Review of existing information on marine biosecurity in the top of the South Island

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Introduction

In March 2008 the National Institute of Water and Atmospheric Research Ltd (NIWA) was subcontracted to The Lawless Edge Ltd (under contract to MAF Biosecurity New Zealand) to provide a review of existing information on marine biosecurity issues in the top of the South Island. This information is provided here as a stand-alone report.

The report begins with a brief description of locations of particular relevance to marine biosecurity in the study area, and species that pose a high risk to core values in the area. This is followed by a summary of past and ongoing biosecurity studies in the region. Information on non-indigenous species known to be present in the region, as a result of the studies described in the previous section, is then summarised. The results of baseline biological surveys of the ports and marinas at Nelson and Picton are described in the next section. Following these descriptions of non-indigenous species present in the region, possible vectors for their introduction and translocation are discussed, with particular emphasis on the ports of Nelson and Picton, for which detailed analyses are available. The final section discusses the management of non-indigenous species in the region, including eradication and prevention of new introductions.

The study area

This review covers the Tasman, Nelson and Marlborough Regions, including Golden and Tasman Bays, the Marlborough Sounds, and the ports of Nelson, Havelock and Picton and their marinas. From a biosecurity point of view a number of locations can be identified as high-value areas (areas that may form a focus for management of marine non-indigenous species or for control of transport vectors of those species). Others are high-risk areas where there is a relatively high likelihood that non-indigenous species may arrive and that may then act as sources of secondary spread within the region.

HIGH-VALUE AREAS

High value areas (HVAs; Forrest et al. 2006, Dodgshun et al. 2007) can be defined on conservation or ecological, commercial or cultural criteria, or a mixture of all three (five outcomes are defined in The Biosecurity Strategy for New Zealand [Biodiversity Council 2003]: environmental, commercial, Māori cultural and spiritual values, human health, and social). Obvious areas of conservation or ecological value in the region include the Westhaven (Te Tai Tapu) Marine Reserve and Westhaven (Whanganui Inlet) Wildlife Management Reserve in Whanganui Inlet, Tonga Island Marine Reserve, Horoirangi Marine Reserve, Long Island – Kokomohua Marine Reserve, the Wakapuaka Taipure and Tory Channel Maitaitai, the Ramsar site on Farewell Spit, and other features such as the Separation Point bryozoan beds (Dodgshun et al. 2007). Areas of commercial value include fishing grounds in Golden and Tasman Bays and the Marlborough Sounds, the marine farming areas in Golden and Tasman Bays, the Marlborough Sounds and Port Underwood, areas of recreational and tourism importance, and shipping channels and facilities.

Definition of HVAs can serve as a focus for characterising human-mediated pathways for the spread of non-indigenous species, helping to make definition of such pathways more manageable at a regional or larger scale (Dodgshun et al. 2007). It also allows priorities to be identified for the allocation of resources in identifying and managing pathways. In this respect, identification of HVAs is complementary to programmes for the management of incursions of introduced species.

At present, however, there is no formal list of HVAs based on conservation/ecological or other criteria for New Zealand (Dodgshun et al. 2007) nor is there any agreement on what areas should be included (informal lists have been developed for some regions in relation, for example, to the development of regional coastal plans: e.g. Morrisey 1994). Dodgshun et al. (2007) provided a preliminary list of "example" HVAs throughout the New Zealand coastal marine area, including the marine reserves in the top of the South Island. Development of a full list of HVAs relevant to the definition of transport pathways for present purposes is beyond the scope of this study.

HIGH-RISK AREAS

High-risk areas for the introduction and spread on non-indigenous species include high-volume commercial ports and marinas that are first-entry points for international vessels, and domestic shipping hubs. In the top of the South Island these include the ports of Tarakohe, Motueka, Nelson, Havelock and Picton, the marinas at Tarakohe, Motueka, Nelson, Havelock, Picton and Waikawa, and the mussel-farming facility at Elaine Bay. The high-density aquaculture areas in the Marlborough Sounds, Golden and Tasman Bays and the salmon farm in Tory Channel might also act as points of introduction and translocation through movement of stock or equipment (as occurred with the spread of *Didemnum vexillum* on an infected salmon cage: see below). In 2005 a proposal was put forward for a coal-transfer facility in Golden Bay. This would consist of a moored structure carrying equipment for transferring coal brought up by barge from the west coast of the South Island on to international bulk carriers. A preliminary assessment of potential environmental effects from this operation identified the risk from introduced marine species carried in ballast water or as hull fouling to marine farms in Golden Bay and to local natural habitats. At the time of writing the proposal appears to be on hold (Paul Barter, Cawthron Institute, pers. comm.).

High-risk areas within ports and marinas include berths, slipways and areas where hull cleaning occurs. Organisms attached to the hull may be dislodged during berthing or slipping, or may discharge larvae while the vessel is berthed (perhaps in response to changes in light regime, salinity or temperature) or thrown overboard. Areas where hull cleaning occurs pose an obvious risk of release of non-indigenous organisms but may be managed to minimise release of material (both biological material and dislodged antifouling paint) to the environment. For example, boats taken out of the water on the travel-hoist at Dickson Marine Ltd in Nelson Marina are cleaned over an area draining to a holding tank.

HIGH-RISK SPECIES

Non-indigenous marine species can have a range of adverse impacts through interactions with native organisms. These include competition with native species, predator-prey interactions, hybridisation, parasitism or toxicity and modification of the physical environment (Ruiz et al. 1999; Ricciardi 2001). Assessing the impact of a NIS in a given location ideally requires information on a range of factors, including the mechanism of their impact and their local abundance and distribution (Parker et al. 1999). To predict or quantify their impacts over larger areas or longer time scales requires additional information on the species' seasonality, population size and mechanisms of dispersal (Mack et al. 2000).

A number of non-indigenous species with known adverse ecological and/or economic effects already occur in the coastal marine area of the top of the South Island. These include the saltmarsh cordgrass *Spartina anglica* (Partridge 1987), the Pacific oyster *Crassostrea gigas* (both of which were deliberately introduced), the kelp *Undaria pinnatifida*, and the ascidians

Didemnum vexillum and *Styela clava* (Inglis et al. 2006a,b). At present the adverse effects of *S. clava* on marine farms are inferred from their effects in Canada[1].

The Ministry of Fisheries identified 6 additional species not yet present in New Zealand but considered to be of relatively high risk of introduction and adverse effects on New Zealand core values (Wotton & Hewitt 2004) responsibility for their management was transferred to the Ministry of Agriculture and Forestry Biosecurity New Zealand (MAF BNZ) in 2004). These species (the seastar *Asterias amurensis*, the macroalga *Caulerpa taxifolia*, the crabs *Carcinus maenas* and *Eriocheir sinensis*, the bivalve *Potamocorbula amurensis* and the polychaete worm *Sabella spallanzanii*[2]) were declared "Notifiable Organisms" under the Biosecurity Act Notifiable Organisms Order 2002 and, together with *Undaria* and *Styela*, were declared "Unwanted Organisms" under the Biosecurity Act 1993 in 2000 (Wotton & Hewitt 2004). Each of the unwanted species has a prior history of invasion outside New Zealand, is known to have significant impacts on native ecosystems or economic values in the regions it has invaded, and is capable of surviving in New Zealand coastal waters (Wotton & Hewitt 2004). Further details of their biology and invasive history are given in Inglis et al. 2005a[3].

DISEASE RISKS ASSOCIATED WITH INTRODUCED SPECIES

Some of the most damaging diseases of humans and terrestrial livestock have resulted from a pathogen jumping from one host, in which it often causes little damage, to a new host in which it is much more virulent (Day & Prince 2007). Epidemic diseases of marine organisms may spread faster than their terrestrial equivalents, perhaps because of the lack of barriers and the ability of pathogens to survive in water between hosts. These two factors suggest that non-indigenous marine species could have the potential to act as reservoirs of disease for native species in their new habitat and that, one such a disease has been introduced, its spread and effect could be rapid and severe. This risk may be particularly severe when the disease affects aquacultured stock, where high population densities may adversely affect their immunological condition, making them more prone to the disease and transmission from host to host is easier. Such cases are well-known in terrestrial agriculture (Day & Prince 2007).

There have also been several instances of diseases or parasites infecting wild stocks as a result of aquaculture, including diseases of salmon, tuna, trout oysters, abalone and shrimp (Day & Prince 2007). Transfers may occur through importation of exotic stock or of unintentionally-introduced species associated with stock or equipment. Introduced species could also serve as reservoirs of disease or parasites for humans. In Asia, the Chinese mitten crab acts as a secondary host of the oriental lung fluke (*Paragonimus westermanii*), which can infect humans if the crab is eaten uncooked (Clarke et al. 1998). The fluke is, however, specific to a gastropod primary host so its introduction outside its natural range through introductions of the crab is uncertain.

The New Zealand Ministry of Agriculture and Forestry (2003) lists notifiable diseases of commercially-important marine finfish, crustacean and molluscs, some of which are already present in New Zealand (e.g. bonamiosis of flat oysters around the South Island and Wellington Harbour), but most of which have not yet been recorded here. The document also lists several non-notifiable diseases of commercially-important marine species that are also considered significant, only one of which is already present. Although import of aquaculture stock and other live marine organisms is controlled, there is potential for the introduction of

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[1] See http://www.biosecurity.govt.nz/files/pests/seasquirt/styela-clava-oia.pdf
[2] A single, mature specimen of *Sabella spallanzanii* was collected in Lyttelton Harbour during target species surveillance by NIWA (see below) in March 2008 (see http://www.biosecurity.govt.nz/media/28-05-08/mediterranean-fanworm)
[3] And see http://www.biosecurity.govt.nz/pest-and-disease-response/surveillance-risk-response-and-management/marine

these diseases through fouling organisms on ships' hulls and other vectors of introduction of non-indigenous species (see the section below on *Pathways for the introduction and translocation of non-indigenous species*).

There are several known or suspected cases of the introduction of diseases or parasites, and subsequent infection of native species or populations, associated with the introduction of marine animals and plants (often in association with imported aquaculture stock) (Torchin et al. 2002). The local potential for this to occur, and the commercial impacts it can have, are illustrated by the recent outbreak and spread of abalone viral ganglioneuritis (AVG) in southern Australia. This disease, which affects the nervous system of abalone and causes high mortality, was first recorded in western Victoria in 2005, initially in farmed stock and later in wild stocks near an infected farm (Handlinger 2007). The history and source of the outbreak are unclear but its introduction to Victoria has been ascribed to import of infected abalone from South Australia as brood stock or to imported feed from Taiwan, where an outbreak of a similar herpes-like virus occurred in abalone in 2003. Subsequent DNA profiling of the Australian strain has suggested, however, that it is not the same as the Taiwanese strain (Victoria Department of Primary Industries 2007). It has spread rapidly among wild stocks of abalone along the Victorian coast, suggesting exposure of a naïve population to a new pathogen. The absence of previous outbreaks in Australia is consistent with the pathogen having been introduced (Thyer 2007). The outbreak has caused large financial losses for the Victorian abalone fishery, which is of much higher value than the relatively small abalone aquaculture industry (Prince 2007).

Reviews of the outbreak (Handlinger 2007, Prince 2007) have highlighted the risk associated with internation and domestic translocation of stock (including movements associated with a programme to develop abalone blood stock sponsored by the Federal Government's Fisheries Research and Development Corporation: Prince 2007), particularly when diseases may jump from one species to another. The effects are compounded when infected aquacultured stock come into contact with wild animals, including those living as uninvited guests in aquaculture facilities and non-indigenous species. In her review of the outbreak, Handlinger (2007) identified a number of lessons to be learned such as the need for improved biosecurity awareness within the aquaculture industry, the wild fishery and their regulators, the need for disease surveillance and translocation policies to minimise risks associated with movement of wild or cultured organisms, mechanisms for sharing of knowledge on diseases, and ongoing education.

PREVIOUS AND ONGOING BIOSECURITY STUDIES RELEVANT TO THE PRESENT REVIEW

Port baseline surveys

In 2000 the Ministry of Fisheries commissioned NIWA to undertake a series of baseline biological surveys of high-volume commercial ports and marinas that are first-entry points for international vessels throughout New Zealand and considered to be high-risk locations for the introduction and spread on non-indigenous species. These included the port of Nelson and Nelson Marina (surveyed in January 2002: Inglis et al. 2005b), and Picton, Picton Marina and Waikawa Marina (surveyed in December 2001: Inglis et al. 2005c). The purpose of these surveys was to determine the identity, prevalence and distribution of native, non-indigenous and cryptogenic (species whose status is unclear because their native distribution is unknown or because their taxonomic identity is poorly understood) species in each location to allow any future incursions of non-indigenous species to be identified. Sampling included a range of habitats, notably wharf piles and other artificial hard structures, and soft sediments in and around ports and marinas, and used a combination of trapping (for crabs and starfish), benthic grabs (for animals living in and on soft substrata), sediment cores for dinoflagellate cysts, and diver-searches. The baseline surveys were repeated three years later (now under the auspices of MAF BNZ) at Nelson (sampled in December 2004: Inglis et al. 2006a), Picton (sampled in January 2005: Inglis et al. 2006b) and their associated marinas, and in 2007 the port and marinas at Tarakohe and Port Underwood were added to the list of locations surveyed. The results for Nelson and Picton are discussed below (both surveys) but at the time of writing the samples from Tarakohe and Port Underwood were still being analysed (Graeme Inglis, NIWA and Barrie Forrest, Cawthron Institute, pers. comm.).

Target species surveillance

In 2001 the Ministry of Fisheries also commissioned NIWA to conduct a programme of six-monthly target-species surveillance for the eight Unwanted Species listed above (*Styela clava* was added to the list of target species in October 2005, following its discovery in the Waitemata Harbour), at those ports considered the highest-risk locations for the introduction of these species. Each port was surveyed four times (twice in summer and twice in winter) between October 2002 and September 2004 (Inglis et al. 2005a). The surveys involved crab and starfish trapping, dredging, diver searches and shoreline searches. After a break of 12 months, an additional round of surveys was done in summer 2005-2006 (also by NIWA: Morrisey et al. 2007). Again, the list of ports included Nelson (sampled in December 2005), and Picton and Havelock were added to the list of ports surveyed (both sampled in December 2005). In addition to the target species, these surveys also opportunistically recorded any other non-indigenous species encountered. MAF BNZ has recently (February 2008) commissioned NIWA to reinstate the target species surveillance programme from summer 2007-2008 through to summer 2010-2011, again including Nelson (sampled in February 2008 in the first round of surveys) and Picton (to be sampled in May 2008).

Delimitation surveys for *Styela clava*

Following the discovery of individuals of *Styela clava* on a boat taken out of the water for hull cleaning in Waikawa Marina, the marina was surveyed (visual searches by divers and observers on the shore or in boats) in October 2005 to determine the abundance and distribution of this species (Morrisey 2005). Subsequent surveys to determine whether *Styela* was present were done in November 2005 in Nelson, Picton (including the port, marina, Shakespeare Bay and Waikawa Marina), Havelock and Tarakohe as part of a nation-wide delimitation study (Gust et al. 2006). In July 2006 a single specimen was found on the hull of a fishing vessel slipped in the Slipway Basin in Nelson Harbour and the Basin was resurveyed (Morrisey et al. 2006). Two more specimens were found on a boat moored for 8-9 months near to where the original vessel had been berthed. The results of the surveys of Waikawa Marina and the Slipway Basin in Nelson are discussed below. No individuals were found in Picton, Havelock or Tarakohe (Gust et al. 2006).

Surveys of vessel movements

MAF BNZ have currently engaged NIWA to conduct a study to evaluate vessel movements to and from the 16 ports and marinas surveyed through the port baseline biological surveys described above. Sources of information include the Lloyds Marine Intelligence Unit database ("SeaSearcher.com"), the results of which are described below for Nelson and Picton, and a questionnaire survey of fishing vessel skippers (summarised below).

Marine biosecurity risk assessment model for the Golden-Tasman Bay region

The Cawthron Institute has funded a PhD student to develop a risk-assessment model that integrates potential natural and human-mediated pathways for the introduction of non-indigenous species to the region (Acosta et al. 2006a). The project has included mapping of dispersion of larvae and other propagules from a range of locations around Golden and

Tasman Bays using a hydrodynamic model, and characterisation of recreational boating pathways (see Figure 1), from which the region has been divided into subregions. Each subregion was then categorised by a “risk priority number”, calculated as the product of: probability of infection; connectivity with other subregions; and probability of detection of an incursion. One of the uses of this ranking is to allow research and surveillance to be focussed on the subregions with highest risk. A manuscript describing this study is currently being prepared for publication (Hernando Acosta, Cawthron Institute, pers. comm.).

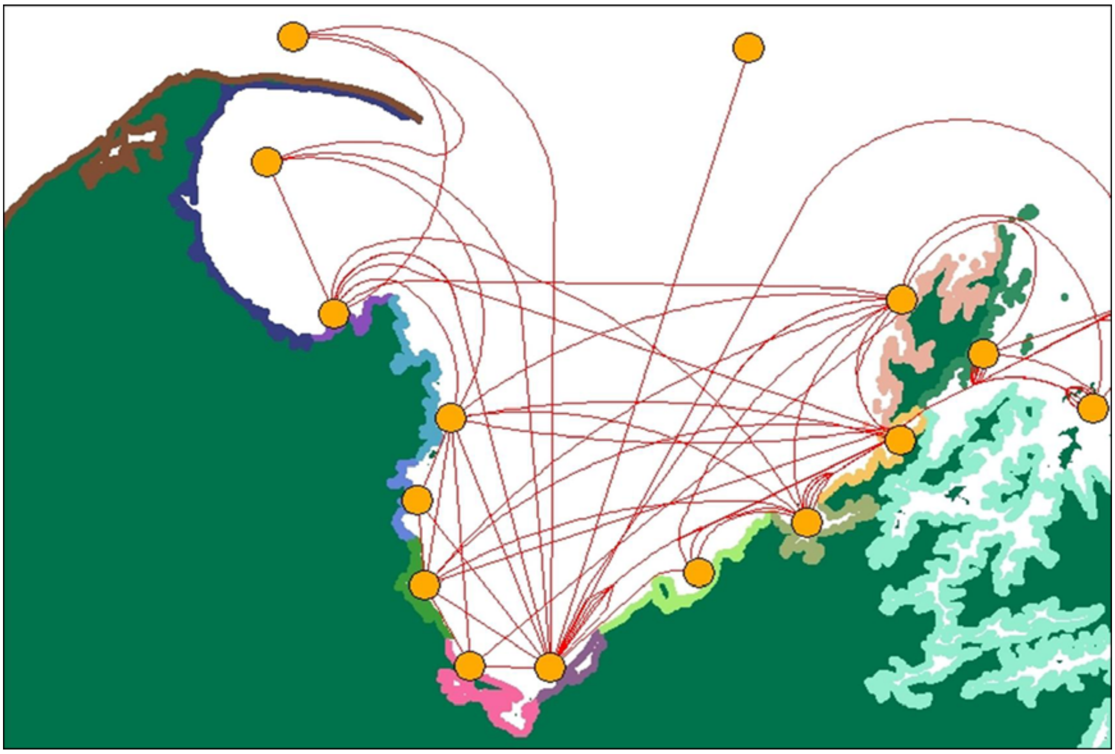

Figure 1 Map showing pathways of recreational vessels among nodes (ports, marinas, etc.) in Golden and Tasman Bays and the eastern Marlborough Sounds (from Acosta et al. 2006b).

Delimitation surveys and studies of control methods for *Didemnum vexillum*

Following the discovery of *D. vexillum* in Shakespeare Bay in December 2001 (see below), the Cawthron Institute carried out a survey of the original infected vessel and a delimitation survey (Coutts 2002a). This was followed by attempts to remove the ascidian from the vessel and surrounding area (Coutts 2002b), a further delimitation survey (Coutts 2002c) and a benefit-cost analyses of potential management options (Sinner & Coutts 2003). The history of the *D. vexillum* incursion in Shakespeare Bay, and the subsequent surveys and management attempts, was described by Coutts & Forrest (2007). Work has continued on methods for control of the spread of *D. vexillum* through aquaculture transfers (Denny & Hopkins 2007, Denny 2008) and for eradication of existing populations (Pannell & Coutts 2007)[4]. Delimitation surveys have also continued in Picton and Nelson Harbours (Keith Heather, Marlborough District Council and Paul Sheldon, Nelson City Council, pers. comm.).

Aquaculture-related studies

Much of the early work on management of non-indigenous marine species in the top of the South Island was related to managing outbreaks on aquaculture facilities and their transfer among aquacultural regions in association with movement of spat or equipment. For example, plans were developed by the industry for the management of the seasquirt *Ciona intestinalis*

[4] See also http://www.biosecurity.govt.nz/pests-diseases/animals/didemnum/control-measures, accessed 26 March 2008.

and *Undaria pinnatifida* and methods were developed for treating spat to prevent transfer of non-indigenous marine species (Forrest & Blakemore 2002, Blakemore & Forrest 2007).

Existing information on non-indigenous species in the top of the South Island

A list of non-indigenous marine species recorded in the top of the South Island during baseline and other surveys is given in Table 1, and contains 35 species (this will not be a complete list of known invasive species in the region because not all will have been recorded in the ports of Nelson and Picton). The characteristics of these species are summarised below, beginning with four high-profile pests (the cord grass *Spartina anglica* (not recorded during baseline surveys because it does not occur in the areas sampled), the macroalga *Undaria pinnatifida* and the ascidians (seasquirts or tunicates) *Didemnum vexillum* and *Styela clava*). The best represented groups of animals and plants in the list are those that live attached to the substratum and are therefore likely to be carried as hull fouling (tube-living polychaete worms, bryozoans, hydroids and algae). Table 2 lists 72 cryptogenic species (i.e. species whose status as introduced or native is uncertain) also found during the surveys.

HIGH-PROFILE PEST SPECIES

Spartina anglica C.E. Hubbard

This species of cord grass grows in estuaries, particularly around the mid-tide level. It occurs throughout New Zealand from Hokianga Harbour to Stewart Island (Partridge 1987). Plants were sent to Motueka from Britain between 1947 and 1950 and successfully established. This follows a world-wide trend of introduction of *Spartina* species to aid in conversion of coastal areas into farmland. The ability of *Spartina anglica* to trap sediment, colonise estuarine mudflats and encroach on existing habitats such as seagrass beds and native saltmarsh, has resulted in loss of native faunal and floral diversity and sometimes changes in shore profile (Partridge 1987). Changes to the Harbours Act 1950 in 1975 halted planting of introduced plants in tidal water.

Ground-based spraying to eradicate *Spartina* began in the Nelson area in the mid-1970s and aerial spraying began in the mid-1980s (Vaughan 2004). Large areas have been treated in Waimea Inlet and Whanganui Inlet and small patches have been treated near Farewell Spit, Kaiteriteri and Riwaka. Surveys to locate remnant populations are conducted annually and those found are treated using the herbicide Gallant. The Department of Conservation and Tasman District Council have recently used a helicopter to locate areas of *Spartina* in Tasman Bay, Golden Bay and Whanganui Inlet, including Waimea Estuary, Moutere Inlet, the Motueka area, the Abel Tasman National Park and Farewill spit coastlines (Department of Conservation media release dated 18 February 2008[5]). Successful eradication programmes for *Spartina* have also been conducted in Southland. The only large area of *Spartina* now left in the South Island is in Havelock Inlet, and this is subject to a control programme by the Department of Conservation and Marlborough District Council[6].

