	0	0	0	0
Crustacea	Thoracica	Balanidae	*Amphibalanus*	*variagatus*	C1	0	0	0	0	1	0
Gastropoda	Neogastropoda	Buccinidae	*Cominella*	*glandiformis*	N	1	1	1	1	0	0
Polychaeta	Phyllodocida	Nereididae	*Perinereis*	*vallata*	N	1	1	1	0	0	0
Polychaeta	Sabellida	Sabellidae	*Oriopsis*	*Indet*	SI	0	0	1	0	0	0

*Status: A = non-indigenous (highlighted by shading), N = native, C! = cryptogenic category 1, C2 = cryptogenic category 2, SI = species indeterminata. See text for details.

Appendix 5d. Results from the dinoflagellate cyst core samples.

					Berth code	TB1		TB3		TB4	
Class	Order	Family	Genus	Species	*Status	1	2	1	2	1	2
Dinophyceae	Gonyaulacales	Gonyaulaceae	*Alexandrium*	*cf.catenella*	C1	0	0	1	0	0	0
Dinophyceae	Gymnodiniales	Gymnodiniacea	*Gymnodinium*	*catenatum*	C1	0	1	1	1	0	0
Dinophyceae	Peridiniales	Peridiniaceae	*Scrippsiella*	*trochoidea*	N	1	0	1	0	0	1
Dinophyceae	Peridiniales	Peridiniaceae	*Protoperidinium*	*sp.*	N	0	1	0	1	0	0

*Status: A = non-indigenous (highlighted by shading), N = native, C1 = cryptogenic category 1, C2 = cryptogenic category 2, SI = species indeterminata. See text for details.

Appendix 5e. Results from the fish trap samples.

					Berth code	TB1				TB3			
					Line No.	1		2		1		2	
Class	Order	Family	Genus	Species	*Status	1	2	1	2	1	2	1	2
Actinopterygii	Anguilliformes	Anguillidae	*Anguilla*	*australis*	N	0	0	1	0	1	1	1	0
Actinopterygii	Mugiliformes	Mugilidae	*Aldrichetta*	*forsteri*	N	1	1	1	1	1	0	1	1
Crustacea	Caridea	Palemonidae	*Palaemon*	*affinis*	N	0	1	0	0	0	0	0	0
Gastropoda	Neogastropoda	Buccinidae	*Cominella*	*glandiformis*	N	1	1	1	0	1	1	1	0

*Status: A = non-indigenous (highlighted by shading), N = native, C1 = cryptogenic category 1, C2 = cryptogenic category 2, SI = species indeterminata. See text for details.

Appendix 5f. Results from the crab trap samples.

					Site code	TB1				TB3			
					Line no.	1		2		1		2	
Class	Order	Family	Genus	Species	*Status	1	2	1	2	1	2	1	2
Actinopterygii	Anguilliformes	Anguillidae	*Anguilla*	*australis*	N	0	0	0	1	0	0	0	0
Actinopterygii	Anguilliformes	Anguillidae	*Anguilla*	*dieffenbachii*	N	0	0	0	1	0	0	0	0
Gastropoda	Neogastropoda	Buccinidae	*Cominella*	*glandiformis*	N	0	0	1	0	0	0	1	1

*Status: A = non-indigenous (highlighted by shading), N = native, C1 = cryptogenic category 1, C2 = cryptogenic category 2, SI = species indeterminata. See text for details.

Appendix 5g. Results from the starfish trap samples.

					Berth code	TB1				TB3			
					Line No.	1		2		1		2	
Class	Order	Family	Genus	Species	*Status	1	2	1	2	1	2	1	2
Gastropoda	Neogastropoda	Buccinidae	*Cominella*	*glandiformis*	N	1	1	1	0	0	0	1	1

*Status: A = non-indigenous (highlighted by shading), N = native, C1 = cryptogenic category 1, C2 = cryptogenic category 2, SI = species indeterminata. See text for details.

Appendix 5h. Results from the shrimp trap samples.

					Site code	TB1				TB3			
					Line No.	1		2		1		2	
Class	Order	Family	Genus	Species	*Status	1	2	1	2	1	2	1	2
Actinopterygii	Perciformes	Trypterigiidae	*Grahamina*	*sp.*	N	0	0	0	0	0	1	0	0

*Status: A = non-indigenous (highlighted by shading), N = native, C1 = cryptogenic category 1, C2 = cryptogenic category 2, SI = species indeterminata. See text for details.

Addendum

After completing these reports we were advised of changes in the identification of one species. The ascidian *Cnemidocarpa sp*. refered to in this report as a new introduction to New Zealand has been revised to *Cnemidocarpa nisiotus* (status: native).