Chatham Islands / Rekohu

Non-Indigenous Species Port Survey

Baseline Surveys of New Ports and Marinas (Research Project ZBS 2005/19)

Biosecurity New Zealand Technical Paper No: 2019/11

Prepared for MAF Biosecurity New Zealand
By E. Jones, M. Stuart, D. McClary

Golder Associates

ISBN (online): 978-1-98-857170-6
ISSN (online): 2624-0203

November 2009

Disclaimer

While every effort has been made to ensure the information in this publication is accurate, the Ministry of Agriculture and Forestry does not accept any responsibility or liability for error or fact omission, interpretation or opinion which may be present, nor for the consequences of any decisions based on this information.

Any view or opinions expressed do not necessarily represent the official view of the Ministry of Agriculture and Forestry.

The information in this report and any accompanying documentation is accurate to the best of the knowledge and belief of Golder Associates (NZ) Ltd. acting on behalf of the Ministry of Agriculture and Forestry. While Golder Associates (NZ) Ltd. has exercised all reasonable skill and care in the preparation of information in this report, neither Golder Associates (NZ) Ltd. nor the Ministry of Agriculture and Forestry accept any liability in contract, tort or otherwise for any loss, damage, injury, or expense, whether direct, indirect or consequential, arising out of the provision of information in this report.

Requests for further copies should be directed to:

MAF Biosecurity New Zealand
Pastoral House,
25 The Terrace
PO Box 2526
WELLINGTON

Tel: 04 894 4100
Fax: 04 894 4227

This publication is also available on the MAF website at www.maf.govt.nz/publications

Abstract

New Zealand's geographic isolation presents the opportunity to protect its unique biodiversity and economy. Knowledge of existing non-indigenous and indigenous biodiversity is required to identify new species threats, detect new species introductions, and undertake effective management of marine biosecurity (Hewitt *et al.* 2004). The Ministry of Agriculture and Forestry – Biosecurity New Zealand (MAFBNZ) has therefore implemented a number of baseline port surveys to elucidate the degree of non-indigenous and indigenous species diversity within New Zealand's ports, marinas and also in regions relatively unaffected by human activities (Campbell *et al.* 2007).

This document presents the results of a baseline survey of native and non-indigenous marine species undertaken at the Chatham Islands, New Zealand between 8 and 13 February 2007. The survey was performed by Golder Associates (NZ) Ltd and the Australian Maritime College's National Centre for Marine and Coastal Conservation in accordance with survey protocols and design prepared by the Centre for Research on Introduced Marine Pests and MAFBNZ.

Four non-indigenous species and twenty-seven cryptogenic (category 1) species were detected at the Chatham Islands during the survey. Known introduced species comprised the bryozoans *Bowerbankia gracilis*, *Bugula flabellata*, *Cryptosula pallasiana* and the algae *Neosiphonia subtilissima*. The red seaweed *N. subtilissima* was recorded previously from the Chatham Islands as *Polysiphonia subtilissima* (Nelson *et al.* 1991), however the bryozoans had not been recorded at this location prior to the survey. *Neosiphonia subtilissima* was widespread about the Chatham Islands; while *B. gracilis* and *B. flabellata* occurred only on the wreckage of the *Thomas Currell*, which was run aground at Port Hutt in 1968. *Cryptosula pallasiana* occurred on wharf pilings at Port Hutt and on the *Thomas Currell*.

The possible origin and potential vectors for the translocation of new species to the Chatham Islands are discussed in relation to the relative risk of new species introductions and the translocation of non-indigenous species that have established at the Chatham Islands. Options for the management of vector pathways and non-indigenous species to prevent new species incursions to the Chatham Islands and the spread of established species are also discussed.

Keywords: Chatham Islands, marine biosecurity, non-indigenous species, baseline survey.

Contents

Page

Abstract **i**

1. Introduction **1**

2. Description of the Port **2**

2.1. General Features of the Chatham Islands 2

2.2. Historical Information – Port Development, Maintenance and Shipping Movements 3

3. Review of Existing Biological Information **9**

4. Survey Methods **12**

4.1. Survey Design and Sampling Methods 12

4.2. Taxonomic Identification 19

4.3. Criteria for Determination of Species and Biosecurity Status 20

4.3. Public Awareness Programme 21

5. Survey Results **22**

5.1. Port Environment 22

5.2. Native Biodiversity 27

5.3. Non-Indigenous Species in the Port 27

5.4. Public Awareness Programme 30

6. Potential Impacts of Non-Indigenous Species Found in the Port **32**

7. Origin and Potential Vectors for the Introduction of Non-Indigenous Species Found in the Port **33**

7.1. Overview 33

7.2. Natural Range Extension 33

7.3. Ballast Water and Hull Fouling 34

7.4. Marine Farming Activities and Fisheries Enhancement 36

7.5. Hull Cleaning 36

8. Influences of the Port Environment and Port Practices on Colonisation and Survival of Non-Indigenous Species **37**

9. Assessment of the Risk of New Introductions to the Port **38**

9.1. Overview 38

9.2. Aquaculture Vectors 39

9.3. Vessel Vectors 39

10. Assessment of the Risk of Translocation of Non-Indigenous Species Found in the Port 41

11. Recommendations 42

11.1. Overview 42

11.2. Management of Existing Non-Indigenous Species in the Port 42

11.3. Prevention of New Introductions 44

Acknowledgements 47

References 47

Tables

Page

Table 1: The most commonly recorded marine fauna and flora from the main taxonomic groups found at the Chatham Islands prior to the Chatham Islands non-indigenous marine species survey. 10