[5] http://www.doc.govt.na/templates/news.aspx?id=45857, accessed 2 April 2008
[6] http://biodiversity.govt.nz/news/media/current/15dec04.html, accessed 2 April 2008

Undaria pinnatifida (Harvey) Suringer, 1873

Image: *U. pinnatifida in situ* (top) and growing on mussel lines in Pelorus Sound (bottom). Photos S. Miller, NIWA

The thalli of this brown kelp can reach 3 m in length and the species is easily distinguished from other laminarian kelp by the midrib and sporophyll (a convoluted reproductive structure at the base of the stipe). It is indigenous to the temperate regions of northeastern Asia (Japan, Korea and China) where it has been cultivated primarily for human consumption for many centuries. *Undaria* is fast becoming a cosmopolitan species worldwide after it was intentionally introduced to Brittany (North Atlantic) in the 1970s for commercial exploitation with Japanese oysters. In New Zealand it has been accorded Unwanted Organism status by the Ministry of Fisheries, preventing its removal, or harvesting, for commercial purposes (although the Biosecurity Act 1993 allows harvesting if there is a pest-management benefit associated and MAF has granted a commercial harvesting permit in Golden Bay: Barrie Forrest, Cawthron Institute, pers. comm.). The primary mechanism of dispersal of *Undaria* between countries is thought to be from spores in ballast water. However, translocation may also occur through various aspects of aquaculture and fisheries activities (such as transportation of infested lines or barges) as well as via vessel hull fouling. In New Zealand, it may have arrived via either hull fouling or ballast water pre-1987.

U. pinnatifida is designated as a 'regional surveillance pest' by the Tasman-Nelson Regional Pest Management Strategy. The strategy has its effect over the combined area that lies within the administrative boundaries of the Tasman District Council and Nelson City Council. The objective of the strategy is to promote the control of *Undaria* and continue surveillance on its distribution. Another objective is to improve the public understanding of its impact and to provide advice and education to vessel owners on identifying and controlling *Undaria*. The distribution of *Undaria* in Nelson Haven has been monitored annually.

Undaria pinnatifida was first discovered in New Zealand in Wellington Harbour in 1987 and was subsequently recorded in the Marlborough Sounds in 1988, Picton in 1991, Port Underwood in 1997, Nelson and Golden Bay in 1998, Wainui Bay in 2001 and Kaikoura in 2002 (Stuart 2004). Baseline port surveys and target-species surveillance have also detected *Undaria* in the Waitemata, Tauranga, Wellington, Lyttelton, Otago and Bluff Harbours to date. It was declared an Unwanted Organism under the Biosecurity Act 1993 in 2000.

Dispersal of spores from stands of *Undaria* may be relatively short-range (metres to hundreds of metres: Forrest et al. 2000). Dispersal of fragments or whole sporophytes (the macroscopic, “kelp” stage of its life-cycle) may occur over hundreds of metres to kilometres. Natural rates of dispersal are, however, likely to depend on local conditions, and may in any case be of secondary importance to human-mediated dispersal, particularly hull fouling (Stuart 2004). A study of hull fouling by the Department of Conservation between 1999 and 2000, focussing on Southland, found that found that 20% of the fishing vessels inspected, 50% of yachts and 35% of launches were fouled with *Undaria* (Stuart 2002, cited in Stuart 2004).

An attempt to control the abundance of *Undaria* by manual removal after it was discovered in Big Glory Bay, Stewart Island (in 1997) resulted in a reduction in the abundance of sporophytes but failed to eradicate it. The use of sodium hypochlorite and a brominated microbiocide was trialled as a method for sterilising floating structures (enclosed in polythene sheeting) but neither was effective (Stuart 2004). Laboratory experiments indicated that hot water was effective against the (microscopic) gametophyte stage (Blakemore & Forrest 2007) and this method was used successfully in the field to disinfect the vessel *Seafresh 1* in the Chatham Islands (Wotton et al. 2004). Super-heated steam has also been used by the Department of Conservation on benthic populations of *Undaria* on Stewart Island (Stuart 2004).

Undaria occurs most commonly on artificial substrata in sheltered harbours (Floc'h et al. 1996) and in the top of the South Island occurs on port and marina structures in Nelson and Picton (including Waikawa Marina) and on droppers on mussel farms in the Marlborough Sounds, among other places. Abundance varies seasonally and is generally much less during warmer months. Colonisation by *Undaria* seems to be facilitated by the presence of cleared areas of substratum, such as those caused by storm events or moderate levels of grazing by herbivores (see review by Stuart 2004). Impacts of *Undaria* may be particularly strong when creation of clear areas coincides with the seasonal appearance of *Undaria* during the spring and early summer. Monitoring of its distribution in Nelson Haven suggests that highest densities are found in relatively sheltered areas with suitable substrata and that it has failed to colonised areas of high wave exposure, such as the outer Boulder Bank and offshore Haulashore Island (information from P. Sheldon, Nelson City Council). Overall extent of distribution remained relatively constant during the years up to 2003 (the date of the last survey).

This opportunistic macroalga is highly invasive and may cause displacement of native species. It has been suggested that *Undaria* has evolved such that it now has the ability to reproduce year-round (Russell et al. 2007). Ecological effects of colonisation by *Undaria* are poorly known. From his review of information on areas colonised in New Zealand, Stuart (2004) concluded that the development of an *Undaria* population does not necessarily completely exclude other macroalgal species, but may reduce their diversity and abundance. Where *Undaria* colonises an area previously lacking diverse, indigenous macroalgal assemblages, biodiversity may increase but the reverse may be true where it displaces species or decreases spatial variability in available habitat. A three-year study of effects of invasion of low-shore assemblages in Lyttelton Harbour (Forrest & Taylor 2002) found no evidence of significant ecological effects.

Didemnum vexillum Kott, 2002

Image: A Coutts, Cawthron.

The cream-white coloured, colonial ascidian, *Didemnum vexillum*, discovered in New Zealand (Whangamata Harbour) in 2001, was identified in the Marlborough Sounds region in 2002. This nuisance ascidian is capable of widespread fouling in the marine environment, and is typically found on artificial structures such as aquaculture equipment, vessel hulls, mooring lines and wharf piles. It poses a potential threat to the New Zealand Greenshell™ mussel industry due to its smothering capabilities.

The story of how *Didemnum* arrived in Shakespeare Bay, Picton via Tauranga, Auckland and Whangamata Harbours, and the development of strategies to manage the incursion, were described by Coutts & Forrest (2007). It was recorded for the first time in New Zealand in Whangamata in October 2001 and two months later on a barge in Shakespeare Bay. From the barge it spread to the seabed, adjacent vessels and artificial structures such as wharf piles. It is not clear whether *D. vexillum* is an introduced species or an indigenous species exhibiting rapid population growth in response to favourable environmental conditions. Consequently, it has not been declared an Unwanted Organism (under the Biosecurity Act) and no formal management action has been taken at a national level (Coutts & Forrest 2007).

Initial attempts to remove the original populations on the barge, seabed and nearby structures in Shakespeare Bay were not successful and *Didemnum* spread to other parts of the bay and was also transported to East Bay (35 km from Shakespeare Bay) via an infected salmon-farm pontoon. Like many ascidians, *Didemnum* has limited larval dispersal capacity (larvae are capable of swimming and settling to form new colonies for only minutes to hours: Coutts & Forrest 2007) and human vectors are important for its long distance dispersal. Its colonisation pattern in Shakespeare Bay also indicated that artificial structures are important stepping stones for its spread and colonisation of natural habitats.

In August 2003 the original infected barge was cleaned (for a second time) and scuttled in deep water, and eradication was attempted in Shakespeare and East Bays. Infected moorings and vessels were slipped, cleaned, antifouled (in the case of vessels) and returned to the water. Three infected barges were beached for three weeks but this method failed to completely remove the infections through desiccation. Two other barges were treated in situ by wrapping in polyethylene sheet and adding granulised chlorine and this method was completely effective. An area of seabed 80 m by 40 m beneath the area where the original barge had been moored was smothered in dredge spoil (predominantly silt-clay), again effectively eliminating *Didemnum*. All the piles at the nearby wharf (many of which were infected) were treated by wrapping in polyethylene sheet, reducing water flow to the *Didemnum* colonies (and other organisms) beneath and promoting anoxic conditions. This method was effective except in areas where the wrapping had become loose or damaged. Smothering with spoil proved ineffective on the rip-rap wall beneath the wharf because of the steepness of the slope. Various chemical or mechanical methods were trialled and were effective but considered too expensive to treat the large area infected. The method eventually chosen was to wrap the area in a geotextile fabric with pore size small enough to retain larvae, but this was not completely successful because gaps in the joins between sheets of the material allowed water exchange and the colonies to survive and reproduce. Nevertheless, Coutts & Forrest (2007) considered that this method is potentially an effective method and that the problems encountered can be addressed. The total cost of the treatment programme eradication attempt was ca $350k.

Because complete eradication was not achieved, reinfection of structures and vessels occurred and, by July 2004, 87% of the wrapped piles, 7 of 22 vessel moorings and both of the wrapped and chlorine-treated barges were reinfected. In their analysis of the *Didemnum* incursion in Shakespeare Bay, Coutts & Forrest (2007) identified a number of key requirements for successful eradication. These are a need for; baseline knowledge of the biota of the incursion location and an effective surveillance programme; clear lines of authority and effective decision-making in responding to incursions; adequate resources to meet project goals; proven treatment methods; buy-in from stakeholders and incentives for exacerbators to participate in management; effective quarantine to prevent spread; and effective project management and quality assurance procedures. Research is also continuing on methods of control, including those for reducing spread with aquaculture transfers (Denny & Hopkins 2007) and FRST-funded work on colonisation of artificial surfaces by *Didemnum* as a model for invasion processes (Barrie Forrest, Cawthron Institute, pers. comm.).

In addition to Shakespeare Bay, *Didemnum vexillum* is currently present in Picton Harbour, eleven embayments throughout Queen Charlotte Sound, one in Port Underwood, eight in Pelorus Sound, Port Nelson, Tarakohe Harbour, Whangamata, Tauranga and Wellington Harbours (Pannell & Coutts 2007). Management of infected sites in these locations is ongoing at locations in Tarakohe, Shakespeare Bay, Queen Charlotte Sound and Picton (Pannell 2008), and treatments of individual infections (by wrapping or removing infected structures) appears to be generally successful. Monitoring is continuing in Port Underwood, Pelorus Sound and Nelson (Pannell 2008). Supporting research in Queen Charlotte Sound and Port Nelson is continuing with FRST funding (Barrie Forrest, Cawthron Institute, pers. comm.). The target-species surveillance programme has also recorded populations of *Didemnum* resembling *D. vexillum* (identification has not been confirmed) in Port Nelson, Whangarei, Tauranga and Otago Harbours and it has recently been recorded in Motueka (Pannell 2008).

Styela clava Herdman, 1881

Image: wdfw.wa.gov

The solitary, hermaphroditic ascidian (commonly known as sea squirt), *Styela clava*, has a long club-shaped body, tapering to a slender and tough stalk. The overall height can reach 12 cm and the stalk can be a third of the total length. The surface of the sea squirt can be leathery with folds and swellings. The siphons at the top (anterior) end are close together. It is native to the north western Pacific. *S. clava* is a fouling pest on ships hulls and oyster beds, and the transport of oysters and any movement of ships probably aided its rapid dispersal (Eno et al. 1997). It has been introduced to both coasts of North America, Europe, Australia and New Zealand.

S. clava is present on coasts in low wave energy environments and sheltered embayments in the upper sublittoral zone to at least 25 m depth where it can reach densities of 500-1500 individuals per square metre (Osman & Whitlach 1999). It can tolerate salinity changes and temperature fluctuations. Overseas it is known to foul aquaculture species such as oysters where it competes for food and predys on oyster and mussel larvae in the water column. Dense fouling on fishing equipment, moorings, ropes etc. can be time consuming to remove and can result in tangling of fishing gear (Parker et al. 1999). As hull fouling, this increases drag on vessels, frequency of hull cleaning and increases fuel costs. In Japan it has been known to impact human health causing an asthmatic condition in oyster shuckers when hammering open *S. clava* fouled oysters in poorly ventilated areas (Cohen 2005).

S. clava was first reported in New Zealand in the Viaduct Basin (Waitemata Harbour) in August 2005 and there appear to be well-established populations in the Waitemata Harbour, Hauraki Gulf and Firth of Thames (Gust et al. 2006). More localised populations have also been found in Lyttelton Port, Lyttelton Marina, Tutukaka and Opua Marinas (Northland) (Gust et al. 2006) and Nelson Port (Morrisey et al. 2006). Individual specimens have been removed from boats taken out of the water in Waikawa Marina (2005), Port Nelson (Slipway Basin: 2006) and Clyde Quay Marina (Wellington Harbour: 2007: Gust et al. 2007). It was declared an Unwanted Organism in October 2005.

Styela clava may have reached the Pacific coast of North America as fouling on ships' hulls, but it may also have been introduced as fouling on imported live oysters (Cohen 2005). It is known to occur on oysters (*Crassostrea gigas*) in Japanese oyster farms, and oysters from Japanese farms were transplanted to Elkhorn Slough (California) in 1929-1934, roughly coincident with its date of first detection in California (1932). From Elkhorn Slough it could have been transported to other parts of California as fouling on coastal shipping or via further transfer of oyster stock (including its recent appearance in Humboldt Bay: Cohen 2005).

The introduction of *Styela clava* to southern England is commonly ascribed to fouling on naval vessels returning from the Korean War in 1952 (Minchin & Duggan 1988, cited in Minchin et al. 2006), having acquired fouling in the Yellow Sea. It is likely to have spread from the original site of introduction to other parts of the United Kingdom and continental Europe on coastal shipping or, locally, by dispersal of eggs and larvae (Lützen 1999). It has also been suggested that *S. clava* reached the Danish coast, where it was first recorded on an oyster bed in the Limfjord, attached to oysters imported from the English Channel and re-laid in the Limfjord (Lützen 1999). Oyster spat imported from Japan in the 1970s, or transplanted within the English Channel region, may have contributed to the establishment of Dutch and French populations (Lützen 1999).

Given the distances involved, the introduction of *Styela clava* to Australia and New Zealand is likely to have occurred via fouling on ships' hulls, either from its native range or from introduced populations in Europe or North America. In view of the disjunct distribution of *S. clava* in New Zealand's North and South Islands, several inoculation events may have occurred (Gust et al. 2006). Research is currently underway to determine the genetic relationships among populations of *S. clava* in New Zealand.

Minchin et al. (2006) noted that *S. clava* tend to be stripped from ships' hulls at speeds above ca 5 kt, unless they occur in more protected habitats such as sea-chests, thruster tubes, or in the lee of stabilisers and other structures on the hull. Lützen (1999) also described *S. clava* as rheophobic (i.e. avoiding strong currents), reducing the likelihood of individuals surviving as fouling on exposed parts of the hulls of rapid vessels in continuous service. Attachment to drifting macroalgae provides another potential means of dispersal. Lützen (1999) stated that fronds of *Sargassum muticum* (a macroalga introduced to Europe from Asia in the early 1970s) with *Styela clava* attached are often washed up on shores in the Limfjord. Fronds become detached from their holdfasts towards the end of the growth cycle and can float for "considerable distances".

Davis & Davis (2004) suggested that a combination of transport mechanisms, including translocation on oyster shell, dispersal on flotsam such as drift macroalgae, fouling on vessel hulls, transport of eggs and larvae in ballast water, and fouling of sea-chests are probably required to explain the present distribution of *S. clava*. Davis (2005) suggested that sea-chests were potentially of greatest importance because they offer a means of transport for established colonies of individuals, and translocated colonies are more likely to establish new populations than a single inoculum of larvae.

Slow-moving and towed vessels are particularly likely mechanisms of introduction, because of the reduced likelihood of individuals being removed from the hull by water currents during transit. Such vessels may also spend longer periods moored in ports of origin and destination than vessels in continuous service. Specimens of *S. clava* found on vessels in New Zealand have been on a tug (Lyttelton), recreational launches and yachts (Auckland, including one that subsequently travelled to Waikawa Marina, Picton, where it was found to harbour a single individual) and fishing vessels (Nelson) that had been berthed for long periods of time (possibly months in one case, years in another). Of these, recreational vessels are perhaps the most likely to have been the vector of inoculation in the ports where they were found, as the other types of vessel tend to spend most of their time in their home port. Methods for managing incursions of *S. clava*, including air-drying, wrapping in plastic, freshwater, acetic acid and chorine immersion, were reviewed by Coutts & Forrest 2005.

OTHER NON-INDIGENOUS SPECIES RECORDED IN THE TOP OF THE SOUTH ISLAND

All of the following species have been recorded I the ports and marinas of Nelson and Picton during baseline and target-species surveys (Table 1, with further details of locations where the occurred in Tables 12 and 20).

Annelida (polychaetes)

Dipolydora armata (Langerhans, 1881)

Image: Geoff Read, NIWA http://www.annelida.net

The burrowing spionid polychaete worm, *Dipolydora armata*, is a cosmopolitan species found in both temperate and tropical waters. It burrows into calcareous substrata such as corals, coralline algae and bivalve shells. The type specimen is recorded from Madeira Island, North Atlantic. The first description was originally published in 1880 as *Polydora armata* although there are possibly several synonyms around the world including *Polydora rogeri* Martin, 1996 (Radashevsky & Nogueira 2003). It was first detected in New Zealand ca. 1900, probably arriving as hull fouling, and has been recorded from Otago and Wellington Harbours, and the Marlborough Sounds (Cranfield et al. 1998). It has been recorded from living shells of commercial shellfish; *Haliotis iris* and *Perna canaliculus*, where it may cause considerable damage and weakening of the structure (Lewis 1998).

Dipolydora flava (Claparède, 1870)

D. flava is also a burrowing spionid polychaete worm distributed throughout temperate and tropical regions, including Japan, Indonesia, Sri Lanka, Uruguay, Argentina and Australia. Its type specimen is recorded from the Gulf of Naples, Italy. The date of introduction to New Zealand is unknown but was probably via hull fouling and/or ballast water. It is known to cause blistering on internal surfaces of bivalves, with the potential to become a significant pest of mollusc aquaculture. It has also been recorded from the Port of Tauranga.

Hydroides elegans Haswell, 1883

Image: John Lewis, Australian Department of Defense DSTO.
(http://www.sms.si.edu/IRLspec/Hydroides_elegans.htm)

The small, tube dwelling polychaete worm, *Hydroides elegans,* consists of 65-80 body segments, reaches up to 20mm in length, and has an opercular crown with 14-17 spines. It constructs hard, sinuous, white, calcareous tubes that foul both natural and artificial structures. It is found subtidally and is highly tolerant of contaminated waters, a range of temperatures (13 – 30^{o}C; Qiu & Qian 1998, Kocak & Kucuksezgin 2000, NIMPIS 2002) and salinities as high as 42 psu (Kocak & Kucuksezgin 2000) although lower salinities (15 – 20 psu) result in mortality (Mak & Huang 1982, Qiu & Qian 1998). Although the type specimen for this species was described from Sydney Harbour, Australia, the native range of *H. elegans* is unknown, as it is possible it was introduced to Australia prior to 1883 (Australian Faunal Directory 2005). *H. elegans* is present in the Caribbean Sea, Brazil, Argentina, northwest Europe, Japan, the Mediterranean, north-west and south-east Africa, and New Zealand. *H. elegans* has been present in New Zealand since at least 1952 and has been recorded from Waitemata and Lyttelton Harbours (Cranfield et al. 1998). During the initial port baseline surveys, *H. elegans* was recorded in Gulf Harbour marina and the Port of Auckland. During the second baseline surveys of Group 1 ports it was recorded from the Port of Nelson.

This species is able to grow in high densities, particularly in tropical and sub-tropical ports, sometimes heavily fouling any newly immersed structure. It creates microhabitat for some species and competes with others for food and space. Direct economic impacts include the cost of cleaning ship hulls, aquaculture gear, and other submerged structures. Other costs include decreased operational efficiency of fouled vessels due to drag and of water intake pipes due to clogging (NIMPIS 2002). Cawthron have reported recent outbreaks of *H. elegans* in Nelson Marina.

Polydora hoplura (Claparède, 1870)


Image: Geoff Read, NIWA http://www.annelida.net

P. hoplura, another burrowing spionid polychaete worm, was recorded from the Marlborough Sounds in 1998 (Cranfield et al. 1998). It is native to the Atlantic coast of Europe and the Mediterranean (Cranfield et al. 1998) and has been introduced to South Africa, Australia and New Zealand probably via hull fouling although it is not known when it first arrived in New Zealand. In New Zealand, it has also been recorded from the Marlborough Sounds, Wellington, Whangarei, Tauranga and Dunedin. It is a common pest of shellfish mariculture, often associated with the introduced Pacific oyster (*Crassostrea gigas*, Handley 1995). Infestations of *P. hoplura* on *C. gigas* were reduced using freshwater or heated seawater treatments (Nel et al. 1996). Variation in temperature and salinities have significant impacts on *Polydora* populations (Zajac 1991).

Spirobranchus polytrema NR (Philipp, 1844)

The serpulid tubeworm, *Spirobranchus polytrema*, is present in a variety of habitats. It has been introduced to Australia, Lord Howe Island, Solomon Islands, Sri Lanka, Japan and the Indo-west Pacific with the type specimen recorded from the Mediterranean. *S. polytrema* was found in Wellington, Napier and Dunedin during the initial NIWA port surveys in 2001/02, and is considered a first record for New Zealand.

Note that burrowing polychaetes have the potential to weaken mollusc shells (i.e. paua, mussel) which may provide easier prey for large predators such as fish, stingrays, and octopus (Shepherd & Breen 1992). High levels of boring have also been correlated with a decrease in shell thickness which has a detrimental effect the health and growth of the host, thus borers may severely affect fishery yield and productivity (McDiarmid et al. 2004).

Arthropoda

Caprella mutica Schurin, 1935


Image: Male (top) and female (bottom) *Caprella mutica*, www.sams.ac.uk.

The Japanese skeleton shrimp, *Caprella mutica*, has an armoured exoskeleton and is one of the larger caprellid amphipods with males attaining body lengths of up to 50 mm (Nishimura 1995). It is native to north-east Asia and Japan although it has spread to twenty-nine non-native locations around the globe, spanning both hemispheres between latitudes 25 and 76°N. *C. mutica* is often associated with aquaculture sites, marinas and oil rigs, where they may occur in large densities, suggesting that ballast water and transfer with Pacific oysters are likely vectors (Ashton et al. 2007). Temperature may limit the global distribution to regions that experience annual temperatures of 0 – 22°C. Other factors that may limit the distribution of Caprella *spp*. include inter-species competition, substratum features, predation, and wave exposure (Ashton et al. 2007 and reference therein). No environmental impacts have been observed to date.

Apocorophium acutum (Chevreux, 1908)

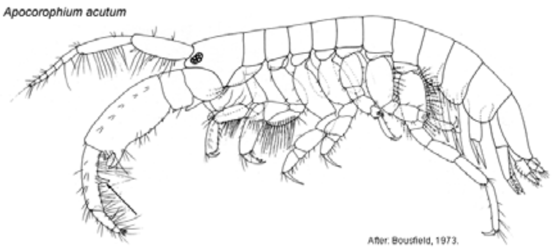

Image and information: Keys to the Northeast Atlantic and Mediterranean amphipods. (http://www.amphipoda.com/acutum.html)

Apocorophium acutum is a corophiid amphipod, known from the Atlantic Ocean (England, France, North America, Brazil, South Africa), Pacific Ocean (New Zealand) and the Mediterranean Sea. The exact native range of this species is not known, although the type specimen of this species was described from Algeria. *A. acutum* inhabits marine sediments in estuarine mudflats and brackish water and fouling assemblages where it builds muddy tubes. It has no known documented impacts.

Bryozoa

Anguinella palmata van Beneden, 1845

Image: PL Cook, www.bryozoa.net.

The cosmopolitan bryozoan, *Anguinella palmata*, forms erect and uncalcified tufts that are pale beige. The tufts comprise a main axis with numerous branches of tubular zooids slightly incurved toward the axis. It may be confused with silt-covered algae. The New Zealand specimens reach up to 6 cm in length, but specimens of 20 cm have been reported from other countries. This species occurs in both intertidal and subtidal habitats preferring eurythermal environments with salinity above 30 psu (http://www.sms.si.edu). The native range of *A. palmata* is unknown, but is thought to be southern Europe. Its current distribution includes Britain, the North Sea, Senegal, Ghana, Zaire, the Atlantic coast of North America, Brazil and Australia. *A. palmata* has been present in New Zealand since at least 1960 and has been recorded from Waitemata Harbour and Nelson (Gordon & Matawari 1992).

Biflustra grandicella

Specimens of a large, foliose, mound-forming bryozoan collected by trawling from southern Golden Bay in 2003 were identified as the introduced species *Biflustra grandicella* (Grange & Gordon 2005). Reports of what may have been the same species were made by fishing vessels in December 2005. This represented the first documented record of *Biflustra grandicella* outside its native Chinese waters (the original description of the species was based on material from Hong Kong).

Surveys of the distribution of *Biflustra grandicella* in Golden Bay during 2003-2005 showed that it established and spread rapidly to occupy an area of ca 255 km^2, with the main distribution covering an area of 44 km^2 in water depths of 15-25 m on muddy sediment (Grange & Gordon 2005). The distribution subsequently retracted to occupy 44 km^2 north of Port Tarakohe in June 2005. *B grandicella* produces a long-lived planktonic larva (in contrast to the the endemic *Hippomenella vellicata*, which has a very similar mound-forming morphology and occurs in the Separation Point beds) and therefore has the potential for rapid spread (Dennis Gordon, NIWA, pers.comm.). However, the population in Golden Bay has apparently reduced substantially since the survey in 2005 (Ken Grange, NIWA, pers. comm.). It has not been recorded in the ports of Nelson or Picton.

Epifauna attached to *B grandicella* colonies in Golden Bay were less abundant and diverse than those found on native, mound-forming bryozoans such as *Hippomella* and *Celleporaria*. Three species of bryozoans and 35 other invertebrate species were collected from 40 colonies of *B grandicella* dredged from Golden Bay. In contrast, 94 species of bryozoans were collected from bryozoan beds dominated by *Celleporaria* in northeastern Tasman Bay (Bradstock & Gordon 1983) and Grange et al. (2003) recorded 37 species of bryozoans and 39 other invertebrate species from a single dredge sample within the Separation Point bryozoan beds. Consequently, it is possible that the spread of *B grandicella* could be accompanied by a loss of associated biodiversity, particularly if it invaded the Separation Point beds.

Bugula flabellata (Thompson in Gray, 1848) (http://www.marbef.org)

Image: K. Hiscock (http://www.marlin.ac.uk).

Bugula flabellata forms an erect, densely tufted, branched colony, growing 2-5 cm in height and appearing buff to pale pink in colour. Often found growing with other erect bryozoans, it attaches to hard surfaces such as piles, pontoons and rocks on the lower intertidal and shallow subtidal where it has been recorded down to 35 m. It is native to the British Isles and the North Sea but has been introduced to Chile, Florida, the Caribbean, northern east and west coasts of the USA, Australia and New Zealand possibly via vessel hull fouling. It was recorded in the Port of Picton in December 2001 (Inglis et al. 2006b) but has probably been in New Zealand pre-1949. It is considered a major fouling organism in ports and harbours although there is no research on potential impacts.

Bugula neritina (Linnaeus, 1758)

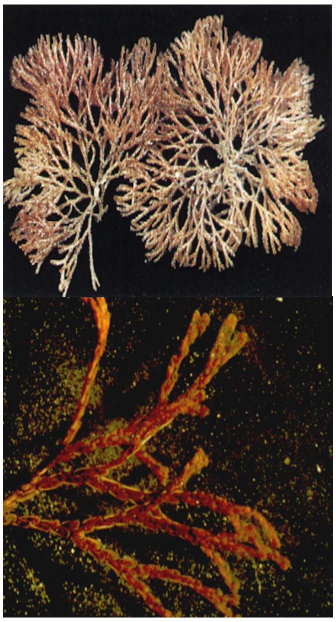

Image: www.marine.csiro.au

The cosmopolitan bryozoan, *Bugula neritina*, has an erect, dichotomously branching, red-purple-brown morphology and is an abundant fouling organism reported from all seas except subarctic and subantarctic regions. It colonises any available substratum such as piles, vessel hulls and buoys where it can form extensive monospecific growths. It is native to the Mediterranean Sea but also occurs in North America, Hawaii, India, Japanese and China Seas, Australia and New Zealand. It was first recorded in New Zealand in 1949, probably arriving as fouling on ships' hulls. Its ecological impacts are as yet unknown, although it is an abundant species in warm waters with sensitivity to cold water (Winston 1982) and low salinity (14 psu is fatal; Mawatari, 1951). It is the source of a novel chemical, bryostatin, which has been shown to be effective against leukaemia (http://www2.bishopmuseum.org). Nudibranchs are known to prey on *B. neritina* (Rudman 2000).

Celleporaria nodulosa (NR) Busk, 1881

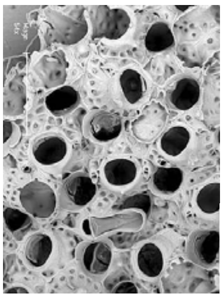

Image: Microscopic detail of *C. nodulosa* (www.bryozoa.net).

The encrusting bryozoan, *Celleporaria nodulosa*, forms low, flat, spreading colonies that have a blue-green tinge. There are more than 100 species in the genus *Celleporaria* world-wide. The type specimen for *C. nodulosa* was first described from the southeastern coast of Australia, where it is widespread. No information exists on its likely impacts on native species. The first record of it from New Zealand was in the Port of Nelson at Kingsford Quay.

Cryptosula pallasiana van Moll, 1803

Image: A.N. Cohen, www.exoticsguide.org.

The cosmopolitan encrusting bryozoan, *Cryptosula pallasiana*, white-pink in colour with orange frilled crusts, and often heavily calcified, is found fouling a variety of substrata including algae, seagrass, ascidians, artificial structures and vessel hulls. A distinguishing feature is the large visible pores. A competitive fouling organism likely introduced via ballast water or hull fouling, the ecological impacts of *C. pallasiana* are as yet unknown in its introduced range, although it is tolerant of reduced salinity (http://www.sms.si.edu). It is native to Florida, the east coast of Mexico and the northeast Atlantic, cryptogenic in the Mediterranean and introduced to the northwest coast of the USA, the Japanese Sea, Australia and New Zealand. It is found throughout New Zealand occurring here since the 1890's (Gordon & Matawari 1992). *C. pallasiana* is eaten by various nudibranchs, sea urchins and fish (www.exoticsguide.org).

Conopeum seurati (Canu) 1908

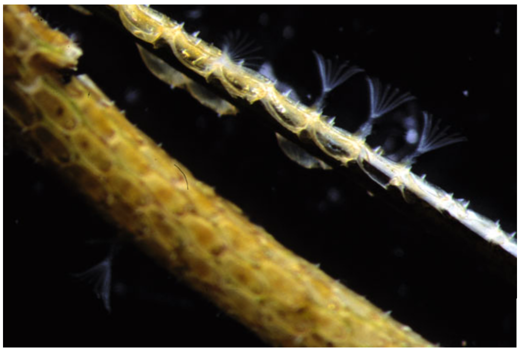

Image: home.hetnet.nl

The encrusting bryozoan, *Conopeum seurati*, forms small whitish colonies on seagrasses and other substrata. Its 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. It is considered a truly estuarine bryozoan, typically collected from areas with a salinity range 18 – 44 psu but has been collected from estuaries in Europe where salinities were < 1 psu (http://www.sms.si.edu).

Electra angulata Levinsen, 1909

The encrusting bryozoan, *Electra angulata*, forms small whitish colonies on a variety of substrata. *E. angulata* is native to Thailand and Japan. Its introduced range and impacts on native organisms are unknown.

Electra tenella Hincks, 1880

An encrusting cheilostome bryozoan, *Electra tenella*, grows to several centimetres diameter. The type specimen is from the Atlantic coast of Florida, and it has also been reported from Puerto Rico as *Conopeum reticulum* (Winston 1982), and from Brazil, Jamaica, Japan, the Bay of Bengal, Botany Bay in Australia, China, and New Zealand. *E. tenella* has been reported as occurring on hard substrata, especially dead shells and barnacles in shallow water harbour areas (Osburn 1940, cited in Winston 1982), but it has rarely been recorded as a fouling species (Winston 1982). Its abundance in Florida appears to be chiefly due to the abundance of drift plastic in this area, which *E. tenella* effectively colonises. Drift plastic may be an important vector for the expansion of the range of this species (Winston 1982). The first record of *E. tenella* in New Zealand was from Pakiri Beach in Northland, where it was found on dead *Atrina* shells in 1977 (Gordon & Matawari 1992). Prior to 1992 it had also been recorded in Gisborne and Napier and on plastic debris in the Hauraki Gulf (Gordon & Matawari 1992).

Schizoporella errata Waters, 1878

Image: J. Hoover, www2.bishopmuseum.org

Schizoporella errata is a heavily calcified, encrusting bryozoan that is typically dark brick red with orange-red growing margins. It assumes the shape of whatever it overgrows. This species may form heavy knobbly incrustations on flexible surfaces such as algae or worm tubes, turning them into solid, sometimes erect branching structures. The thickness of the growth is dependent upon the age of the colony. Multilaminar encrustations 1 cm thick are common. *S. errata* is thought to be native to the Mediterranean. It has been introduced to many worldwide locations in warm temperate-subtropical seas probably via hull fouling, and has been reported from West Africa, the Red Sea, the Persian Gulf, South Australia, New Zealand, the Hawaiian Islands, the Pacific coast of North America, the east coast of North America through to the Caribbean and Brazil. *S. errata* occurs in shallow water on various hard substrates (pilings, hulls, coral rubble, etc.) in harbours and embayments. It is also occasionally found on rocky or coral reefs. *S. errata* can compete with other fouling organisms for space and large encrustations of this species are known to smother other biota (Cocito et al. 2000).

Tricellaria inopinata d'Hondt & Occhipinti Ambrogi, 1985

Image: home.hetnet.nl

T. inopinata is an erect, robust, opportunistic bryozoan tolerant of polluted and turbid waters and a wide range of temperatures and salinities (temperature 2-3°C to 34.5°C, low salinity to 2.0-3.5%). It grows on a variety of anthropogenic and natural substrata such as vessel hulls, buoys, ropes, and other flora and fauna. *T. inopinata* belongs to a species complex (*T. porteri-occidentalis-inopinata*), the native distribution of the complex occurring along the United States Pacific Coast (Osburn 1950 cited in Occhipinti Ambrogi 2000). It may have been introduced either with oysters or shipping traffic from the Pacific (Occhipinti Ambrogi 2000). It was first detected in New Zealand pre-1964 and has been recorded from Whangarei, Gisborne, Taranaki and Lyttelton. It has a high reproductive potential which may explain the drastic reduction in frequency and abundance of native bryzoan species following its invasion in the Laguna di Venezia (Italy; Occhipinti Ambrogi 2000). There is currently no known management (biological, chemical or mechanical) for *T. inopinata*.

Watersipora subtorquata (d'Orbigny, 1842)

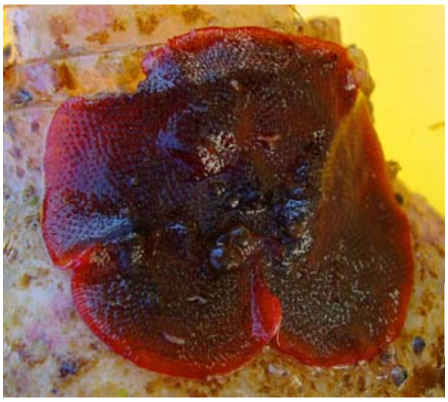

Image: S. Miller, NIWA

Watersipora subtorquata is an encrusting bryozoan, dark red-brown that often stains fingertips upon handling. It fouls a variety of substrata including vessel hulls, piles, pontoons, rocks and seaweed, and is resistant to many antifouling toxins. The type specimen is recorded from Rio de Janeiro, Brazil (Gordon & Matawari 1992); its native range is unknown but may include the wider Caribbean and South Atlantic. It has been introduced to the north-western Pacific, Australia and New Zealand. It was probably introduced in New Zealand via hull fouling and/or ballast water pre-1982, and occurs from Bluff to Whangarei.

Zoobotryon verticillatum (Delle Chiaje), 1828

Image: Basil Hart, Dickson Marine (Refits) Ltd (www.dicksonmarine.com)

Z. verticillatum (= *Z. pellucidum*) is a common, shallow-water, colonial bryozoan forming transparent-white or yellowish bushes of stolons that resemble spaghetti. These erect, branching stolons extend away from the substratum and can be up to 45 cm in length. The colonies themselves may exceed 15 – 20 cm diameter. It superficially resembles an alga but is pale in colour, close examination reveals tiny clusters of animal tentacles along the branches. *Z. verticillatum* is a cosmopolitan species whose origin is unknown but its distribution extends to both tropical and temperate waters. It is found on hard substrates in bays and harbours and is common on ship hulls, which is a probable vector and may clog industrial seawater pipes[7]. Huge outbreaks of *Z. verticillatum* may form at temperatures >22°C and higher salinities (>30 psu), although the colonies can overwinter during colder periods. Abundant growth of this species may impact fisheries by fouling fishing gear, crowd out native sessile organisms and affect food webs in the water column by their active suspension feeding[8]. Cranfield et al. (1998) give the New Zealand distribution of *Z. verticillatum* as the Manukau and Waitemata Harbours. It was also recorded in Tauranga during the second baseline survey but had not been reported from Nelson or Picton until it was noted as common around Port Nelson and Nelson Marina during the target-species surveillance in February 2008 (NIWA pers. obs.). It was also present on a boat in Nelson Marina in March 2008 when the vessel was taken out of the water to clean off abundant growths of the polychaete *Hydroides elegans* (see photograph above).

Chordata

Oncorhynchus tshawytscha (Walbaum, 1792)

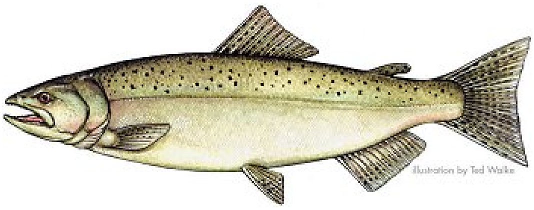

Image: Top www.fish.state.pa.us; bottom www.nmfs.noaa.gov/pr/species/fish/.

The largest of the Pacific salmon, *Oncorhynchus tshawytscha* (known as chinook salmon) has an average weight of 13.6 kg. It is blue-green on the back and top of the head with silvery sides and white ventral surfaces. It has black spots on its tail and the upper half of its body, with the male being more colourful. There is dimorphism between the sexes. It is native to the Arctic and Northwest Pacific from Point Hope, Alaska, to Ventura River, California and northeastern Asia (Page & Burr 1991). It is an introduced species in New Zealand. *O. tshawytscha* is anadromous; it is born in freshwater, migrates to the ocean returning to freshwater to spawn. Its average lifespan is 3.5 years, dying shortly after spawning. It is commercially and recreationally important, particularly in the Pacific Northwest, however, it is listed as endangered on the US Federal List (Scott 2003). It is a predatory fish and may compete with native fish populations.

[7] http://webs.lander.edu/rsfox/invertebrates/zoobotryon.html
[8] http://www.elkhornslough.org/research/aquaticinvaders/aquatic21.htm

Cnidaria (Hydroids)

Eudendrium generale von Lendenfeld, 1885

The small (2 – 30 cm) branching hydroid, *E. generale*, can be found attached to rocks or calcareous bryozoa from intertidal rocky shores to sheltered waters and deep ocean (Southcott & Thomas 1982). The life cycle includes a planktonic planula larva. The type specimen is from southern Australia with it recently recorded from the Antarctic (Puce et al. 2002) and New Zealand (Napier and Picton).

Lafoeina amirantensis (NR) Millard & Bouillon, 1973

Lafoeina amirantensis is a small epizootic hydroid in the family Campanulariidae. It is known from South Australia, Tasmania, the Seychelles (Indian Ocean), Belize, Panama, and Brazil (Smithsonian Tropical Research Institute 2004, Migotto and Cabral 2005). Details of its native range and ecological impacts are unknown. Specimens obtained during NIWA surveys of the Port of Nelson are thought to be the first known records of this species in New Zealand.

Filellum serpens Hassall, 1848

The hydroid, *Filellum serpens* is epiphytic on many species of hydroids and on bryozoans (Vervoort & Watson 2003). The type locality is Dublin, on the Irish Sea. The species is regarded as having a cosmopolitan distribution (Vervoort & Watson 2003), including records from the Svalbard Archipelago in the Arctic Circle, Iceland, the Bay of Fundy in the northwest Atlantic, the Gulf of Mexico and Gulf of Texas and Australia. However, the species can only be recognised with certainty when fertile, and sterile colonies may easily be confused with *Filellum serratum* (Clarke, 1879) and *Filellum antarcticum* (Hartlaub, 1904); both have been recorded in New Zealand (see Vervoort & Watson 2003). *F. serpens* is believed to occur with *F. serratum* in suitable habitats all around New Zealand, but specimens examined have been infertile and therefore the true presence of *F. serpens* in New Zealand is still to be proven by records of fertile colonies (Vervoort & Watson 2003).

Synthecium campylocarpum Allman, 1888

Colonies of the hydroid, *Synthecium campylocarpum,* are pale yellow. It is native to Australia, with its type locality being New South Wales. The exact pattern of distribution of the species is quite obscure due to frequent erroneous synonymisation, but it is probably restricted to (sub)tropical waters of the eastern part of Indonesia, the north of Australia, and New Zealand.

Synthecium subventricosum Bale, 1914

The hydroid, *Synthecium subventricosum*, forms large colonies (<6 cm) that are usually straggly with a strong tendency towards the formation of stolonal tendrils that develop short, secondary stems (Vervoort & Watson 2003). The type locality is the Great Australian Bight, at water depths between 73-183 m. The species is found in eastern and northern Australia, Indonesia, Japan and New Zealand where it is widely distributed, with records from depths between 37 and 302 m (Vervoort & Watson 2003). However, there is some confusion as to the taxonomy of *S. subventricosum* with it thought to be a small form of *S. elegans* forma *subventricosum* (Ralph 1958). *S. subventricosum* was recorded from the Ports of Nelson and Timaru during NIWA surveys.

Macroalgae: Rhodophyta

Heterosigma akashiwo (Y. Hada) Y. Hada ex Y. Hara & M. Chihara

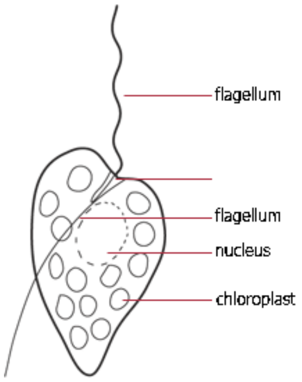

Image: http://www.liv.ac.uk?hab

This microscopic (12 – 18 µm) red alga, *Heterosigma akashiwo*, episodically forms toxic red tides that impact the survival of organisms at all trophic levels. Its native range is unknown. The global distribution of *H. akashiwo* is increasing as is the frequency of harmful algal blooms featuring *H. akashiwo* (*http://www.agu.org/revgeophys/anders01/anders01.html)*

Griffithsia crassiuscula (C. Agardh, 1842)

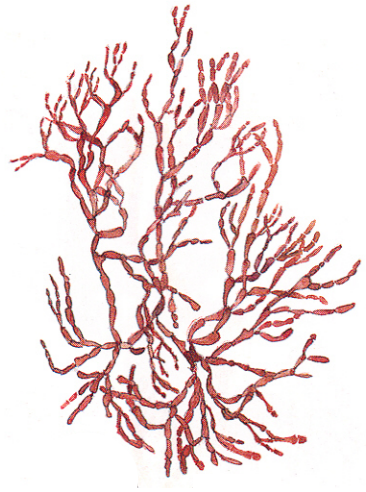

Image: N. Adams, 1994

The small, filamentous red alga, *Griffithsia crassiuscula*, may reach 10 cm in height, is bright rosy red to pink and has a turgid texture. It is thought to be native to southern Australia. It is commonly found in the subtidal epiphytic on other algae, shells, rocks and pebbles. It probably arrived in New Zealand as hull fouling pre-1954. It has been recorded from Bluff, Lyttelton, Picton, Taranaki, Timaru and Wellington, and has no known impacts although there is little research on this species.

Polysiphonia subtilissima Montagne, 1840

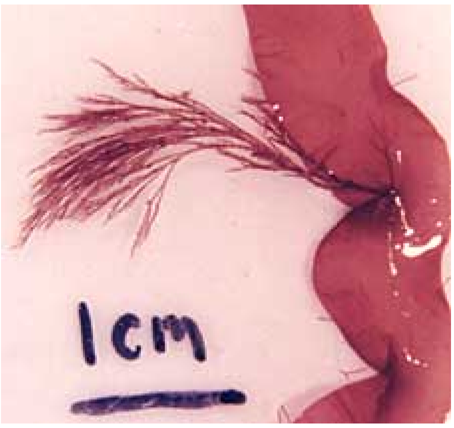

Image: *Polysiphonia subtilissima* epiphytic on *Grateloupia* (http://omp.gso.uri.edu)/.

The tufted, very delicate pink to pale-crimson alga, *Polysiphonia subtilissima*, with slender, much divided stems grows to ca. 4 cm high. It is typically epiphytic, found in the subtidal in sheltered, warm and muddy bays. The type locality is Cayenne, French Guiana (Silva et al. 1996). Its distribution includes Europe, Atlantic Islands, North America, Caribbean Islands, South America, Africa, Indian Ocean Islands, South-west Asia, South-east Asia, Australia, New Zealand and the Pacific Islands. In New Zealand it is often associated with oysters and mussel farms.

Polysiphonia senticulosa Harvey, 1862

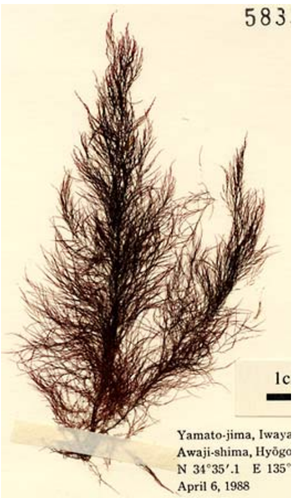

Image: www.lib.kobe-u.ac.jp

The red alga, *Polysiphonia senticulosa,* is a distinctive red to brownish purple colour (Nelson & Maggs 1996) that may be epiphytic and epilithic, and is abundant late winter/early spring. It is similar to *P. subtilissima* but distinguished by the width of upper axes. It was first described from Washington, USA, and has been reported from south-eastern Alaska to southern British Columbia and Australia. It has recently been recorded from Picton, New Zealand. It was possibly spread via shipping.

Macroalgae: Heterokontophyta

Asperococcus bullosus J.V. Lamouroux, 1813

Image: *Asperococcus bullosus* epiphytic on seagrass, www.algaebase.org

This hollow, intestine-like, brown alga, *Asperococcus bullosus*, is pale yellowish brown with a gelatinous texture. It may reach 50 cm in height and 5 – 10 cm width. The type specimen is from the Mediterranean coast of France and was first reported in New Zealand in 1957. It is also found in the North Atlantic, Baltic Mediterranean, Canary Islands, South Africa, Japan and Australia. It is an annual, typically present during February and inhabits sheltered, subtidal environments where it may be epiphytic on seagrass (D'Archino & Nelson 2006).

Chnoospora minima (Hering) Papenfuss, 1956

Image: www.coralreefnetwork.com

The warm-water, dichotomously branched alga, *Chnoospora minima*, is golden/grey-brown, wiry with sharply pointed branch tips, growing up to 20 cm in height. The type specimen is from Port Natal, South Africa but it has been reported from throughout the tropical and subtropical Indian, Pacific and Atlantic Oceans, and Caribbean Sea (Nelson & Duffy 1991). It inhabits both high and low intertidal exposed sites with morphological variation from wave action seen. *C. minima* was found in the Port of Underwood, Marlborough Sounds in 1990 where it is locally abundant but unattached on sandy mud substratum with a restricted distribution. Nelson & Duffy (1991) suggest it was an early introduction to New Zealand associated with shore whaling and American vessels between 1829 and 1839 in Port Underwood. Reproduction of *C. minima* occurs at temperatures between 18 – 26^{o}C (Nelson & Duffy 1991); the lower temperature in Port Underwood may inhibit reproduction, combined with oceanographic and physical barriers, spread of *C. minima* would likely be prevented.

Cutleria multifida (Turner) Greville, 1830 [also (JE Smith) Greville]

Image: www.horta.uac.pt

The brown alga, *Cutleria multifida*, has many synonyms including *Ulva multifida*. It is golden or greenish-brown with a soft flaccid texture, 20 – 30 cm high, irregularly dichotomously-branched, or split, into narrow segments. Its type locality is Yarmouth, Norfolk, England although it is found in Northern and Southern Europe, Southern Africa, Australia and New Zealand (http://data.gbif.org/species/13298592). It was first recorded in New Zealand in 1870. It occurs from the lower intertidal to subtidal on stones, shells, etc. in certain sheltered harbours. Its presence in ports and harbours suggests it was introduced via shipping during the 19th century (Adams 1983).

Mollusca (bivalves)

Crassostrea gigas Thunberg, 1793

Image: upload.wikimedia.org

The Pacific oyster, *Crassostrea gigas*, is an important aquaculture species throughout the world, including New Zealand. It has a white elongated shell, with an average size of 150-200 mm. The two valves are solid, but unequal in size and shape. The left valve is slightly convex and the right valve is quite deep and cup shaped. One valve is usually entirely cemented to the substratum. The shells are sculpted with large, irregular, rounded, radial folds. *C. gigas* is native to the Japan and China Seas and the northwest Pacific. It has been introduced to the west coast of both North and South America, the West African coast, the northeast Atlantic, the Mediterranean, Australia, New Zealand, Polynesia and Micronesia. It is cryptogenic in Alaska. *C. gigas* will attach to almost any hard surface in sheltered waters. Whilst they usually attach to rocks, the oysters can also be found in muddy or sandy areas. Oysters will also settle on adult oysters of the same or other species. They prefer sheltered waters in estuaries where they are found in the intertidal and shallow subtidal zones, to a depth of about 3 m. *C. gigas* settles in dense aggregations in the intertidal zone, resulting in the limitation of food and space available for other intertidal species. *C. gigas* has been present in New Zealand since the early 1960s. Little is known about the impacts of this species in New Zealand, but it is now a dominant structural component of fouling assemblages and intertidal shorelines in northern harbours of New Zealand and the upper South Island. *C. gigas* is now the basis of New Zealand's oyster aquaculture industry, having displaced the native rock oyster, *Saccostrea glomerata*.

Limaria orientalis (Adams & Reeve 1850)

This bivalve is native to eastern Australia and the tropical Indo-Pacific[9] and was first recorded in New Zealand in 1972 at Goat Island Bay, Leigh, north of Auckland (Grange 1974). By 1993 it had become so common around the entrance to the Waitemata Harbour and the adjacent Hauraki Gulf that it was one of the characteristic species of the benthic faunal assemblages (Hayward et al. 1997). It has also been recorded from the Bay of Islands and Coromandel (Cranfield et al. 1998). It is now common in the seabed around, and on the dropper ropes of, mussel farms in the Marlborough Sounds (NIWA, unpublished data). It has not been recorded in the ports of Nelson or Picton.

L. orientalis occurs in the low intertidal and subtidally to 20 m (references in Grange 1974). It has a white shell, bright red foot and gills, and an orange mantle and tentacles. It is capable of moving over the substratum using its muscular foot and can also swim, either by coordinated movements of the tentacles or by creating jets of water from the mantle cavity (Grange 1974). At rest it may for a nest of small stones or shell gravel, held together with byssus threads. Its impacts in its introduced range are unknown.

Theora lubrica Gould, 1861

Image: research.calacademy.org

The small bivalve (<15 mm), *Theora lubrica*, has a thin, elongated, transparent shell with fine concentric ridges visible. It is native to the Japanese and China Seas but has been introduced to the west coast of the USA, Australia and New Zealand probably via ballast water. It was first detected in New Zealand in 1971 (Cranfield et al. 1998) and has since been recorded from Lyttelton to the Bay of Islands. It typically inhabits muddy sediments and has been found as deep as 100 m. It is an indicator species for eutrophic and anoxic environments hence often found in estuarine type localities. It may have detrimental habitat modification effects becoming the dominant mollusc species (Boyd 1999) although it has been found in the diets of demersal fish (green back flounder and red gurnard) in Australia (Parry et al. 1995). It has been observed at densities of 370/0.1m^2 in Japan (Kikuchi & Tanaka 1978) and may liberate nitrogenous compounds from bottom sediments (Yamada & Kayama 1987).

[9] http://data.acnatsci.org/obis/search.php/16460 accessed 30/4/08

Porifera (sponges)

Halisarca dujardini (Johnston, 1842)

The encrusting cold-water sponge, *Halisarca dujardini*, is a cosmopolitan species distributed from the Arctic and Antarctica, the Subantarctic Islands, Australia, New Zealand, Chile, England to the Atlantic and Mediterranean. It probably arrived in New Zealand via hull fouling and/or ballast water pre-1973. It inhabits the shallow subtidal to a depth of 450 m depth. It has no known impacts and has been recorded from Auckland, Taranaki, Wellington, Dunedin and Bluff.

Urochordata (ascidians)

Ciona intestinalis Linnaeus, 1767

Image: dbtgr.hgc.jp

Ciona intestinalis is a solitary ascidian, commonly found in dense aggregations on rocks, algal holdfasts, seagrass, shells and artificial structures such as pylons, buoys and ships hulls. It usually hangs vertically upside-down in the water column, attached to hard surfaces. It is cylindrical, 100-150 mm in length with distinctive inhalant and exhalant apertures (siphons) having yellow margins and orange/red spots. The body wall is generally soft and translucent with the internal organs visible. They can also be hard and leathery due to heavy fouling. The type specimen of *C. intestinalis* was described from Europe by Linnaeus 1767. It is thought to have been introduced to Chile and Peru, the northern west coast of the USA, equatorial West Africa and South Africa, Australia and New Zealand. *C. intestinalis* is considered cryptogenic to Alaska, the east coast of the USA and Canada, Greenland, Iceland, Japan, China and south east Asia. It is often found in enclosed and semi-protected marine embayments and estuaries and although it occurs in the low intertidal and shallow subtidal zones, *C. intestinalis* clearly decreases in abundance with depth. Australian populations appear to be in decline, disappearing from port areas where the species had previously dominated in the 1950s-1960s and the same phenomenon has been observed in New England, USA. Its high filtration rates and large numbers can reduce water turbidity and food availability in shallow waters and it can out-compete native species for food and space. Since it appeared in southern California in 1917, native species of ascidians previously found in the harbours have disappeared or have become much rarer. It is known to be a nuisance fouling species in aquaculture facilities such as mussel rope culture, oyster farms and suspended scallop ropes in Nova Scotia and other parts of North America, the Mediterranean, South Africa, Korea and Chile, and recently in the Marlborough Sounds, New Zealand.

Eudistoma elongatum (Herdman, 1886)

A single colony of this colonial ascidian was found at Parapara Inlet, Golden Bay in December 2005 but there have been no subsequent reports from the top of the South Island. The species is native to the central east coast of Australia and was reported on oyster farms in Houhora Harbour, Northland in early 2005. It has subsequently been reported from oyster racks and natural substrata such as rocky shores, intertidal sand and mud flats and eelgrass beds in Parengarenga Harbour, Rangaunu Harbour, and the Bay of Islands, where it is well established, forming unsightly growths of white, sausage-like colonies up to 2 m long (more usually up to 30 cm) and 15-30 cm in diameter. It has been reported growing on aquaculture (oyster) stock, where it may potentially increase costs associated with cleaning stock for sale and perhaps compete with stock for food. Its ability to establish in the top of the South Island is not known at present but may be temperature-limited. NIWA is currently investigating the biology, ecology and potential methods of control for this species in the Bay of Islands.

POTENTIAL INVASIVE SPECIES

Although not recorded from the Marlborough Sounds/Tasman region during surveys undertaken by NIWA, the following species have the potential to invade this region.

Dinoflagellate

Gymnodinium catenatum Graham, 1943

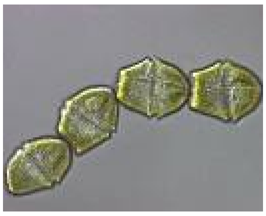

Image: http://www.marine.csiro.au

The presence of the toxic dinoflagellate, *Gymnodinium catenatum*, was investigated in 2001 in the Port of Nelson with no resting cysts or motile cells detected (Taylor & MacKenzie 2001). *G. catenatum* is the only known unarmoured dinoflagellate that produces toxins responsible for PSP (Paralytic Shellfish Poisoning). It also poses threats to wild and aquaculture shellfish industries, due to economic losses resulting from farm closures.

Macroalgae: Rhodophyta

Grateloupia turuturu (Montagne) Howe

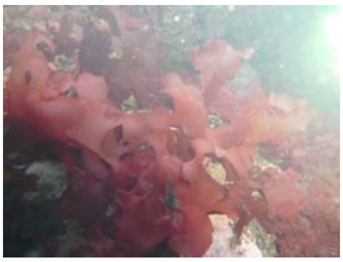

Image: S Miller, NIWA

The invasive red alga, *Grateloupia turuturu*, was discovered in Wellington in 2007. A population of this species is present in close proximity to the ferry terminal at Kaiwharawhara, Wellington. There is concern that it may be transported via ferry hull fouling to the Port of Picton. Introduced from Japan, it was first observed in North America in 1996 more than likely introduced as spores via ballast water discharge. It can block sunlight to understorey species and reproduces easily.

CRYPTOGENIC SPECIES

Cryptogenic species (those whose status as native or introduced cannot be determined with certainty because of inadequate knowledge of their taxonomy or natural distributional range) present a special problem in detecting and managing pest incursions. From a precautionary point of view, it would be wise to treat them in the same way as known introduced species if they show sudden changes in distribution or abundance. However, there may be limitations to this if their status as cryptogenic prevents them from being declared as "Unwanted Organisms", as occurred with *Didemnum vexillum*, whose status as native or introduced is still in dispute (Mike Page, NIWA, pers. comm.).

RESULTS OF THE BASELINE SURVEYS

The following is derived from Inglis et al. 2006a and b. Descriptions of the non-indigenous species recorded in locations surveyed in the top of the South Island are given above.

The repeat survey of the Port of Nelson (December 2004) recorded 257 species or higher taxa, including 13 non-indigenous species (Tables 1 and 12). Although many species also occurred in the initial, January 2002 baseline survey of the port, the degree of overlap was not high. Around 52% of the native species, 46% of non-indigenous species, and 62% of cryptogenic species recorded during the repeat survey were not found in the earlier survey. This is not simply attributable to the greater sampling effort in the second survey. The species assemblage in each survey was characterised by high diversity, a comparatively large proportion of uncommon species, and patchy local distributions that are typical of marine biota. As a consequence, the estimated numbers of undetected species were comparatively high. In the initial baseline survey, for example, six of the 13 non-indigenous species (46%) were each found in just a single sample. The rate of recovery of two of these species (*Bugula flabellata* and *Celleporaria nodulosa*) increased in the second survey along with the increased sampling effort, but the other four species were either undetected in the second survey (*Schizoporella errata* and *Anguinella palmata*) or were again found in just a single sample (*Cryptosula pallasiana* and *Lafoeina amirantensis*). Furthermore, of the six non-indigenous species that were detected only in the second survey, three (50%) were present in just a single sample. This makes it difficult to determine if the new records in the second survey represent incursions that occurred after the first survey or, rather, are species that were present, but undetected during the first survey due to their sparse densities or distribution.

Similarly, the absence in the second survey of six nonindigenous species that were recorded in the first survey (the polychaete *Polydora hoplura*, the ascidian *Ciona intestinalis* and the bryozoans *Conopeum seurati, Electra angulata, Schizoporella errata* and *Anguinella palmata*) could be explained either by sampling error (i.e. chance failure to detect the species due to spatial or temporal variability in their distribution) or local extinction since the initial baseline survey. For most of these species, sampling error is the most likely explanation. *Anguinella palmata*, *Ciona intestinalis*, *Conopeum seurati*, *Cryptosula pallasiana*, *Schizoporella errata*, and *Polydora hoplura* have all been present in New Zealand for more than 40 years and have been recorded in other studies in the Nelson region (Cranfield et al. 1998). Their absence from one, or other, of the baseline surveys is most likely to be attributed to low prevalence during the time of the survey. However, although *Electra tenella* and *Synthecium campylocarpum* are known from other locations in New Zealand, the specimens recorded from Nelson represent new distribution records and, therefore, are potentially recent incursions.

The repeat survey of the Port of Picton recorded 249 species or higher taxa, including 167 native species, 11 non-indigenous species, 36 cryptogenic species and 35 species indeterminata (Tables 1 and 20). Although many species also occurred in the initial, December 2001 baseline survey of the port, the degree of overlap was not high. Around 46% of the native species, 55% of non-indigenous species, and 50% of cryptogenic species recorded during the repeat survey were not found in the earlier survey. This is not simply attributable to the greater sampling effort in the second survey. The species assemblage in each survey was characterised by high diversity, a comparatively large proportion of uncommon species, and patchy local distributions that are typical of marine biota. As a consequence, the estimated numbers of undetected species were comparatively high. In the initial baseline survey, for example, all of the non-indigenous species except *Undaria pinnatifida* were found in four or fewer samples. Whilst the increased sampling effort in the second survey recorded six non-indigenous species that were not found in the first survey, it did not markedly improve the rate of recovery of the six species recorded infrequently in the first survey. Two of these six (*Griffithsia crassiuscula* and *Halisarca dujardini*) were detected in only five samples in the repeat survey and two of them (the polychaetes *Polydora hoplura* and *Dipolydora armata*) were not recorded in the second survey. Furthermore, of the 6 non-indigenous species that were detected in the second survey but not the first, 3 (50%) were present in just a single sample (*Tricellaria inopinata, Cryptosula pallasiana* and *Eudendrium generale*), and all six were present in five or fewer samples. This makes it difficult to determine if the new records in the second survey represent incursions that occurred after the first survey or, rather, are species that were present, but undetected during the first survey due to their sparse densities or distribution. Similarly, the absence of the non-indigenous annelids *Dipolydora armata* and *Polydora hoplura* in the second survey could be explained either by sampling error or local extinction since the initial baseline survey.

In each case, additional information can be used to address this problem. Three of the nonindigenous species recorded only in the second survey – *Bugula neritina, Cryptosula pallasiana* and *Theora lubrica* – have been present in New Zealand for more than 30 years (>100 years in the case of *C. pallasiana*) and have either been recorded previously from Picton Harbour (*B. neritina, C. pallasiana*) or are known from nearby areas (*T. lubrica*) (Gordon and Matawari 1992; Cranfield et al. 1998). Each of these species was present in fewer than 5 samples in the second survey. It seems likely, therefore, that they were present in Picton during the first survey, albeit at small densities, and were not detected by the survey because of their rarity. Similarly, *Tricellaria inopinata* has a cosmopolitan distribution, has been recorded from elsewhere in the South Island (in Lyttelton Harbour, Gordon and Matawari 1992), and is likely to have been present but undetected during the initial survey of Picton. The two non-indigenous species detected in the first but not the repeat survey, *Dipolydora armata* and *Polydora hoplura,* are also well-established in New Zealand and known from locations near Picton (Marlborough Sounds and Wellington Harbour, Read 1975; Cranfield et al. 1998) and are likely to have been present in Picton despite not being encountered in the re-survey. The remaining two species that were detected in the repeat, but not in the initial survey – *Spirobranchus polytrema* and *Eudendrium generale* – were new records for New Zealand in the initial baseline surveys, have relatively limited national distributions and are new records for Picton in the repeat survey. Although the evidence is only circumstantial, these two species are the most likely to represent new incursions.

Pathways for the introduction and translocation of non-indigenous species

BACKGROUND

Hewitt et al. (2004) listed nine categories of potential pathways for the introduction of non-indigenous marine species (ships; moveable structures; other craft; aquaculture fisheries; wild fisheries; aquarium industry and public aquaria; marine leisure tourism, research and education; other: Table 3), each of which contains several potential pathways of relevance to New Zealand, and more than 20 of these pathways are considered “active”. Currently, the most important pathways for the introduction of new, non-indigenous marine species to New Zealand are ballast water, fouling of the hulls and other below-water parts of ships (sea chests, bow-thrusters, intake grills, etc) and the aquarium trade (Dodgshun et al. 2007). Deliberate introductions have been a source of non-indigenous species in the past, the example most relevant to the top of the South Island being *Spartina anglica* (Partridge 1987). Once new species have arrived, these same vectors, together with the transfer of aquaculture equipment and stock, can distribute them within New Zealand.

Accidental or intentional release of organisms from private or public aquaria may represent a small but overlooked pathway for introduction of non-indigenous species. Ther are several examples of aquarium species that have become established in the wild outside their natural range, the best-known of which is the invasive alga *Caulerpa taxifolia*, native to northern Australia but now present in southern Australia, the Mediterranean and the USA. A related species, *C. racemosa*, is also invasive in the Mediterranean and has been reported on sale in a pet shop in Nelson (Hernando Acosta, Auckland University of Technology, pers. comm.).

Ballast water is perhaps the most important mechanism of introduction at present, and the most general in terms of the types of organism that may be carried (Carlton 1985, Dodgshun et al. 2007). Vessels are expected to comply with the Voluntary Controls on the Discharge of Ballast Water in New Zealand[10]. 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. 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.

New Zealand received 4.4 million tonnes of ballast water in 2002 (an increase of 11% on the previous year: Hewitt et al. 2004) and all ports of first entry received discharges. The major contributors in terms of types of shipping were bulk carriers and tankers (which tend to arrive empty to New Zealand and load cargo for export) and more than a quarter of the total originated in the northwest Pacific. Australia is also an important source of ballast water discharged in New Zealand. The origin of a further quarter of the total is unrecorded, indicating the incompleteness of records of ballast water discharge in New Zealand.

Ballast exchange requirements do not currently apply to ballast water that is taken up domestically. Consequently, ballast water is likely to represent an important mechanism for

[10] www.fish.govt.nz/sustainability/biosecurity

translocation of non-indigenous marine species among different ports and coastal regions within New Zealand.

Historically, hull fouling has represented the major route for introductions of marine species to New Zealand, with an estimated 69% of accidental introductions arriving via this vector (Cranfield et al. 1998). Increasing use of ballast water and improved antifouling practices have, however, somewhat reduced its relative importance today. Nevertheless, Dodgshun et al. (2007) list international and domestic commercial shipping services, tourist and cruise vessels (particularly those visiting high value areas such as Fiordland and the Subantarctic Islands), fishing vessels, moored recreational vessels and barges as key fouling pathways.

The majority of merchant vessels arriving in New Zealand in 2002 had good maintenance schedules and operated at high speeds, which minimised external hull fouling (James & Hayden 2000). However, these vessels contain a range of niche habitats on their hulls, such as sea chests (recesses housing water intakes for ballasting, engine cooling and fire fighting, and covered with a grill with apertures of slots 15-25 mm wide and up to 250 mm long; Dodgshun et al. 2007), other intakes and grills, bow-thrusters and "dry-docking support strips" (areas of the hull on which it rests during dry-docking and antifouling and which are consequently not treated with antifoulant). These habitats may contain much heavier fouling than more exposed parts of the hull (Coutts et al. 2003, Coutts & Taylor 2004).

Slower-moving international vessels, such as barges, drilling platforms and floating docks, or those that may remain berthed or anchored for long periods, such as cable-laying vessels, survey vessels or cruise ships, are particularly prone to fouling (Dodgshun et al. 2007). They may, therefore, represent particularly significant vectors for introduction (as evidenced by the recent introduction of brown mussels [*Perna perna*] from the Ocean Patriot oil rig that defouled in Golden Bay[11]). The hull-maintenance schedules of international recreational yachts vary considerably and these can also represent an important risk. Floerl et al. (NIWA, unpublished data) encountered fouling organisms on 82% of 182 international yachts arriving at four entry points to New Zealand (including Nelson). As with commercial vessels, niche habitats on the hulls of these yachts contained a disproportionate diversity and biomass of fouling organisms.

Compared to international vessel traffic, local traffic is likely to include a larger proportion of slow-moving vessels, vessels that have spent long periods at anchor or berth, and vessels with poor antifouling maintenance. These factors, and the larger volume of local traffic, suggest that local traffic probably represents a disproportionately large risk of translocation of organisms once they have arrived in New Zealand. The case of the dispersal of the colonial ascidian *Didemnum vexillum* (whose status as an introduced or native organism is still unclear: Mike Page, NIWA, pers. comm.) by local domestic movement of a barge (the *Steel Mariner*) provides an extreme example (see Coutts & Forrest 2007).

The records of fishing vessel movements obtained during the ongoing MAF BNZ study "Evaluation of vessel movements among New Zealand ports and marinas (carried out by NIWA as project number ZBS2005-13) shows that in the top of the South Island, Nelson is the main source port, followed by Picton, Havelock, Kaikoura, Motueka, Tarakohe and Westhaven Inlet (Table 4). These data (based on questionnaires mailed to vessel operators) are likely to be incomplete and refer only to vessels less than 99 tonnes. They do not include trips where the vessel returned to its point of origin without stopping at another port. Nevertheless, they provide some indication of the relative numbers of vessels departing from

[11] Following clean-up dredging, MAF BNZ has announced that the risk of establishment of *Perna perna* in Golden Bay is negligible: see http://www.biosecurity.govt.nz/media/20-05-08/dredging

each port and the geographical range of destination ports. For example, the 16 vessels departing from Nelson travelled as far as Dunedin, Greymouth, Lyttelton, Milford Sound, Timaru and Manukau. Vessels from Picton, Tarakohe and Westhaven Inlet also travelled to ports outside the top of the South Island.

Introductions of non-indigenous species to New Zealand on aquaculture stock and equipment are considered a low risk (Hewitt et al. 2004) and there are apparently no records of such species being introduced to New Zealand in this way (Dodgshun et al. 2007). A number of introduced species (e.g. *Undaria pinnatifida*, the bivalve *Limaria orientalis* and the solitary ascidians *Ciona intestinalis* and *Styela clava*) are, however, known to colonise floating structures, including marine farms, and aquaculture facilities may therefore act as reservoirs for their secondary spread (Dodgshun et al. 2007).

Dodgshun et al. (2007, their Figure 9) have mapped existing and proposed marine farming regions in New Zealand, showing the main pathways of movement of equipment, vessels, spat, seed stock and mussels. The main source of these vectors to aquaculture areas in Tasman and Golden Bays are mussel spat and seed from Kaitaia. The Marlborough Sounds aquaculture areas receive spat from Kaitaia (either direct or ongrown in Coromandel/Firth of Thames) and spat ropes or single-seed from Kawhia/Aotea Harbours. Single seed mussels are sent from the Sounds to Coromandel/Firth of Thames, and there is also exchange between the Sounds and Golden/Tasman Bays. There is a voluntary ban on transfers of single-seed mussels from the Sounds to Stewart Island.

As discussed above, the Cawthron Institute has developed a risk-assessment model that integrates potential natural and human-mediated pathways for the introduction of non-indigenous species to the region (Acosta et al. 2006b). The project has included characterisation of recreational boating pathways, from which the region has been divided into subregions. Each subregion was then categorised by a "risk priority number", calculated as the product of: probability of infection; connectivity with other subregions; and probability of detection of an incursion. This ranking allows research and surveillance to be focussed on the subregions with highest risk.

POSSIBLE VECTORS FOR THE INTRODUCTION AND TRANSLOCATION OF NON-INDIGENOUS SPECIES TO AND FROM PORT NELSON

Background

The following is derived from the reports of the first and second baseline surveys (Inglis et al. 2005b and 2006a).

General features of the port

The Port of Nelson currently consists predominantly of linear berth face, and incorporates berthage operated by Port Nelson Ltd (www.portnelson.co.nz) and several independent fishing companies. These include two of New Zealand's largest operators, Amaltal and the Sealord Group. There are two heavy-duty wharves: the remodelled Main Wharf and Brunt Quay; and two multipurpose berths: McGlashen Quay and Kingsford Quay (Figure 2). There are also three designated lay-up berths for ship repair work and refitting. The main independently operated berth is McKellar Quay, with several other smaller wharves and facilities designated for use by fishing fleets. Port Nelson is Australasia's largest fishing port. Nelson interests hold over half of New Zealand's sustainable catching rights and, as such, this port is used heavily by various fishing vessels (www.portnelson.co.nz). In 2000, there were 79 registered fishing vessels in Port Nelson (Sinner et al. 2000). Dodgshun et al. (2007) cite a value of 108 registered fishing vessels in Tasman Bay (Nelson) (this figure was current at

2002 – see p. 6 of their report). Berth construction is a mixture of concrete and wood decking on Australian hardwood or concrete piles, with some solid concrete berths (lay-up berths). Table 5 summarises berthage facilities at Port Nelson. The port has MAF inspection and quarantine, and customs clearance facilities.

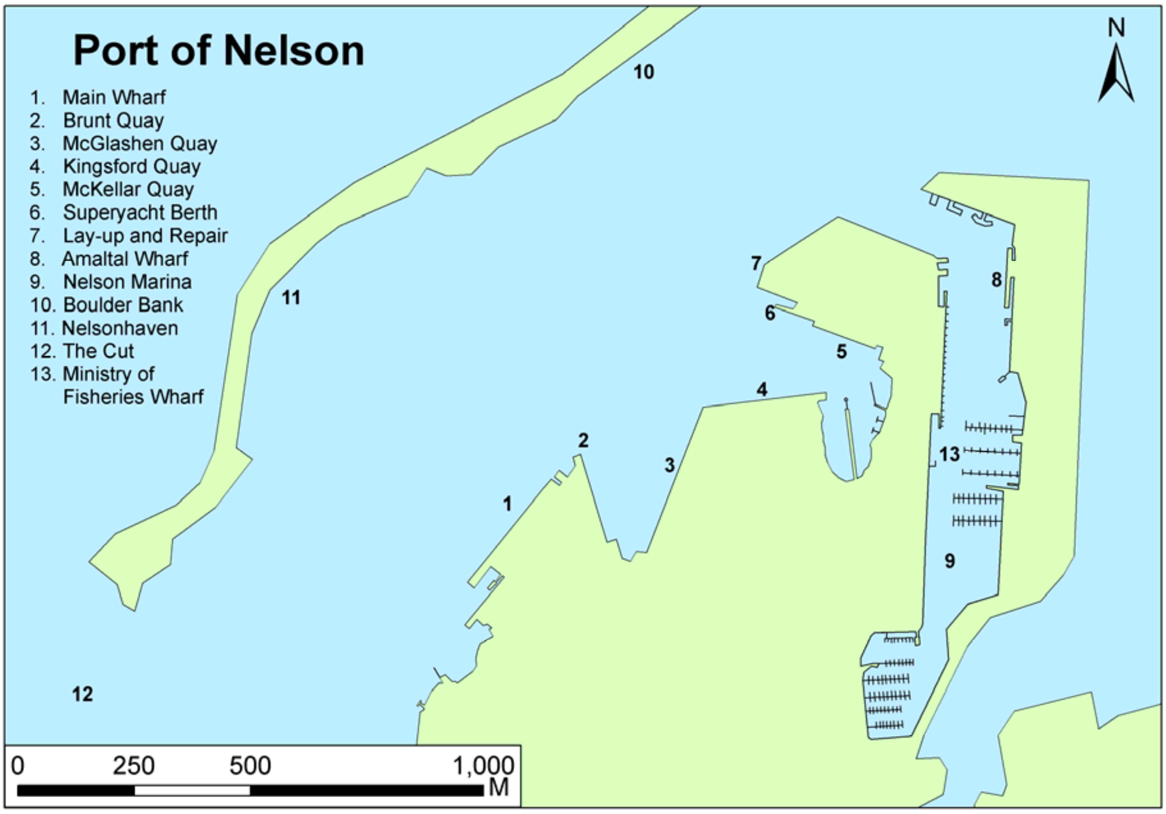

Figure 2 Map showing features of Port Nelson referred to in the text (from Inglis et al. 2006a).

There is a recreational marina east of the port in Dixon Basin. During the 1980's the Nelson Harbour Board dredged the area between Vickerman Street reclamation and the Matai River to create Dixon Basin. The marina currently has 515 pontoon berths (plus ca 30 pole moorings and ca 30 swing moorings) for vessels up to 20 m in length (www.ncc.govt.nz). Additional berths have been constructed over the past few years and it is expected that the marina will reach full capacity in two to three years. The port also contains a superyacht berth where yachts larger than 20 m are able to moor. Vessels unable to be berthed immediately in the port may anchor outside the harbour in Tasman Bay, off the Boulder Bank approximately 1 nautical mile north of The Cut.

Within the port, there is on-going annual maintenance dredging at the approach and entrance channels (out to 1.8 km into Tasman Bay from the entrance) and in the harbour (inner harbour channels, Dixon Basin approach channel, Dixon Basin and shipping berths) to clear debris that derives mainly from the Maitai River and Nelson Haven sand banks, with an average of 50,000 m^3 of spoil removed per annum (Port Nelson Ltd 2005). The port is dredged to a minimum depth of 9.8 m. The spoil is taken out into southern Tasman Bay where it is deposited in consented spoil grounds approximately 3.5 km west of the harbour entrance (Port Nelson Ltd 2005). In addition to maintenance dredging, capital dredging of 50,000 m^3 was conducted in 2002-2003 to increase the approach channel and inner harbour depth by 300 mm. The Tasman Bay spoil grounds also received the dredge spoil originating from additional berth constructions at the Nelson marina (in 2005, 10,000 m^3 from the marina was deposited in these spoil grounds).

Capital works since the port baseline survey in January 2002 have included a squaring-off of the west end of Brunt Quay wharf, completed in June 2005. The new section has a concrete deck and steel piles. Each year approximately five to ten piles are replaced or encased in concrete in general maintenance works, mostly on Main Wharf North and some on McGlashen Quay. In terms of future development, Port Nelson Ltd is proposing a small reclamation behind Main Wharf South.

Imports and exports

Port Nelson is a net export facility; a higher volume of cargo is loaded than unloaded (Taylor 1998). In 2004, cargo volume was 2.5 million tonnes and increased to over 2.6 million tonnes in 2006 and 2007 (Port Nelson Ltd 2007).

Increased containerisation of export apples and timber products resulted in a container throughput of 51,128 TEU[12] in 2004, rising to 71,815 TEU in 2007 (Port Nelson Ltd 2007). The volumes and value of goods imported and exported through the Port of Nelson are summarised below. These data describe only cargo being loaded for, or unloaded from, overseas ports and do not include domestic cargo (Statistics New Zealand 2006b). Also available from Statistics New Zealand (2006a) was a breakdown of cargo value by country of origin or destination and by commodity for each calendar year; we analysed the data for the period 2002 to 2005 inclusive (i.e. the period between the first and second baseline surveys).

Imports

The weight of cargo unloaded at the Port of Nelson has increased each year since the 2002 initial baseline survey, with 139,461 tonnes gross weight being unloaded in the year ended June 2005 (Statistics New Zealand 2006b). This represents an increase in weight of almost 43% compared to the year ending June 2002. Overseas cargo unloaded at the Port of Nelson accounted for less than 1% both by weight and by value of the total overseas cargo unloaded at New Zealand's seaports.

The Port of Nelson received imports from 75 countries of initial origin between 2002 and 2005 inclusive (Statistics New Zealand 2006a). During this time, the Port of Nelson imported most of its overseas cargo by value from Japan (45%), Australia (16%), Thailand (7%), China (4%) and France (4%). Japan and Australia were ranked first and second, respectively, each year. Thailand ranked third every year except 2005, where China was third and Thailand was fourth. France, Germany and the United States also ranked in the top five in some years (Statistics New Zealand 2006a).

Exports

In the year ending June 2005, the Port of Nelson loaded 1,187,575 tonnes of cargo for export (Statistics New Zealand 2006b). This represented an increase on 2003 and 2004 figures, but a drop of 3.5% compared to the year ending June 2002. For the financial years ending June 2002 to 2005, overseas cargo loaded at the Port of Nelson accounted for around 5% by weight and around 3% by value of the total overseas cargo loaded at New Zealand's seaports.

The Port of Nelson loaded cargo for export to 103 countries of final destination between 2002 and 2005 inclusive (Statistics New Zealand 2006a). During this time, the Port of Nelson exported most of its overseas cargo by value to Australia (20%), Japan (19%), the USA

[12] TEU = twenty foot equivalent unit. This is a standard size of container and a common measure of capacity in the container logistics business.

(10%), China (9%) and unknown destinations in the European Union (8%). Australia ranked first and Japan second in all years except 2002, when their ranks were reversed. The USA and China ranked third or fourth each year except in 2004 when the USA ranked fifth and "Destination unknown – EU" ranked third (Statistics New Zealand 2006a).

Shipping movements and ballast discharge patterns in Port Nelson

Vessels are expected to comply with the Voluntary Controls on the Discharge of Ballast Water in New Zealand (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. According to Inglis (2001), a total volume of 157,000 m^3 of ballast water was discharged in Port Nelson in 1999, with the largest country-of-origin volumes of 43,099 m3 from Japan, 9,335 m^3 from Taiwan, 3,243 m^3 from Australia, and 100,238 m^3 unspecified.

Port Nelson Ltd recorded 997 vessel arrivals (over 100 GT) in the 2007 financial year, slightly lower than the 1,012 arrivals in the 2006 financial year and down from 1,470 in 2003 (Port Nelson Ltd 2007). As well as a high volume of domestic shipping traffic, Port Nelson handles vessels from a range of international destinations.

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

International vessel movements

Based on an analysis of the LMIU 'SeaSearcher.com' database, there were 311 vessel arrivals to the Port of Nelson from overseas ports between 2002 and 2005 inclusive (Table 6). These came from 28 different countries represented by most regions of the world. The greatest number of overseas arrivals during this period came from the following areas: Australia (75), Japan (70), the northwest Pacific (42), Pacific Islands (29), and the east Asian seas (20; Table 6). The previous ports of call for 12 of the international arrivals were not stated in the database. Vessels arriving from Australia came mostly from ports in Queensland (22 arrivals) and New South Wales (21), followed by 15 arrivals from Victoria, 8 from Tasmania, 5 from South Australia and 4 from Western Australia (Table 7). The major vessel types arriving from overseas at the Port of Nelson were general cargo vessels (116 arrivals), bulk /cement carriers (106 arrivals), and container ships and ro/ro (43 arrivals; Table 6).

According to the 'SeaSearcher.com' database, during the same period 849 vessels departed from the Port of Nelson to 28 different countries, also represented by most regions of the world. The greatest number of departures for overseas went to Australian ports as their next port of call (376 movements) followed by Japan (274) and the northwest Pacific (90; Table 8). The major vessel types departing to overseas ports from the Port of Nelson were container ships and ro/ro (358 movements), passenger / vehicle / livestock carriers (266), bulk / cement carriers (103) and general cargo vessels (93; Table 8).

Domestic vessel movements

The 'SeaSearcher.com' database contains movement records for 2,420 vessel arrivals to the Port of Nelson from New Zealand ports between 2002 and 2005 inclusive. These arrived from 16 different ports in both the North and South Islands (Table 9). The greatest number of domestic arrivals during this period came from Wellington (761 arrivals), Lyttelton (494 arrivals), Napier (223 arrivals), Nelson (i.e. closed-loop trips; 212 arrivals), and Auckland (158 arrivals). Container ships and ro/ro's were by far the dominant vessel type arriving at the Port of Nelson from other New Zealand ports (1158 arrivals), followed by general cargo vessels (444 arrivals), passenger / vehicle / livestock carriers (266 arrivals), bulk / cement carriers (247 arrivals) and fishing vessels (183 arrivals; Table 9).

During the same period, the 'SeaSearcher.com' database contains movement records for 1,876 vessel departures from the Port of Nelson to 17 New Zealand ports in both the North and South Islands. The largest numbers of domestic movements from the Port of Nelson travelled to Wellington (439 movements), Napier (255), Tauranga (246) and Nelson (i.e. closed-loop trips; 212 departures; Table 10). Container ships and ro/ro's dominated the vessel types leaving the Port of Nelson on domestic voyages (841 movements), followed by general cargo vessels (466 movements), bulk / cement carriers (250 movements) and fishing vessels (193 movements; Table 10).

Possible vectors for the introduction of non-indigenous species

The non-indigenous species located in the Port of Nelson are thought to have arrived in New Zealand via international shipping. They may have reached the Port of Nelson directly from overseas or through domestic spread (natural and/or anthropogenic) from other New Zealand ports. Table 11 indicates the possible vectors for the introduction of each NIS recorded from the Port of Nelson during the baseline port surveys. Likely vectors of introduction are largely derived from Cranfield et al. (1998) and expert opinion. They suggest that only one of the 19 NIS (5%) probably arrived via ballast water, 13 species (68%) were most likely to be associated with hull fouling, one species (5%) is suspected to have arrived on drift plastic and four species (22%) could have arrived via either hull fouling or ballast water.

Assessment of the risk of new introductions to the port movements

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

Between 2002 and 2005, there were 311 vessel arrivals from overseas to the Port of Nelson. The greatest number of these came from Australia (75, including 49 from southeastern Australia), Japan (70), the northwest Pacific (42, predominantly from China and Korea) and the Pacific Islands (29; Table 6). With the exception of the Pacific Islands, most of this trade is with ports from other temperate regions that have coastal environments similar to New Zealand's.

Bulk carriers and tankers that arrive empty carry the largest volumes of ballast water. In the Port of Nelson these came predominantly from the northwest Pacific (35 visits), Japan (33 visits) and Australia (29 visits; Table 6). Smaller, slower moving vessels, such as barges and fishing boats, tend to carry a greater density of fouling organisms than faster cargo vessels. In the port of Nelson, these came predominantly from Australia and undisclosed locations (Table 6).

Based on the shipping patterns described above, shipping from southern Australia, the northwest Pacific (predominantly China and Korea) and Japan present the greatest risk of introducing new non-indigenous species to the Port of Nelson. Because of the relatively short transit time, shipping originating in southern Australia (particularly Victoria and Tasmania) carries, perhaps, the greatest overall risk. Furthermore, six of the eight marine pests on the New Zealand Register of Unwanted Organisms are already present in southern Australia (*Carcinus maenas*, *Asterias amurensis*, *Undaria pinnatifida*, *Sabella spallanzanii*, *Caulerpa taxifolia*, and *Styela clava*). The native range of other two species – *Eriocheir sinensis* and *Potamocorbula amurensis* – is the northwestern Pacific, including China and Japan.

Assessment of translocation risk for introduced species found in the port

Between 2002 and 2005, vessels departing from the Port of Nelson travelled to 16 other ports throughout New Zealand. Wellington, Napier and Tauranga were the next ports of call for the most domestic vessel movements from Nelson (Table 10). Although many of the non-indigenous species found in the re-survey of the Port of Nelson have been recorded in other locations throughout New Zealand (Table 12), they are not universally present in the other ports. There is, therefore, a risk that species established in the Port of Nelson could be spread to other New Zealand locations.

Of greatest concern is the one species present in Nelson that is on the New Zealand Register of Unwanted Species: the invasive alga *Undaria pinnatifida*. *Undaria* has been present in New Zealand since at least 1987 and has spread through shipping and other vectors to 11 of the 16 ports and marinas surveyed during the baseline surveys (the exceptions being Opua, Whangarei Port and Marina, Gulf Harbour Marina and Tauranga Port). Until recently, it was absent from the Ports of Taranaki (New Plymouth) and Tauranga. Mature sporophytes were discovered in the Port of Taranaki during the repeat baseline port survey there in March 2005. Some isolated sporophytes have also been discovered independently on rocky reefs near the Port of Tauranga, but the alga does not appear to be established in the port itself. Bulk carriers, general cargo and container vessels regularly ply between Nelson and the Port of Tauranga. There is, therefore, a risk that it could be spread to this location by shipping from Nelson.

The Port of Nelson receives regular traffic from Lyttelton Harbour, by a range of vessel types. Lyttelton is one of only two locations nationwide that the clubbed ascidian, *Styela clava*, has been recorded from outside the Hauraki Gulf; the other being Tutukaka Marina (Gust et al. 2006). This species is on the New Zealand Register of Unwanted Species, and is considered a significant pest of aquaculture (particularly long-line mussel culture). There is concern about the potential for it to spread to important mussel growing areas in the Marlborough Sounds (which lies on the shipping route between Lyttelton and Nelson) and the Coromandel.

Because they are fouling organisms, the risk of translocating *U. pinnatifida* from Nelson and *S. clava* into Nelson is highest for slow-moving vessels, such as yachts and barges, and vessels that have long residence times in port. In the Port of Nelson, cargo and bulk (including fuel) carriers, recreational craft, and seasonal fishing vessels that are laid-up for significant periods of time pose a particular risk for the introduction and spread of these species.

Slow-moving vessels may also pose a particular risk for the spread of the two non-indigenous species recorded from Nelson that are new to New Zealand. Both the bryozoan *Celleporaria nodulosa* and the hydroid *Lafoeina amirantensis* have relatively restricted distributions nationwide and are likely to be transported as hull fouling (*Lafoeina amirantensis* may also be transported in ballast water). *Celleporaria nodulosa* was recorded in the Ports of Nelson and Gisborne in the first baseline survey, and in Nelson and Timaru in the second baseline surveys of Group 2 ports. Although it is known to have a widespread distribution on the southeastern coast of Australia, little is currently known about this species' native range or impacts in its introduced range. *Lafoeina amirantensis* was first discovered in New Zealand waters from the Port of Nelson, and was not detected in any of the fifteen other locations searched nationwide. It is known to occur in South Australia and the Seychelles, although details of its native and introduced range and ecological impacts are unknown.

Management of existing non-indigenous species in the port

More than half of the NIS detected in this survey of Nelson appear to be well established in the port. However, there were five NIS recorded in this survey that were recorded from only one site. They included three species that were not recorded during the initial baseline survey of Nelson (the polychaete worm *Hydroides elegans*, the bryozoan *Electra tenella*, and the hydroid *Filellum serpens?*) and two species that were present in only a single sample each in the initial baseline survey of Nelson (the hydroid *Lafoeina amirantensis* and the bryozoan *Cryptosula pallasiana*). With the exception of *C. pallasiana*, all of these species occur in no, or few, other New Zealand ports, and thus do not appear to be widely distributed in New Zealand. An attempt to eradicate or control these species is warranted only if their distribution in the port is limited, there is potential for them to cause significant harm should they spread, and management measures are likely to be effective. *Hydroides elegans* is known to be a problem fouling species that can cause overgrowth of native species and densely cover submerged marine structures, as occurred in early 2008 (NIWA, pers. obs.). There is only limited information about potential impacts of the other species.

POSSIBLE VECTORS FOR THE INTRODUCTION AND TRANSLOCATION OF NON-INDIGENOUS SPECIES TO AND FROM PORT OF PICTON

Background

The following is derived from the reports of the first and second baseline surveys (Inglis et al. 2005c and 2006b).

General features of the port

The Port of Picton is located at the head of the sheltered Queen Charlotte Sound, on the northeastern tip of the South Island of New Zealand (14° 17'S, 174° 00'E). The inner part of the Sound is generally over 20 m in depth. The minimum depth in the main channel west of Long Island is 13.4 m, whilst the alternative channel to the east of Long Island has a minimum water depth of 19.2 m. Neap tidal range is 0.6 m and spring tidal range 1.7 m[13].

The head of Picton Harbour is divided into two bays by Kaipupu Point, with the Port of Picton including facilities in both bays. The Port of Picton is currently run by Port Marlborough NZ Ltd (www.portmarlborough.co.nz), established in 1988. It is a relatively small shipping port, but has berths serving both road and rail traffic for the Cook Strait interisland ferry services. The port also has wharves for water taxis, commercial launches, vessels at anchor, and large visiting recreational vessels. Vessels unable to be berthed immediately in the port may anchor inside the Sound west of Mabel Island (41°16'S, 174°00.7'E) in 25 m of water. Dodgshun et al. (2007) cite a value of 106 registered fishing vessels in the Marlborough Sounds, including Picton (this figure was presumably current at the time of their report).

The main port activity takes place at Picton, situated at the head of the eastern bay where there are a number of finger wharves including three ferry terminal berths and the Waitohi

[13] http://portmarlborough.co.nz/Port%20Facilities/Picton%20Harbour

Wharf (Figure 3). Waitohi Wharf is a general-purpose finger wharf providing berths and facilities for overseas and coastal cargo vessels – mainly those involved in coastal trading (salt loading, cement discharge), fishing and those which sail the Cook Strait. The wharf also serves as the berth for passenger cruise ships, accommodating vessels up to 265 m long.

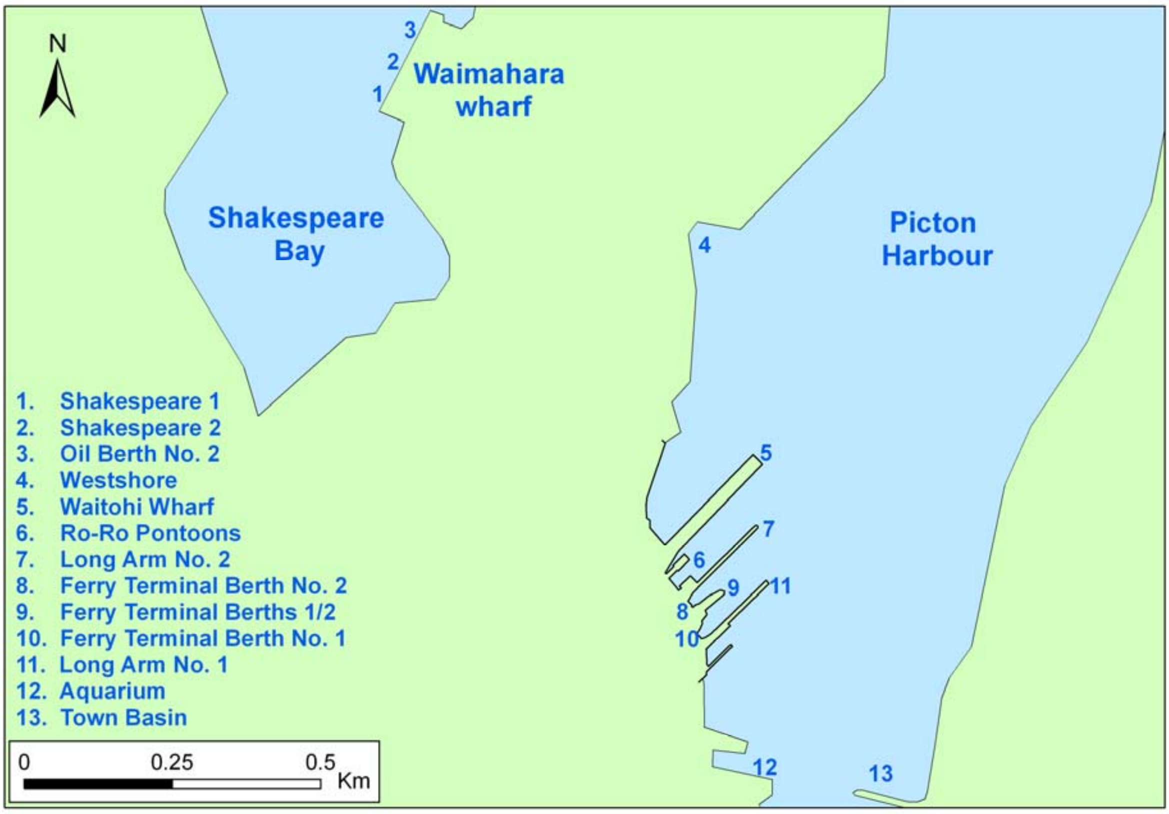

Figure 3 Map showing features of Picton Harbour referred to in the text (from Inglis et al. 2006b).

In 2000, the new deep water port facility, Waimahara Wharf, opened in the western bay, Shakespeare Bay. This new development complements the port's existing facilities. The 200 m long Waimahara Wharf is designed as a multi purpose berth for timber, logs and coal with the ability to be expanded northwards if required. With a depth alongside of 15.3 m at low tide the wharf provides deep-water access. The addition of mooring dolphins will allow Panamax vessels to be accommodated. The Waimahara Wharf was not sampled during the first baseline survey (Inglis et al. 2005c) because marine pest surveys at the site were being undertaken by the Cawthron Institute. In response to a request from Biosecurity NZ, survey sites at the Waimahara Wharf were included during the second baseline survey. Construction of another new berth in an area called the Westshore on the western side of Picton Harbour was completed in the second half of 2005 (after the completion of the second baseline survey) to provide berth space for commercial fishing vessels.

Berth construction within the port is predominantly concrete deck on a mixture of steel casing (concrete internally) and precast concrete piles with wooden fendering piles. Further details of the dimensions of each berth, the adjacent draught and the cargo each berth handles are provided in Table 13.

Within the port, there is no on-going maintenance dredging, and no capital dredging has occurred since the initial baseline survey in December 2001. Scouring by vessel thrusters and propellers ensures the berths are kept free from sedimentation.

Between August and November 2005 (i.e. after the second baseline survey had been completed in January 2005), a 30 m long steel sheet pile berth was constructed on the Westshore of Picton Harbour for commercial fishing vessels (Table 13), driven through the existing edge of rock batters. This involved some rearranging of the rock wall but no dredging. Also after the January 2005 survey, a slipway was cut into the northern end of the existing reclamation as part of the construction of boat building premises there. No land reclamation has occurred on the Westshore and no further capital works are currently planned for the Westshore.

Port Marlborough operates three recreational marinas in the Marlborough Sounds; Picton Marina adjacent to the Port of Picton, Waikawa Marina also within Queen Charlotte Sound and five minutes drive from Picton, and Havelock Marina at the head of Pelorus Sound. The Picton Marina has 232 floating concrete pier/wooden pile berths for vessels 8-35+ m in length (www.portmarlborough.co.nz). An expansion of the Picton Marina has recently been completed, with a breakwater constructed at Shirley Beach between September and December 2000 and the installation of floating jetties completed around mid 2003. This involved a small volume of dredging along the shore line for berths, with the dredged material placed on land behind sheet piling.

Waikawa Marina has 600 floating concrete pier/wooden pile berths for vessels 8-20 m in length, and 70 additional individual lock-up boat sheds (www.portmarlborough.co.nz). There have been no recent capital works conducted at Waikawa Marina but there is currently a proposal to expand the marina by ca 500 berths (http://www.marlboroughmarinas.co.nz/Home, accessed 2 April 2008). This expansion will include extension of an existing mole and construction of a rubble breakwall.

Imports and exports

The volumes and value of goods imported and exported through the Port of Picton are summarised below. These data describe only cargo being loaded for, or unloaded from, overseas ports and do not include domestic cargo (Statistics New Zealand 2006b). Also available from Statistics New Zealand (2006a) was a breakdown of cargo value by country of origin or destination and by commodity for each calendar year; we analysed the data for the period 2002 to 2005 inclusive (i.e. the period between the first and second baseline surveys).

Imports

The Port of Picton received imports from just 3 countries of initial origin between 2002 and 2005 inclusive (Statistics New Zealand 2006a). Cargo in the “ships, boats and floating structures” commodities class unloaded in 2003 arrived from the Bahamas, whilst the wood and wooden articles unloaded in 2005 came from the Republic of Korea and India.

Exports

The weight of overseas cargo loaded at the Port of Picton increased each financial year between the years ending June 2002 and June 2005 (Statistics New Zealand 2006b). In the year ending June 2005, the Port of Picton loaded 387,295 tonnes of cargo for export, representing a 51.3% increase compared to the 256,004 tonnes loaded in the 2001-2002 financial year. The value of this cargo increased by 14% during this period, with a value of $33 million in the year ending June 2005. For the financial years ending June 2002 to 2005, overseas cargo loaded at the Port of Picton accounted for 1 to 1.8% by weight and 0.1% by value of the total overseas cargo loaded at New Zealand’s seaports.

The Port of Picton exported cargo in 8 different commodity categories between January 2002 and December 2005 inclusive (Statistics New Zealand 2006a). Wood and wooden articles were by far the dominant commodity category by value, representing 96% by value of the cargo loaded and being the only commodity that was loaded for export every year between 2002 and 2005 (Statistics New Zealand 2006a).

The Port of Picton loaded cargo for export to 19 countries of final destination between January 2002 and December 2005 inclusive (Statistics New Zealand 2006a). During this time, the Port of Picton exported most of its overseas cargo by value to the Republic of Korea (74%), and India (17.5%). The Republic of Korea ranked first and India second in all years except 2002, when the People's Republic of China ranked second.

Shipping movements and ballast discharge patterns

Vessels are expected to comply with the Voluntary Controls on the Discharge of Ballast Water in New Zealand (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. A total volume of 6,956 m^3 of ballast water was discharged in the Port of Picton in 1999, with the largest country-of-origin volumes of 1,618 m^3 from Japan, 154 m3 from Australia, and 5,184 m^3 unspecified (Inglis 2001). This figure is three orders of magnitude lower than the recorded ballast water discharge into the Port of New Plymouth, and two orders of magnitude lower that the volumes discharged in Lyttelton, Tauranga, Whangarei and Nelson Ports (Inglis 2001), providing an indication of the relatively small scale of commercial shipping operations at the Port of Picton.

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

International vessel movements

Based on an analysis of the 'Seaseacher.com' database, there were 26 vessel arrivals to the Port of Picton from overseas ports between 2002 and 2005 inclusive. These arrived from 6 different countries (Table 14), with more than half coming from Australia (15 arrivals), and the remainder arriving from China, Korea (both in the northwest Pacific region), Japan, New Caledonia (Pacific Islands), and Aruba (off the South America Atlantic coast). Of the 15 vessels arriving from Australia, 4 came from ports in New South Wales, 4 from Tasmania, 3 from Victoria, 2 from Queensland and 2 from South Australia (Table 15). These were mostly bulk / cement carriers, and this vessel type represented over two-thirds of the total international arrivals (Table 14).

According to the 'Seasearcher.com' database, during the same period 50 vessels departed from the Port of Picton to 7 different countries (Table 16). The greatest number of departures for overseas went to ports in the Republic of Korea (northwest Pacific region) as their next port of call (32 movements) followed by the Republic of Singapore (east Asian seas region; 8 departures), Australia (5), India (central Indian Ocean region; 2 departures), and one each for

Japan, China (in the northwest Pacific) and the Philippines (east Asian seas). Forty-seven of the 50 movements were bulk / cement carriers, with the remaining three being passenger / vehicle / livestock carriers (Table 16).

Domestic vessel movements

The 'Seasearcher.com' database contains movement records for 103 vessel arrivals to the Port of Picton from New Zealand ports between 2002 and 2005 inclusive. These vessels arrived from 13 different ports in both the North and South Islands (Table 17). The greatest number of domestic arrivals during this period came from Wellington (26 arrivals), Lyttelton (20 arrivals), Nelson (15 arrivals), and Napier (10 arrivals). Bulk / cement carriers were by far the dominant vessel type arriving at the Port of Picton from other New Zealand ports (70 arrivals) followed by passenger / vehicle / livestock carriers (20 arrivals; Table 17).

During the same period, the 'Seasearcher.com' database contained movement records for 77 vessel departures from the Port of Picton to 12 New Zealand ports in both the North and South Islands. The most domestic movements departed the Port of Picton for Wellington (19 movements), Whangarei (13), Napier (11) and Lyttelton (11; Table 18). Similar to the domestic arrivals, vessels departing the Port of Picton on domestic voyages were mostly bulk / cement carriers (42 movements), followed by passenger / vehicle / livestock carriers (22 movements; Table 18).

The data described above do not include scheduled ferry movements, or vessels under 99 gross tonnes including fishing and recreational vessels. The Port of Picton facilitates a significant interisland passenger/freight service involving two companies: The Interisland Line and Strait Shipping. Each year Interislander vessels accommodate over one million passengers, 230,000 domestic vehicles and operate over 5,700 sailings (www.interislander.co.nz), while Strait Shipping runs 1,300 return trips between Picton and Wellington annually (www.strait.co.nz). Just seven movement records for these ferries are included in the 'Seasearcher.com' database, signifying the origination or cancellation of a route for a particular vessel. Many fishing vessels are also registered in the Port of Picton (69 in the year 2000, Sinner et al. 2000).

Possible vectors for the introduction of non-indigenous species to the port

The non-indigenous species located in the Port of Picton are thought to have arrived in New Zealand via international shipping. They may have reached the Port of Picton directly from overseas or through domestic spread (natural and/or anthropogenic) from other New Zealand ports. Table 19 indicates the possible vectors for the introduction of each NIS recorded from the Port of Picton during the baseline port surveys. Likely vectors of introduction are largely derived from Cranfield et al. (1998) and expert opinion. They suggest that only 1 of the 11 NIS (9%) probably arrived via ballast water, 7 species (67%) were most likely to be associated with hull fouling, and 3 species (27%) could have arrived via either of these mechanisms.

Assessment of the risk of new introductions to the port

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

The Port of Picton receives comparatively little international commercial shipping compared with other New Zealand ports. Between 2002 and 2005, there were only 26 vessel arrivals from overseas to the Port of Picton recorded in the "SeaSearcher.com" database. The majority of these came from Australia (15) and the northwest Pacific (China and Korea, 6 arrivals; Table 14). Most trade vessels arriving in Picton from overseas are, therefore, coming from ports in other temperate regions that have coastal environments similar to New Zealand's. Bulk carriers comprised the greatest proportion of vessel types arriving at Picton from overseas (18 of the 26 arrivals). Empty vessels of these types carry the largest volumes of Cumulative number of taxa ballast water and may, therefore, be more likely to carry invasive species that can be transported in ballast water. In the Port of Picton these vessels came from Australia (9 arrivals), the northwest Pacific (6), Japan (2) and the Pacific Islands (one arrival; Table 14). Six of the remaining eight vessel arrivals were passenger/ vehicle/ livestock carriers, which typically discharge relatively small volumes of ballast water. Smaller, slower moving vessels, such as barges, tugs and fishing boats, tend to carry a greater density of fouling organisms than faster cargo vessels. Only two vessels of this type were recorded as arriving in Picton (from Australia) between 2002 and 2005 (Table 14).

Based on shipping patterns at the Port of Picton and similarities in coastal environments, shipping from southern Australia, China, Korea, and Japan present a low, but on-going risk of introduction of new NIS to the Port of Picton. Thirteen of the 15 vessel arrivals from Australia recorded in the 'Seasearcher.com' data came from southern Australia. Because of the relatively short transit time, shipping originating in southern Australia (particularly Victoria and Tasmania) carries, perhaps, the greatest overall risk. Furthermore, six of the eight marine pests on the New Zealand Register of Unwanted Organisms are already present in southern Australia (*Carcinus maenas*, *Asterias amurensis*, *Undaria pinnatifida*, *Sabella spallanzanii*, *Caulerpa taxifolia*, and *Styela clava*). The native range of other two species – *Eriocheir sinensis* and *Potamocorbula amurensis* – is the northwestern Pacific, including China and Japan.

The small number of international arrivals suggests that the overall risk of introductions directly from overseas ports would be relatively low, and is probably lower than the risk of non-indigenous species being translocated to the Port of Picton from other ports in New Zealand. The Port of Picton is connected directly to the ports of Wellington and Nelson by regular coastal shipping and between 2002 and 2005 received 103 arrivals of commercial shipping vessels from a total of 13 New Zealand ports (Table 17). The LMIU "SeaSearcher.com" database recorded the majority of vessels arriving in Picton from other New Zealand ports between 2002 and 2005 as arriving mostly from Wellington (26 arrivals), Lyttelton (20 arrivals), Nelson (15 arrivals), Napier (10 arrivals), Tauranga (8 arrivals), Whangarei (8 arrivals) and Timaru (5 arrivals), and the majority of these are bulk carriers (Table 17). These ports (particularly Lyttelton and Timaru) have many non-indigenous species that have not been recorded in Picton, including the unwanted ascidian *Styela clava* (recorded in Lyttelton, the Hauraki Gulf and Tutukaka marina). However, due to its fouling nature, the risk of translocating *Styela clava* is greatest for slow-moving vessels, which comprised only 2 of the 20 arrivals to Picton from Lyttelton between 2002 and 2005 recorded by the LMIU "SeaSearcher.com" database (Table 17). Picton is a gateway to the South Island, particularly from Wellington, and other slow-moving vessels such as barges, yachts and pleasure craft arriving from the North Island may, therefore, present an increased risk of introduction of non-indigenous species to Picton. In 2005, *S. clava* was found on the hull of a launch that had recently arrived in Waikawa Marina, Picton, from Viaduct Harbour, Auckland, where *S. clava* is well-established. The launch was removed from the water and cleaned of all fouling. A subsequent search of the surrounding marina did not find any additional specimens (Morrisey 2005). Nevertheless, this incident does highlight the potential for continuing transportation of unwanted species into Picton by slow-moving vessels.

Assessment of translocation risk for introduced species found in the port

Between 2002 and 2005, vessels departing from the Port of Picton travelled to 12 ports throughout New Zealand. Wellington, Whangarei, Napier, Lyttelton, Nelson and Tauranga were the next ports of call for the most domestic vessel movements from Picton (Table 18).

Although all of the non-indigenous species found in the re-survey of the Port of Picton have been recorded in other locations throughout New Zealand (Table 20), they are not universally present in the other ports. There is, therefore, a risk that species established in the Port of Picton could be spread to other New Zealand locations.

This is illustrated by the one species present in Picton that is on the New Zealand Register of Unwanted Species: the invasive alga *Undaria pinnatifida*. *Undaria pinnatifida* has been present in New Zealand since at least 1987 and has spread through shipping and other vectors to 11 of the 16 ports and marinas surveyed during the baseline surveys (the exceptions being Opua, Whangarei Port and marina, and Gulf Harbour marina). Until recently, it was absent from the Ports of Taranaki (New Plymouth) and Tauranga. A small number of vessels travel between Picton and the P ports north of Auckland where *U. pinnatifida* has not yet become established. There is, therefore, a small risk that it could be spread to these locations by shipping from Picton (or any other location in which it is currently established).

Because it is a fouling organism, the risk of translocating *U. pinnatifida* is highest for slow-moving vessels, such as yachts and barges, and vessels that have long residence times in port. In the Port of Picton, cargo and bulk (including fuel) carriers, recreational craft, and seasonal fishing vessels that are laid up for significant periods of time pose a particular risk for the spread of this species. Such vessels also pose a significant risk of translocation of colonial ascidians in the genus *Didemnum* (classed as cryptogenic category 1 in this report due to uncertainty of their geographic origins). Two species of *Didemnum* that exhibit invasive behaviour have been recorded from the Port of Picton: *D. incanum* (in the initial survey, Inglis et al. 2005c) and *D. vexillum* (on a barge moored in Shakespeare Bay, Coutts 2002a). During the re-survey of the Port of Picton, colonies of *Didemnum* were observed carpeting the seafloor near the wharf at Shakespeare Bay. Elsewhere in New Zealand, *Didemnum vexillum* has been reported only from Nelson, Tarakohe, Wellington, Whangamata (Coromandel Peninsula) and the Bay of Plenty, and there is, therefore, a risk that it and other *Didemnum* species could be transported by shipping to other ports where it is not already established. *Didemnum vexillum* has the potential to be a significant fouling pest of aquaculture (particularly longline mussel culture and seafloor scallop enhancement). It may be spread as fouling on poorly maintained commercial or recreational vessels, on fouled ropes and buoys, or other submerged marine structures.

One other non-indigenous species recorded from the repeat survey of Picton, the hydroid *Eudendrium generale,* has a relatively restricted distribution nationwide (Table 20) and could, therefore, be spread from Picton to other locations. Information on the ecology of this species is limited, but it is not known to have potential for significant impacts.

Management of existing non-indigenous species in the port

All except three of the NIS detected in Picton appear to be well-established in the port. However, the hydroid *Eudendrium generale* and the bryozoans *Tricellaria inopinata* and *Cryptosula pallasiana* were each recorded from only one site in this survey (Table 20). None of these were recorded from the initial survey of the Port of Picton and thus may not be well established in Picton. However, the bryozoans are present in several other New Zealand ports. In contrast, *E. generale* has only been recorded from two other New Zealand ports (Napier and Wellington).

Management of existing non-indigenous species in the top of the South Island

The following is derived from the reports of the second baseline surveys (Inglis et al. 2006a and b).

ERADICATION

For most marine NIS, eradication by physical removal or chemical treatment is not yet a cost-effective option. Local population controls are unlikely to be effective for species that are widespread within a port. They may be worth considering for more restricted species (such as the polychaete worm *Hydroides elegans*, the bryozoans *Cryptosula pallasiana* and *Electra tenella*, and the hydroids *Filellum serpens?* and *Lafoeina amirantensis* recorded in Nelson), but a more detailed delimitation survey is needed for such species to determine their current distribution and abundance more accurately before any control measures are considered. Management should be directed toward preventing spread of species established in the port to locations where they do not presently occur. This is particularly important for invasive species with known or potential adverse effects. Such management will require better description of its distribution within each location and of the location and frequency of movements of potential vectors that might spread it to other domestic and international locations.

Summary of methods for eradication of introduced pests

Removal by hand

Removal by hand has been used to treat small areas of natural seabed infected with *Didemnum vexillum* beneath pontoons, moorings, vessels and mussel farms (Pannell & Coutts 2007). Infected macroalgal beds in Hitaua Bay, Queen Charlotte Sound, were treated by divers using knives to cut out infected plants which were then disposed of in landfill. Subsequent inspection showed that divers had overlooked some infected plants but the method was generally considered cost-effective (Pannell & Coutts 2007). At the same location and at Shakespeare Bay, submerged pine trees infected with *Didemnum vexillum* were cut into manageable-sized pieces and lifted from the water onto a barge for disposal on land. Colonies left behind on the seabed were collected by divers.

Desiccation

One of the simplest methods to treat structures infected with non-indigenous organisms is to remove them from the water and allow them to dry thoroughly. Mussel farm infrastructure (ropes, floats, moorings) have been treated by emersion for 7 d or removal and replacement and floating pontoons have been treated by lifting clear of the water on mussel floats (Pannell & Coutts 2007). The method can be very labour-intensive and was found not to be completely effective in treating structures infected with *Styela clava* in Canada (LeBlanc et al. 2007).

Plastic wrapping

This method has been used successfully for eradication of encrusting organisms, notably colonial ascidians, on a variety of hard structures (Pannell & Coutts 2007). Plastic balage wrap (75 cm wide) has been used on wharf piles, silage covers to encapsulate vessels, floating jetties and pontoons, and plastic tubing to treat infected moorings. Larger plastic sheets (10 m wide) were used successfully to treat areas of *Didemnum vexillum* on rip-rap beneath Waimahara Wharf in Shakespeare Bay. Plastic silage covers have also been used to treat natural areas of seabed beneath *Didemnum*-infected pontoons, moorings, vessels and mussel farms. Various chemicals can be added to the water inside the wrapping to act as toxicants (e.g. acetic acid) or to enhance the development of anoxia (sugar, sodium sulphite). Plastic wrapping has also been used to treat infected mussel lines when only a few isolated colonies were present on the crop (rather than the moorings, floats and backbones).

Geotextile filter fabric

Smothering with geotextile fabric with a pore-size small enough to retain larvae was used to treat areas of rip-rap rock infected with *Didemnum vexillum* in Shakespeare Bay (Pannell & Coutts 2007). The technique was not successful because of difficulty in sealing the edges of the fabric, which allowed the infection to spread to the outer surface of the fabric.

Hot water and super-heated steam

The microscopic gametophytes of *Undaria pinnatifida* are killed by exposure to temperatures >60°C, as shown by laboratory and field experiments in Picton (Blackmore & Forrest 2007). Heat-treatment was therefore used to disinfect the hull of the sunken trawler *Seafresh 1* in the Chatham Islands in 2001 (Wotton et al. 2004). Heat was applied using i) a plywood box containing heating elements that was applied to the hull of the vessel and heated the water inside the box to 70°C (maintained for 10 minutes); ii) a Petrogen flame torch. The box contained a vent that allowed expanding water and steam to escape into a filter bag to collect any dislodged gametophytes. The torch was used to treat parts of the hull that could not be treated with the box (curved and inaccessible areas). Those parts of the vessel exposed above the seabed and likely to have been contaminated by *Undaria* prior to sinking (i.e. areas below the water line) were treated. Treatment took four weeks, during which the box was applied to the hull over 300 times. No *Undaria* sporophytes were found on the vessel after cleaning (the final inspection was done in December 2003). Research is currently underway on the use of heat to treat fouling assemblages in ships' seachests (Barrie Forrest, Cawthron Insitute, pers. comm.).

Use of toxic chemicals

Copper sulphate and chlorine (sodium hypochlorite) were used to eradicate the introduced mussel *Mytilopsis* sp. from three marinas in Darwin Harbour, Australia in 1999 (Bax et al. 2002). Copper sulphate was found to be more effective at killing the mussels in situ than chlorine. Treatment of the large areas represented by the marinas was made more feasible because all three could be sealed off from the adjacent harbour by lock gates.

Other potential biocides for use in controlling aquatic fish pests are reviewed by Clearwater & Hickey (2003), including ammonia, lime and chlorine. It is important to note that use of any biocide will require a resource consent from the appropriate regional council and if the chemical in question has not previously been approved for use as a biocide it will require approval from the Environmental Risk Management Authority.

Acetic acid and chlorine were used successfully in field trials to treat infestation of *Styela clava* in the Viaduct Basin, Auckland (Coutts & Forrest 2005). Acetic acid has also been shown to be a cost-effective method of treating mussel seedstock to reduce the risk of tranlocating a range of fouling taxa (Forrest et al. 2007). Freshwater has proved effective in treating *Styela clava* overseas (Coutts & Forrest 2005) and mussel stock in New Zealand to remove *Didemnum vexillum* without harm to the stock[14]. NIWA has recently (March 2008) trialled the use of concentrated acetic acid, hydrated lime (calcium hydroxide) solution and ammonium sulphate solution (applied as separate treatments using backpack sprayers) to eradicate intertidal colonies of the introduced colonial ascidian *Eudistoma elongatum* on oyster racks and rocky habitats in Northland. The results of this study (funded by MAF

[14] see http://www.frst.govt.nz/news/Fresh-Water-a-Cure-for-Deadly-Salt-Water-Pest

Biosecurity New Zealand) are not yet available. Trials are also in progress by the Cawthron Institute to test the effectiveness of lime, hypochlorite (bleach) and acetic acid in treating populations of *Didemnum* and other fouling organisms on artificial settlement plates and clumps of mussels (Barrie Forrest, Cawthron Institute, pers. comm.).

Other methods

An LPG-fuelled torch and a heated (to ca 90^{o}C), sugar-based foam were trialled as additional methods to eradicate *Eudistoma elongatum* in the NIWA study in Northland, described above.

Scrapers or brushes are sometimes used by vessel operators to defoul vessels without the cost of removing the vessel from the water. Clearly, there is a risk that biological material removed from the hull, including non-indigenous species, will not be killed and may be spread over a wider area. Diver-operated portable rotating brush systems have been trialled for use in New Zealand that claim to remove and collect all of the biofouling. However, experimental trials have found that this is not always the case and that a portion of the fouling assemblage remains on the hull (Hopkins and Forrest 2007). Fouling organisms may also be stimulated to spawn by the mechanical disturbance involved. A trial of a related method to remove *Didemnum* from the hull of a vessel using an underwater vacuum device and special cutter concluded that the method was too labour intensive and ineffective (Coutts 2002b).

Diver-operated suction devices have been used to remove the alga *Caulerpa taxifolia* in New South Wales (Creese et al. 2004) and in the Mediterranean (Meinesz et al. 2001).

Immersion of infected structures in freshwater or the alteration of the salinity of the water in which the introduced species is living (for example, by diversion of storm-water runoff into a saline lake or by dredging the mouth of an estuary to allow the influx of full-strength seawater) have also been used to control pest species in coastal environments (reviewed by Gust et al. 2007).

PREVENTION OF NEW INTRODUCTIONS

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

Options are currently lacking, however, for effective in-situ treatment of biofouling and sea chests. 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. Activities such as in-water cleaning of vessel hulls and sea chests increase the likelihood that fouling species transported into the port will become established there and should be discouraged by local authorities and port managers. Slow moving barges or vessels that are laid up in overseas ports for long periods before travelling to New Zealand can carry large densities of non-indigenous marine organisms with them. Cleaning and maintenance of these vessels should be encouraged by port authorities and shipping companies prior to their departure for New Zealand waters.

Studies of historical patterns of invasion have suggested that changes in trade routes can herald an influx of new NIS from regions that have not traditionally had major shipping links with the country or port (Carlton 1987, Hayden et al. in review). The growing number of baseline port surveys internationally and an associated increase in published literature on marine NIS means that information is becoming available that will allow more robust risk assessments to be carried out for new shipping routes. We recommend that port companies consider undertaking such assessments for their ports when new import or export markets are forecast to develop. The assessment would allow potential problem species to be identified and appropriate management and monitoring requirements to be put in place.

As several recent analyses have shown, the large area of habitat available for marine organisms within shipping ports and the logistic difficulties of sampling in these environments mean that detection probabilities are likely to be comparatively low for species with low prevalence, even when species-specific survey methods are used (Inglis et al. 2003; Inglis 2003; Hayes et al. 2005; Gust et al. 2006; Inglis et al. 2006a and b). In generalised pest surveys, such as the baseline port surveys, this problem is compounded by the high cost of identifying all specimens (native and non-indigenous) which constrains the total number of samples that can be taken (Inglis 2003). A consequence is that a high proportion of comparatively rare species will remain undetected by any single survey. This problem is not limited to non-indigenous species, as around 35% of native species recorded in each survey also occurred in just a single sample. Nor is it unique to marine assemblages. These results reflect the spatial and temporal variability that are features of marine biological assemblages (Morrisey et al. 1992a, 1992b) and the difficulties that are involved in characterising diversity within hyper-diverse assemblages (Gray 2000; Gotelli and Colwell 2001; Longino et al. 2002).

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

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Table 1 Non-indigenous marine species recorded from the Marlborough Sounds/Nelson/Tasman region during surveys undertaken by NIWA during the last 7 years.

Phylum, Class	Order	Family	Genus, species
Annelida			
Polychaeta	Sabellida	Serpulidae	*Hydroides elegans*
Polychaeta	Sabellida	Serpulidae	*Spirobranchus polytrema*
Polychaeta	Spionida	Spionidae	*Polydora hoplura*
Polychaeta	Spionida	Spionidae	*Dipolydora armata*
Polychaeta	Spionida	Spionidae	*Dipolydora flava*
Arthropoda			
Malacostraca	Amphipoda	Caprellidae	*Caprella mutica*
Malacostraca	Amphipoda	Corophiidae	*Apocorophium acutum*
Bryozoa			
Gymnolaemata	Cheilostomata	Bugulidae	*Bugula flabellate*
Gymnolaemata	Cheilostomata	Bugulidae	*Bugula neritina*
Gymnolaemata	Cheilostomata	Candidae	*Tricellaria inopinata*
Gymnolaemata	Cheilostomata	Cryptosulidae	*Cryptosula pallasiana*
Gymnolaemata	Cheilostomata	Electridae	*Conopeum seurati*
Gymnolaemata	Cheilostomata	Electridae	*Electra angulata*
Gymnolaemata	Cheilostomata	Electridae	*Electra tenella*
Gymnolaemata	Cheilostomata	Lepraliellidae	*Celleporaria nodulosa*
Gymnolaemata	Cheilostomata	Schizoporellidae	*Schizoporella errata*
Gymnolaemata	Cheilostomata	Watersiporidae	*Watersipora subtorquata*
Gymnolaemata	Ctenostomata	Nolellidae	*Anguinella palmata*
Chordata			
Actinopterygii	Salmoniformes	Salmonidae	*Oncorhynchus tshawytscha*
Cnidaria			
Hydrozoa	Hydroida	Campanulinidae	*Lafoeina amirantensis*
Hydrozoa	Hydroida	Eudendriidae	*Eudendrium generale*
Hydrozoa	Hydroida	Lafoeidae	*Filellum serpens?*
Hydrozoa	Hydroida	Syntheciidae	*Synthecium campylocarpum*
Hydrozoa	Hydroida	Syntheciidae	*Synthecium subventricosum*

Table 1 Continued.

Phylum, Class	Order	Family	Genus, species
Mollusca			
Bivalvia	Ostreoida	Ostreidae	*Crassostrea gigas*
Bivalvia	Veneroida	Semelidae	*Theora lubrica*
Phaeophyta			
Phaeophyceae	Cutleriales	Cutleriaceae	*Cutleria multifida*
Phaeophyceae	Ectocarpales	Chordariaceae	*Asperococcus bullosus*
Phaeophyceae	Ectocarpales	Chordariaceae	*Chnoospora minima*
Phaeophyceae	Laminariales	Alariaceae	*Undaria pinnatifida*
Porifera			
Demospongiae	Halisarcida	Halisarcidea	*Halisarca dujardini*
Rhodophyta			
Florideophyceae	Ceramiales	Ceramiaceae	*Griffithsia crassiuscula*
Florideophyceae	Ceramiales	Rhodomelaceae	*Polysiphonia subtilissima*
Florideophyceae	Ceramiales	Rhodomelaceae	*Polysiphonia senticulosa*
Urochordata			
Ascidiacea	Aplousobranchia	Cionidae	*Ciona intestinalis*

Table 2 Cryptogenic marine species recorded from the Marlborough Sounds/Nelson/Tasman region during surveys undertaken by NIWA. Category 1 cryptogenic species (C1)[1]; Category 2 cryptogenic species (C2)[2] (modified from Inglis et al. 2005 b, c and 2006 a, b).

Phylum, Class	Order	Family	Genus, species	Status
Annelida				
Polychaeta	Eunicida	Lumbrineridae	*Lumbrineris Lumbrineris-01 [Glasby unpub]*	C2
Polychaeta	Phyllodocida	Nereididae	*Neanthes Neanthes-A*	C2
Polychaeta	Phyllodocida	Nereididae	*Perinereis perinereis-A*	C2
Polychaeta	Phyllodocida	Phyllodocidae	*Eulalia bilineata*	C1
Polychaeta	Phyllodocida	Phyllodocidae	*Eulalia Eulalia-NIWA-2*	C2
Polychaeta	Phyllodocida	Phyllodocidae	*Eulalia Eulalia-NIWA-3-stripey*	C2
Polychaeta	Phyllodocida	Phyllodocidae	*Pirakia Pirakia-A*	C2
Polychaeta	Phyllodocida	Polynoidae	*Lepidonotus Lepidonotus-A*	C2
Polychaeta	Phyllodocida	Syllidae	*Autolytin-unknown sp. A*	C2
Polychaeta	Phyllodocida	Syllidae	*Eusyllis Eusyllis-A*	C2
Polychaeta	Phyllodocida	Syllidae	*Eusyllis Eusyllis-B*	C2
Polychaeta	Phyllodocida	Syllidae	*Eusyllis Eusyllis-D*	C2
Polychaeta	Sabellida	Sabellidae	*Megalomma Megalomma-A*	C2
Polychaeta	Sabellida	Serpulidae	*Serpula Serpula-C*	C2
Polychaeta	Sabellida	Serpulidae	*Serpula Serpula-D*	C2
Polychaeta	Spionida	Spionidae	*Paraprionospio Paraprionospio-A [pinnata]*	C2
Polychaeta	Terebellida	Terebellidae	*Lanassa Lanassa-A*	C2
Polychaeta	Terebellida	Terebellidae	*Terebella Terebella-B*	C2
Bryozoa				
Gymnolaemata	Cheilostomata	Phidoloporidae	*Rhynchozoon larreyi*	C1
Gymnolaemata	Cheilostomata	Scrupariidae	*Scruparia ambigua*	C1
Cnidaria				
Hydrozoa	Hydroida	Bougainvilliidae	*Bougainvillia muscus*	C1
Hydrozoa	Hydroida	Campanulariidae	*Clytia hemisphaerica*	C1
Hydrozoa	Hydroida	Campanulariidae	*Obelia dichotoma*	C1
Hydrozoa	Hydroida	Campanulinidae	*Phialella quadrata*	C1
Hydrozoa	Hydroida	Haleciidae	*Halecium delicatulum*	C1
Hydrozoa	Hydroida	Plumulariidae	*Plumularia setacea*	C1

Table 2 Continued.

Phylum, Class	Order	Family	Genus, species	Status
Crustacea				
Malacostraca	Amphipoda	Aoridae	*Aora typica*	C1
Malacostraca	Amphipoda	Corophiidae	*Meridiolembos sp. aff. acherontis*	C2
Malacostraca	Amphipoda	Lysianassidae	*Parawaldeckia sp. aff. P. stephenseni*	C2
Malacostraca	Amphipoda	Lysianassidae	*Parawaldeckia sp. aff. P. vesca*	C2
Malacostraca	Brachyura	Grapsidae	*Plagusia chabrus*	C1
Malacostraca	Brachyura	Portunidae	*Nectocarcinus sp.*	C2
Dinophyta				
Dinophyceae	Gymnodiniales	Gymnodiniaceae	*Gymnodinium catenatum*	C1
Dinophyceae	Peridiniales	Gonyaulacaceae	*Alexandrium minutum*	C1
Dinophyceae	Peridiniales	Gonyaulacaceae	*Alexandrium ostenfeldii*	C1
Mollusca				
Bivalvia	Mytiloida	Mytilidae	*Mytilus galloprovincialis*	C1
Gastropoda	Nudibranchia	Polyceridae	*Polycera hedgpathi*	C1
Porifera				
Demospongiae	Dictyoceratida	Dysideidae	*Dysidea new sp. 1*	C2
Demospongiae	Dictyoceratida	Dysideidae	*Dysidea new sp. 3*	C2
Demospongiae	Dictyoceratida	Dysideidae	*Euryspongia new sp. 1*	C2
Demospongiae	Halichondrida	Halichondriidae	*Halichondria new sp. 1*	C2
Demospongiae	Halichondrida	Halichondriidae	*Halichondria new sp. 5*	C2
Demospongiae	Halichondrida	Halichondriidae	*Hymeniacidon new sp. 1*	C2
Demospongiae	Halichondrida	Halichondriidae	*Hymeniacidon perleve*	C1
Demospongiae	Haplosclerida	Callyspongiidae	*Callyspongia diffusa*	C1
Demospongiae	Haplosclerida	Callyspongiidae	*Dactylia new sp. 1*	C2
Demospongiae	Haplosclerida	Chalinidae	*Adocia new sp. 1*	C2
Demospongiae	Haplosclerida	Chalinidae	*Adocia new sp. 2*	C2
Demospongiae	Haplosclerida	Chalinidae	*Chalinula new sp. 2*	C2
Demospongiae	Haplosclerida	Chalinidae	*Haliclona new sp. 1*	C2
Demospongiae	Haplosclerida	Chalinidae	*Haliclona new sp. 4*	C2
Demospongiae	Haplosclerida	Chalinidae	*Haliclona new sp. 6*	C2
Demospongiae	Haplosclerida	Chalinidae	*Haliclona new sp. 7*	C2
Demospongiae	Haplosclerida	Chalinidae	*Haliclona new sp. 14*	C2
Demospongiae	Poecilosclerida	Acarnidae	*Iophon proximum*	C1
Demospongiae	Poecilosclerida	Chondropsidae	*Chondropsis kirkii*	C1
Demospongiae	Poecilosclerida	Chondropsidae	*Chondropsis new sp. 1*	C2

Table 2 Continued.

Phylum, Class	Order	Family	Genus, species	Status
Demospongiae	Poecilosclerida	Crellidae	*Crella (Pytheas) incrustans*	C1
Demospongiae	Poecilosclerida	Esperiopsidae	*Esperiopsis new sp. 1*	C2
Demospongiae	Poecilosclerida	Mycalidae	*Mycale (Carmia) new sp. 3*	C2
Demospongiae	Poecilosclerida	Mycalidae	*Paraesperella new sp. 1 (macrosigma)*	C2
Rhodophyta				
Raphidophyceae	Chattonellales	Chattonellaceae	*Heterosigma akashiwo*	C1
Urochordata				
Ascidiacea	Aplousobranchia	Didemnidae	*Didemnum* species group (includes *D.vexillum, D. incanum,* and other *Didemnum* species) #	C1
Ascidiacea	Aplousobranchia	Holozoidae	*Distaplia sp.*	C2
Ascidiacea	Aplousobranchia	Polyclinidae	*Aplidium phortax*	C1
Ascidiacea	Phlebobranchia	Rhodosomatidae	*Corella eumyota*	C1
Ascidiacea	Stolidobranchia	Botryllinae	*Botrylliodes leachii*	C1
Ascidiacea	Stolidobranchia	Pyuridae	*Microcosmus australis*	C1
Ascidiacea	Stolidobranchia	Pyuridae	*Microcosmus squamiger*	C1
Ascidiacea	Stolidobranchia	Pyuridae	*Pyura sp.*	C2
Ascidiacea	Stolidobranchia	Styelidae	*Asterocarpa cerea*	C1
Ascidiacea	Stolidobranchia	Styelidae	*Styela plicata*	C1

[1] **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, but for which there are no known records outside the New Zealand region.
[2] **Cryptogenic species Category 2** Species that have recently been discovered but for which there is insufficient systematic or biogeographic information to determine whether New Zealand lies within their native range. This category includes previously undescribed species that are new to New Zealand and/or science.
* 1 = Present, 0 = Absent
# Because of the complex taxonomy of this genus, *Didemnum* specimens from the second survey could not be identified to species level, but are reported here collectively as a species group "*Didemnum* sp."

Table 3 List of international and domestic pathways of relevance to New Zealand (from Hewitt et al. 2004).

Category	Pathway
Ships	Ballast water and sediments
	Hull fouling
	Solid ballast
Moveable structures	
(Oil platforms, barges, dredgers, floating docks)	Hull fouling
	Ballast water and sediments
Other craft	Hull projections and cavities (sea-chests, thrusters, and internal piping)
(Merchant, fishing, and recreational/leisure)	Hull boring
	Aquatic cargo (wells and tanks)
	Anchor/anchor chains/lockers/moorings
	Scuppers and bulwarks
	Small craft trailers
	Dredging spoil
Aquaculture fisheries	Intentional release and stock movements
	Accidental release
	Gear movement
	Discarded nets, floats, traps
	Discarded packaging materials
	Discharge of feeds (live, fresh, and frozen)
	Release of transgenic and GMO species
Wild fisheries	Stock movement
	Population re-establishment
	Processing of live, fresh, and frozen products
	Live bait movement
	Gear and transport media (water) movement
	Discarded/lost fishing gear
	Discard of target and non-target species (bycatch)
	Live trade for consumption: accidental/intentional release
Aquarium industry and public aquaria	Intentional release
	Accidental release
	Untreated aquarium and waste discharge
	Living food movement
Marine leisure tourism	Live bait movement
	Accidental/intentional transport and release of fishing catch
	Diving gear movement
	Fishing gear (including boots) movement
Research and education	Intentional release
	Accidental release
	Water and waste discharges
	Living food movement
	Diving gear movement
	Field and experimental gear movement
	Restoration, mitigation and rehabilitation
Other	Alteration of water courses and flow regimes
	Irrigation canals (including saline ponds)
	Municipal and other waste/water treatment discharges

Table 4 Records of fishing vessel movements in the top of the South Island during the period 2004-2006, based on data from questionnaires sent to vessel operators (B. Hayden, NIWA, unpublished data). They include only those vessels less than 99 tonnes and do not include trips where the vessel returned to its port of origin without stopping at another port. The study was done by NIWA under MAF BNZ contract ZBS2005-13.

Origin	Destination	2004	2005	2006
D'urville Island	Mana			1
D'urville Island	Nelson			1
French Pass	French Pass			1
Gore Bay	Kaikoura			2
Havelock	Havelock			1
Havelock	Motueka			1
Havelock	Nelson	1		4
Havelock	Outer Pelorus Sound			1
Havelock	Picton		1	
Havelock	Port Underwood		1	
Havelock	Tarakohe			3
Kaikoura	Akaroa			2
Kaikoura	Gore Bay			1
Kaikoura	Kaikoura			2
Kaikoura	Picton			1
Marahau	Greymouth			1
Motueka	Motueka			1
Motueka	Pelorus Sound			1
Motueka	Queen Charlotte Sound			1
Motueka	Westport			1
Nelson	Dunedin	1	1	4
Nelson	D'urville Island			1
Nelson	Gisborne			1
Nelson	Greymouth	1		1
Nelson	Havelock	1		5
Nelson	Karitane		1	
Nelson	Lyttelton		1	1
Nelson	Mana			1
Nelson	Manukau	1	1	1
Nelson	Milford Sound			1
Nelson	Motueka			1
Nelson	Nelson		1	6
Nelson	Tarakohe			1
Nelson	Tasman Bay			1
Nelson	Timaru			3
Nelson	Westport	2	2	4
Pelorus Sound	Havelock			1
Picton	Kaikoura			2
Picton	Manukau			1
Picton	Nelson	1	1	2
Picton	New Plymouth	1		
Picton	Ngawi			1
Picton	Picton			3
Picton	Port Underwood	1	1	
Picton	Raglan			1
Picton	Wellington		1	1

Table 4 Continued.

Origin	Destination	2004	2005	2006
Port Underwood	Lyttelton		1	1
Port Underwood	Picton	1		1
Port Underwood	Port Underwood			2
Port Underwood	Westhaven Inlet		1	
Robin Hood Bay	Robin Hood Bay			1
Tarakohe	Motueka			1
Tarakohe	Nelson			3
Tarakohe	Wellington		1	
Tarakohe	Westhaven Inlet			1
Waikawa	Bluff			1
Waikawa	Waikawa			1
Westhaven Inlet	Coromandel			1
Westhaven Inlet	Nelson			1
Westhaven Inlet	Picton		1	
Westhaven Inlet	Westhaven Inlet			1

Table 5 Berthage facilities in Port Nelson (from Inglis et al. 2006a).

Berth	Section	Purpose	Construction	Length (m)	Depth (m below chart datum)
Coastal Berth		Multipurpose	Concrete deck/wood piles	85	6
Main Wharf	North	Heavy-duty cargo, petroleum products	Wood deck/wood piles	160	9
	South		Concrete deck/concrete piles + wooden fender piles	119	10.5
Brunt Quay		Heavy-duty cargo	Concrete deck/concrete piles + wooden fender piles	196	10.3
McGlashen Quay	North	General and break-bulk cargoes	Concrete deck/wood piles	155	9.2
	South	Bitumen and methanol discharge	Concrete deck/wood piles	200	9.2
Kingsford Quay		Break bulk, general cargoes, logs	Concrete deck/wood piles	174	9.5
	East	Break bulk, general cargoes, logs, vessel lay-up	Concrete deck/wood piles	85	6.5
Lay-up Berth	1	Lay-up, fish unloading	Solid concrete	85	8
	2		Solid concrete	65	6.5
	3 + pontoon		Solid concrete + steel pontoon on wood piles	105	5.5
McKellar Quay (Sealord)	East	Independently operated fishing vessels	Concrete deck/wood piles	128	7
	Centre		Concrete deck/wood piles	60	5
	West		Concrete deck/wood piles	45	5.5
Dog Leg (Sanford Ltd)			Concrete deck/wood piles	43	5.5
Amaltal Fishing Co.			Concrete deck/wood piles	130	7
Donker Marine			Concrete deck/wood piles	70	5

Table 6 Number of vessel arrivals from overseas to the Port of Nelson by each general vessel type and previous geographical area, between 2002 and 2005 inclusive (data from LMIU “SeaSearcher.com” database) (from Inglis et al. 2006a).

Geographical area of previous port of call	Bulk/ cement carrier	Bulk/ oil carrier	Dredge	Fishing	General cargo	LPG/ LNG	Passenger/ vehicle/ livestock	Other (inc pontoons, barges, mining & supply ships, etc)	Passenger ro/ro	Research	Tanker (inc chemical/ oil and ashphalt)	Container/ unitised carrier and ro/ro	Tug	Total
Australia	26			5	18		11	1			3	9	2	75
Japan	33			1	31		3					2		70
Northwest Pacific	35			2	3							2		42
Pacific Islands	3			2	10							14		29
East Asian seas	4				2			1			1	11	1	20
West coast North America inc USA, Canada & Alaska					12							1		13
Red Sea coast inc up to the Persian Gulf					12									12
Unknown (not stated in database)			1	6	1							3	1	12
Gulf States	3				6									9
U.S, Atlantic coast including part of Canada					6									6
South America Pacific coast					4									4
South & East African coasts	1				1		1							3
United Kingdom inc Eire				1	1			1						3
Central America inc Mexico to Panama					1		1							2
Gulf of Mexico					2									2
North African coast					2									2
Scandinavia inc Baltic, Greenland, Iceland etc				1								1		2
Africa Atlantic coast					1									1
European Mediterranean coast					1									1
N.E. Canada and Great Lakes	1													1
North European Atlantic coast					1									1
South America Atlantic coast					1									1
Total	106	0	1	18	116	0	16	3	0	0	4	43	4	311

Table 7 Number of vessel arrivals from Australia to the Port of Nelson by each general vessel type and Australian state, between 2002 and 2005 inclusive (data from LMIU "SeaSearcher.com" database) (from Inglis et al. 2006a).

Australian state of previous port of call	Bulk/ cement carrier	Bulk/ oil carrier	Dredge	Fishing	General cargo	LPG/ LNG	Passenger/ vehicle/ livestock	Other (inc pontoons, barges, mining & supply ships, etc)	Passenge r ro/ro	Research	Tanker (inc chemical/ oil and ashphalt)	Container/ unitised carrier and ro/ro	Tug	Total
Queensland	11				4							5	2	22
New South Wales	5			1	11		1	1			1	1		21
Victoria	4						9				1	1		15
Tasmania	2			2	2							2		8
South Australia	4						1							5
Western Australia				2	1						1			4
Total	26	0	0	5	18	0	11	1	0	0	3	9	2	75

Table 8 Number of vessel departures from the Port of Nelson to overseas ports, by each general vessel type and next geographical area, between 2002 and 2005 inclusive (data from LMIU "SeaSearcher.com" database) (from Inglis et al. 2006a).

Geographical area of next port of call	Bulk/ cement carrier	Bulk/ oil carrier	Dredge	Fishing	General cargo	LPG / LNG	Passenger/ vehicle/ livestock	Other (inc pontoons, barges, mining & supply ships, etc)	Passenger ro/ro	Research	Tanker (inc chemical/ oil and ashphalt)	Container/ unitised carrier and ro/ro	Tug	Total
Australia	3			3	15		3	1			8	338	5	376
Japan	31			1	3		230				2	7		274
Northwest Pacific	62			1	6		21							90
East Asian seas	3				4		6				4	8	1	26
North European Atlantic coast					25									25
U.S, Atlantic coast including part of Canada					21									21
United Kingdom inc Eire					12									12
Pacific Islands				2	1		2					4		9
West coast North America inc USA, Canada & Alaska	1				5							1		7
Central Indian Ocean	3													3
South America Atlantic coast							2							2
South America Pacific coast					1		1							2
Gulf States							1							1
South & East African coasts				1										1
Total	103	0	0	8	93	0	266	1	0	0	14	358	6	849

Table 9 Number of vessel arrivals from New Zealand ports to the Port of Nelson by each general vessel type and previous port, between 2002and 2005 inclusive (data from LMIU "SeaSearcher.com" database) (from Inglis et al. 2006a).

Previous port of call	Bulk/ cement carrier	Bulk/ oil carrier	Dredge	Fishing	General cargo	LPG/ LNG	Passenger/ vehicle/ livestock	Other (includes pontoons, barges, mining & supply ships, etc)	Passenger ro/ro	Research	Tanker (including chemical/ oil and ashphalt)	Container/ unitised carrier and ro/ro	Tug	Total
Wellington	21			6	33		65				19	609	8	761
Lyttelton	30		1	10	118		148	2			19	165	1	494
Napier	19				42						10	152		223
Nelson				147	11		1	2				45	6	212
Auckland	19			6	35		18				5	75		158
Tauranga	52				45						6	25	1	129
Timaru	5			13	7						4	68	1	98
Dunedin	12			1	18		32					10		73
New Plymouth	19				34	2					9	2	4	70
Bluff	16				47						1			64
Onehunga	6				51							1		58
Westport	26		6				1						1	34
Whangarei	14				3						11			28
Picton							1	1				6	1	9
Gisborne	8													8
Greymouth													1	1
Total	247	0	7	183	444	2	266	5	0	0	84	1158	24	2420

Table 10 Number of vessel departures from the Port of Nelson to New Zealand ports by each general vessel type and next port of call, between 2002 and 2005 inclusive (data from LMIU "SeaSearcher.com" database) (from Inglis et al. 2006a).

Next port of call	Bulk/ cement carrier	Bulk/ oil carrier	Dredge	Fishing	General cargo	LPG/ LNG	Passenger/ vehicle/ livestock	Other (includes pontoons, barges, mining & supply ships, etc)	Passenger ro/ro	Research	Tanker (includin g chemical/ oil and ashphalt)	Container/ unitised carrier and ro/ro	Tug	Total
Wellington	18			6	2		7				6	396	4	439
Napier	31				114		1				6	103		255
Tauranga	69			1	89						6	76	5	246
Nelson				147	11		1	2				45	6	212
Auckland	14			4	87			2			4	52		163
New Plymouth	21			1	20	2					16	100	2	162
Onehunga	12				113			1				4		130
Lyttelton	21		1	15	12		5	1			21	33	2	111
Timaru	6			17	4						1	24		52
Westport	19		7											26
Whangarei	11										13			24
Dunedin	10			2	8		1					1		22
Picton	8						1					6		15
Bluff	5				4						2			11
Gisborne	5													5
Mount Maunganui					1							1		2
Tarakohe					1									1
Total	250	0	8	193	466	2	16	6	0	0	75	841	19	1876

Table 11 Non-indigenous marine species recorded from the Port of Nelson during the first survey (T1) and second survey (T2) (from Inglis et al. 2006a). 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	T1*	T2*	Probable means of introduction	Date of introduction or detection (d)
Annelida							
Polychaeta	Sabellida	Serpulidae	*Hydroides elegans*	0	1	H or B	Pre-1952
Polychaeta	Spionida	Spionidae	*Polydora hoplura*	1	0	H	Unknown[1]
Bryozoa							
Gymnolaemata	Cheilostomata	Bugulidae	*Bugula flabellata*	1	1	H	Pre-1949
Gymnolaemata	Cheilostomata	Cryptosulidae	*Cryptosula pallasiana*	1	1	H	1890s
Gymnolaemata	Cheilostomata	Electridae	*Conopeum seurati*	1	0	H	Pre-1963
Gymnolaemata	Cheilostomata	Electridae	*Electra angulata*	1	0	H	Unknown[1]
Gymnolaemata	Cheilostomata	Electridae	*Electra tenella*	0	1	Drift plastic	1977
Gymnolaemata	Cheilostomata	Lepraliellidae	*Celleporaria nodulosa (NR)*	1	1	H	Jan 2002[d]
Gymnolaemata	Cheilostomata	Schizoporellidae	*Schizoporella errata*	1	0	H	Pre-1960
Gymnolaemata	Cheilostomata	Watersiporidae	*Watersipora subtorquata*	1	1	H or B	Pre-1982
Gymnolaemata	Ctenostomata	Nolellidae	*Anguinella palmata*	1	0	H	1960

Table 11 Continued.

Phylum, Class	Order	Family	Genus and species	T1*	T2*	Probable means of introduction	Date of introduction or detection (d)
Cnidaria							
Hydrozoa	Hydroida	Campanulinidae	*Lafoeina amirantensis (NR)*	1	1	H or B	Jan 2002[d]
Hydrozoa	Hydroida	Lafoeidae	*Filellum serpens?*	0	1	H	1848
Hydrozoa	Hydroida	Syntheciidae	*Synthecium campylocarpum*	0	1	H	1890
Hydrozoa	Hydroida	Syntheciidae	*Synthecium subventricosum*	0	1	H	1955
Mollusca							
Bivalvia	Ostreoida	Ostreidae	*Crassostrea gigas*	1	1	H	1961
Bivalvia	Veneroida	Semelidae	*Theora lubrica*	1	1	B	1971
Phycophyta							
Phaeophyceae	Laminariales	Alariaceae	*Undaria pinnatifida*	0	1	H or B	Pre-1987
Urochordata							
Ascidiacea	Aplousobranchia	Cionidae	*Ciona intestinalis*	1	0	H	Pre-1950

[1] Date of introduction currently unknown but species had been encountered in New Zealand prior to the present survey.
* 1 = Present, 0 = Absent

Table 12 Non-indigenous marine organisms recorded from the Port of Nelson survey and the techniques used to capture each species (from Inglis et al. 2006a). Species distributions throughout the port and in other ports and marinas around New Zealand are indicated.

Genus & species	Capture techniques in the Port of Nelson	Locations detected in the Port of Nelson		Detected in other locations surveyed in ZBS2000_04
		First survey	Second survey	
Annelida				
Hydroides elegans	Pile scrape		McGlashen Quay	Auckland
Polydora hoplura	Pile scrape	McGlashen Quay		Dunedin, Lyttelton, Picton, Tauranga, Timaru, Wellington, Whangarei
Bryozoa				
Anguinella palmata	Pile scrape	McGlashen Quay		Auckland
Bugula flabellata	Pile scrape	Lay-Up & Repair Facility	Main Wharf, McGlashen Quay, Superyacht	Auckland, Bluff, Dunedin, Lyttelton, Napier, New Plymouth, Opua, Picton, Tauranga, Timaru, Wellington, Whangarei
Cryptosula pallasiana	Pile scrape	Lay-Up & Repair Facility	McGlashen Quay	Dunedin, Gisborne, Lyttelton, New Plymouth, Picton, Timaru, Wellington, Whangarei
Electra angulata	Benthic grab, pile scrape	Main Wharf		
Electra tenella	Pile scrape		Lay-Up & Repair Facility	Tauranga
Celleporaria nodulosa	Pile scrape	Kingsford Quay	Kingsford Quay, McGlashen Quay, Superyacht	Gisborne, Timaru
Conopeum seurati	Pile scrape	Kingsford Quay, Lay-Up & Repair Facility, Main Wharf, McGlashen Quay		Lyttelton, Whangarei
Schizoporella errata	Benthic grab	Main Wharf		Auckland, Whangarei
Watersipora subtorquata	Pile scrape	Kingsford Quay, Lay-Up & Repair Facility, Main Wharf, McGlashen Quay	Kingsford Quay, Main Wharf, McGlashen Quay, Superyacht	Auckland, Bluff, Dunedin, Gisborne, Lyttelton, Napier, New Plymouth, Opua, Picton, Tauranga, Timaru, Wellington, Whangarei

Table 12 Continued.

Genus & species	Capture techniques in the Port of Nelson	Locations detected in the Port of Nelson		Detected in other locations surveyed in ZBS2000_04
Cnidaria				
Lafoeina amirantensis	Benthic sled, Pile scrape	Main Wharf	Lay-Up & Repair Facility	
*Filellum serpens?**	Pile scrape		Main Wharf	
Synthecium campylocarpum	Benthic sled, crab trap, pile scrape		Main Wharf, McGlashen Quay, Superyacht	
Synthecium subventricosum	Pile scrape		Lay-Up & Repair Facility, Main Wharf	Timaru
Mollusca				
Crassostrea gigas	Pile scrape	Kingsford Quay, Lay-Up & Repair Facility, Main Wharf, McGlashen Quay	Kingsford Quay, Lay-Up & Repair Facility, Main Wharf, McGlashen Quay, Superyacht	Auckland, Dunedin, New Plymouth, Opua, Whangarei
Theora lubrica	Benthic sled, benthic grab	Kingsford Quay, McGlashen Quay	Amaltal Wharf, Kingsford Quay, Main Wharf, Marina, McGlashen Quay, Nelson Haven North, Nelson Haven South, The Cut	Auckland, Gisborne, Lyttelton, Napier, New Plymouth, Opua, Picton, Wellington, Whangarei
Phycophyta				
Undaria pinnatifida	Benthic sled, Starfish trap		Marina, The Cut, Ministry of Fisheries Wharf	Dunedin, Gisborne, Lyttelton, Napier, New Plymouth, Picton, Timaru, Wellington,
Urochordata				
Ciona intestinalis	Benthic sled, pile scrape	Lay-Up & Repair Facility, McGlashen Quay		Lyttelton, Napier, Timaru

* Identification is questionable for this species due to presence of infertile colonies only

Table 13 Berthage facilities in the Port of Picton (from Inglis et al. 2006b).

Berth	Berth No.	Purpose	Construction	Length of berth (m)	Maximum draught (m)	Maximum beam (m)
Inter-island ferry terminal	1	Vehicle-carrying high speed ferries	Concrete deck/wood and steel casing piles + wooden pile fendering	120	7.5	26
	2	Road and rail-carrying conventional ferries	Concrete dec/steel casing piles + wooden pile fendering	160	7.5	22
	3	Vehicle-carrying conventional vessels	Concrete dec/steel casing piles + wooden pile fendering	140	7.5	16
Waitohi Wharf	East	General-purpose finger wharf, cargo berths, overseas and coastal vessels, Cook Strait roll on-roll off vessels, fishing vessels	Concrete deck/concrete piles + wooden pile fendering	210	10.3	32
	West		Concrete deck/steel casing piles + wooden pile fendering	210	10.3	32
Waimahara Wharf (Shakespeare Bay)		Multi-purpose berth for timber, logs and coal	Concrete deck/concrete piles + rubber strung timber fendering	200	15.3	No limit
West shore		Commercial fishing vessels	Steel sheet pile on rock wall	30	2.5	No limit

Table 14 Number of vessel arrivals from overseas ports to the Port of Picton by each general vessel type and country of previous port of call, between 2002 and 2005 inclusive (data from LMIU “SeaSearcher.com” database) (from Inglis et al. 2006b).

Country (and geographic area) of previous port of call	Bulk/ cement carrier	Bulk/ oil carrier	Dredge	Fishing	General cargo	LPG/ LNG	Passenger/ vehicle/ livestock	Other (inc pontoons, barges, mining & supply ships, etc)	Passenger ro/ro	Research	Tanker (including chemical/ oil and ashphalt)	Container/ unitised carrier and ro/ro	Tug	Total
Australia (Australia)	9						3	1	1				1	15
Republic of Korea (northwest Pacific)	3													3
People's Republic of China (northwest Pacific)	3													3
Japan (Japan)	2													2
New Caledonia (Pacific Islands)	1						1							2
Aruba (South America Atlantic coast)							1							1
Total	18						5	1	1				1	26

Table 15 Number of vessel arrivals from Australia to the Port of Picton by each general vessel type and previous Australian state, between 2002 and 2005 inclusive (data from LMIU "SeaSearcher.com" database) (from Inglis et al. 2006b).

Australian state of previous port of call	Bulk/ cement carrier	Bulk/ oil carrier	Dredge	Fishing	General cargo	LPG/ LNG	Passenger/ vehicle/ livestock	Other (inc pontoons, barges, mining & supply ships, etc)	Passenger ro/ro	Research	Tanker (inc chemical/ oil and ashphalt)	Container/ unitised carrier and ro/ro	Tug	Total
New South Wales	1						2	1						4
Tasmania	2						1		1					4
Victoria	3													3
Queensland	2													2
South Australia	1												1	2
Total	9						3	1	1				1	15

Table 16 Number of vessel departures from the Port of Picton to overseas ports, by each general vessel type and country of next port of call, between 2002 and 2005 inclusive (data from LMIU "SeaSearcher.com" database) (from Inglis et al. 2006b).

Country (and geographic area) of next port of call	Bulk/ cement carrier	Bulk/ oil carrier	Dredge	Fishing	General cargo	LPG	Passenger/ vehicle/ livestock	Other (includes pontoons, barges, mining & supply ships, etc)	Passenger ro/ro	Research	Tanker (including chemical/ oil and ashphalt)	Container/ unitised carrier and ro/ro	Tug	Total
Republic of Korea (northwest Pacific)	32													32
Republic of Singapore (east Asian seas)	8													8
Australia (Australia)	2						3							5
India (Central Indian Ocean)	2													2
Japan (Japan)	1													1
People's Republic of China (northwest Pacific)	1													1
Philippines (east Asian seas)	1													1
Total	47						3							50

Table 17 Number of vessel arrivals from New Zealand ports to the Port of Picton by each general vessel type and previous port, between 2002 and 2005 inclusive (data from LMIU “SeaSearcher.com” database) (from Inglis et al. 2006b).

Previous port of call	Bulk/ cement carrier	Bulk/ oil carrier	Dredge	Fishing	General cargo	LPG/ LNG	Passenger/ vehicle/ livestock	Other (includes pontoons, barges, mining & supply ships, etc)	Passenger ro/ro	Research	Tanker (includin g chemical/ oil and ashphalt)	Container/ unitised carrier and ro/ro	Tug	Total
Wellington	13						8	1	4					26
Lyttelton	9						9	1					1	20
Nelson	8						1					6		15
Napier	10													10
Tauranga	8													8
Whangarei	8													8
Timaru	5													5
Auckland	2						1							3
Bluff	2													2
Westport	2													2
Gisborne	2													2
Dunedin	1													1
Stewart Is.							1							1
Total	70						20	2	4			6	1	103

Table 18 Number of vessel departures from the Port of Picton to New Zealand ports by each general vessel type and next port of call, between 2002 and 2005 inclusive (data from LMIU “SeaSearcher.com” database) (from Inglis et al. 2006b).

Next port of call	Bulk/ cement carrier	Bulk/ oil carrier	Dredge	Fishing	General cargo	LPG/ LNG	Passenger/ vehicle/ livestock	Other (includes pontoons, barges, mining & supply ships, etc)	Passenger ro/ro	Research	Tanker (includin g chemical/ oil and ashphalt)	Container/ unitised carrier and ro/ro	Tug	Total
Wellington	7						7	1	4					19
Whangarei	13													13
Napier	8						3							11
Lyttelton	4						7							11
Nelson							1	1				6	1	9
Tauranga	3						2							5
Gisborne	3													3
Westport	2													2
Auckland							1							1
Onehunga	1													1
Dunedin							1							1
Bluff	1													1
Total	42	0	0	0	0	0	22	2	4	0	0	6	1	77

Table 19 Non-indigenous marine species recorded from the Port of Picton during the first survey (T1) and second survey (T2) (from Inglis et al. 2006b). 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. * 1 = Present, 0 = Absent.

Phylum, Class	Order	Family	Genus and species	T1*	T2*	Probable means of introduction	Date of introduction or detection (d)
Annelida							
Polychaeta	Sabellida	Serpulidae	*Spirobranchus polytrema* ***(NR)***	0	1	H	Nov 2001[d]
Polychaeta	Spionida	Spionidae	*Dipolydora armata*	1	0	H	~1900
Polychaeta	Spionida	Spionidae	*Polydora hoplura*	1	0	H	Unknown[1]
Bryozoa							
Gymnolaemata	Cheilostomata	Bugulidae	*Bugula flabellata*	1	1	H	Pre-1949
Gymnolaemata	Cheilostomata	Bugulidae	*Bugula neritina*	0	1	H	1949
Gymnolaemata	Cheilostomata	Candidae	*Tricellaria inopinata*	0	1	H	Pre-1964
Gymnolaemata	Cheilostomata	Cryptosulidae	*Cryptosula pallasiana*	0	1	H	1890s
Gymnolaemata	Cheilostomata	Watersiporidae	*Watersipora subtorquata*	1	1	H or B	Pre-1982
Cnidaria							
Hydrozoa	Hydroida	Eudendriidae	*Eudendrium generale* ***(NR)***	0	1	H[2]	Jan 2003[d]
Mollusca							
Bivalvia	Veneroida	Semelidae	*Theora lubrica*	0	1	B	1971
Phycophyta							
Florideophyceae	Ceramiales	Ceramiaceae	*Griffithsia crassiuscula*	1	1	H	Pre-1954
Phaeophyceae	Laminariales	Alariaceae	*Undaria pinnatifida*	1	1	H or B	Pre-1987
Porifera							
Demospongiae	Halisarcida	Halisarcidae	*Halisarca dujardini*	1	1	H or B	Pre-1973

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

[2] Based on Cranfield et al's (1998) estimation for a congeneric species *Eudendrium ritchiei*.

Table 20 Non-indigenous marine organisms recorded from the Port of Picton survey and the techniques used to capture each species (from Inglis et al. 2006b). Species distributions throughout the port and in other ports and marinas around New Zealand are indicated.

Genus & species	Capture techniques in the Port of Picton	Locations detected in the Port of Picton*		Detected in other locations surveyed in ZBS2000_04
		First survey	Second survey	
Annelida				
Spirobranchus polytrema	Pile scrape		Ferry Terminal Berths1/2, Waitohi Wharf	Dunedin, Lyttelton, Napier, Timaru, Wellington
Dipolydora armata	Pile scrape	Ferry Terminal 3		Wellington
Polydora hoplura	Pile scrape	Ferry Terminal 3		Dunedin, Lyttelton, Nelson, Tauranga, Timaru, Wellington, Whangarei
Bryozoa				
Bugula flabellata	Benthic grab, benthic sled, pile scrape, pile visual	Ferry Terminal 2, Ferry Terminal 3, Waitohi Wharf	Ferry Terminal Berths 1/2, Long Arm No.1, Shakespeare Bay 2, Waitohi Wharf, Waitohi East, Waitohi End, Waitohi West	Auckland, Bluff, Dunedin, Lyttelton, Napier, Nelson, New Plymouth, Opua, Tauranga, Timaru, Wellington, Whangarei
Bugula neritina	Benthic sled, pile scrape		Ferry Terminal Berths 1/2, Shakespeare Bay 2	Auckland, Dunedin, Gisborne, Lyttelton, Napier, New Plymouth, Opua, Tauranga, Timaru, Whangarei
Tricellaria inopinata	Pile scrape		Shakespeare Bay 2	Gisborne, Lyttelton, New Plymouth, Whangarei
Cryptosula pallasiana	Pile scrape		Ferry Terminal Berths 1/2	Dunedin, Gisborne, Lyttelton, Nelson, New Plymouth, Timaru, Wellington, Whangarei
Watersipora subtorquata	Pile scrape, benthic grab, benthic sled	Ferry Terminal 2, Ferry Terminal 3	Ferry Terminal Berths 1/2, Long Arm No.1, Shakespeare Bay 2, Waitohi West	Auckland, Bluff, Dunedin, Gisborne, Lyttelton, Napier, Nelson, New Plymouth, Opua, Tauranga, Timaru, Wellington, Whangarei
Cnidaria				
Eudendrium generale	Pile scrape		Long Arm No.1	Napier, Wellington

Table 20 Continued.

Genus & species	Capture techniques in the Port of Picton	Locations detected in the Port of Picton*		Detected in other locations surveyed in ZBS2000_04
Mollusca				
Theora lubrica	Benthic grab, benthic sled		Long Arm No.1, Waitohi West	Auckland, Gisborne, Lyttelton, Napier, Nelson, New Plymouth, Opua Wellington, Whangarei
Phycophyta				
Griffithsia crassiuscula	Pile scrape, benthic sled	Waitohi Wharf	Waitohi Wharf, Waitohi End, Waitohi West	Bluff, Lyttelton, New Plymouth, Timaru, Wellington
Undaria pinnatifida	Pile scrape, benthic grab, benthic sled	Ferry Terminal 2, Ferry Terminal 3, Waitohi Wharf	Ferry Terminal Berths 1/2, Long Arm No.1, Shakespeare Bay 2, Waitohi Wharf, Waitohi End)	Dunedin, Gisborne, Lyttelton, Napier, Nelson, New Plymouth, Timaru, Wellington,
Porifera				
Halisarca dujardini	Pile scrape, benthic sled	Ferry Terminal 2, Waitohi Wharf	Ferry Terminal Berths 1/2, Waitohi West, Waitohi Wharf	Auckland, Bluff, Dunedin, Lyttelton, New Plymouth, Wellington

* NB. Some site names differed between the first and second surveys. The site names “Ferry Terminal Berths 1/2” and “Long Arm No. 1” used in the second survey were recorded in the first survey as “Ferry Terminal 2” and “Ferry Terminal 3”, respectively.