Table 2: Species and biosecurity status (adapted from Inglis *et al*. 2006a-m). 21

Table 3: Physical data (water temperature, salinity, dissolved oxygen, visibility, maximum depth and substrate type) recorded during the Chatham Islands survey, February 2007. 23

Table 4: Location of non-indigenous and cryptogenic species detected during port survey. 35

Table 5: Non-indigenous and cryptogenic species recorded as biofouling of vessels voyaging to Chatham Islands (Stuart & McClary 2008). 38

Table 6: List of non-indigenous marine species recorded at New Zealand mainland ports that have vessels voyaging to the Chatham Islands (Inglis *et al*. 2008a-c, Nelson 1999, Cranfield *et al*. 1998, Nelson & Maggs 1996, Adams 1983). 40

Figures

Page

Figure 1: Location of the Chatham Islands. 2

Figure 2: Sites at the Chatham Islands that were known to be frequented by whaling vessels between 1807 to 1885. 5

Figure 3: The wreck of the *Thomas Currell* at Port Hutt, Chatham Island. 6

Figure 4: Number of records for marine taxa found at the Chatham Islands prior to the Chatham Islands port survey. 9

Figure 5: Paua (*Haliotis iris*) on rocky subtidal substrate at Canister Cove, Pitt Island (left), and spiny dogfish (*Squalus acanthias*) at Omatuku Rock on the northeast coast of Chatham Island (right). 11

Figure 6: Sample locations around Chatham Island and Pitt Island. 13

Figure 7*: In situ* photographs of quadrats sampled using the pile scraping method. 14

Figure 8: Diver preparing to deploy clove oil emulsion at a 'poison station'. 15

Figure 9: Divers deploying the infaunal core; the contents of each core was emptied into a nylon bag *in situ* (black bag in divers hand; right). 16

Figure 10: Field staff retrieving a sediment sample from the javelin core. 16

Figure 11: Field staff retrieving a plankton sample from a small net for phytoplankton (left) and a larger net for zooplankton (right). 17

Figure 12: Diagram of an opera house crab trap. 18

Figure 13: Beach seining and beach wrack searches on the nearshore. 19

Figure 14: Water temperatures recorded during the Chatham Islands survey, February 2007. Dark shading denotes sea surface readings and light shading demotes readings taken near the sea floor. 25

Figure 15: Salinity recorded during the Chatham Islands survey, February 2007. Dark shading denotes sea surface readings and light shading demotes readings taken near the sea floor. 25

Figure 16: Dissolved oxygen levels recorded during the Chatham Islands survey, February 2007. Dark shading denotes sea surface readings and light shading demotes readings taken near the sea floor. 26

Figure 17: Proportion of mud (<63 µm grain size), sand (63 µm – 2 mm) and gravel (> 2 mm) and total organic carbon from sediment samples collected during the Chatham Islands port survey, February 2007. (Note that hard substrates were present at Sites 12-14, 28, 29, 31, 32, 35 and 36. * denotes samples that were collected at 50 m from the site). 26

Figure 18: Proportion of species diversity for taxonomic groups detected during the Chatham Islands port survey. 27

Figure 19: Site occupancy of indigenous, non-indigenous and cryptogenic taxa at the Chatham Islands. 28

Figure 20: Site occupancy of non-indigenous and cryptogenic (C1) species relative to measures of rarity based on percentage quartiles of total taxa site occupancy (i.e., Figure 19). 28

Figure 21: *Colpomenia durvillaei* collected from the slipway at Kaingaroa, Chatham Island on 26 October 2001. A herbarium specimen (left), and Kaingaroa wharf showing railway irons when the specimen was found (right). 29

Figure 22: *Clan MacLeod*, the research vessel used in the survey. 31

Figure 23: Slipway at Kaingaroa (left) and haulout area at Waitangi (right), Chatham Island.36

1. Introduction

Non-indigenous species have been identified as one of the major threats to biodiversity (Gurevitch & Padilla 2004, Carlton 1996, Lubchenco *et al.* 1991). The increasing rate of non-indigenous marine species introductions has become a matter of global concern (Carlton 1989, Ruiz *et al*. 1997, Cohen & Carlton 1998, Grosholz 2005). Non-indigenous species can adversely affect natural ecosystems, commerce and human health (Ribera & Boudouresque1995, Ruiz *et al*. 1997, AFF – Australia 2002). Therefore, management and decision-making in marine biosecurity have to be guided by a precautionary approach both in the identification of biosecurity threats and rapid response to pest incursions before an organism is established and negatively affecting New Zealand's economy, human health, and biodiversity (Gullett 1997, Cooney 2004, Cooney & Dickson 2005, Peel 2005). Effective surveillance is the key to the early detection and effective management of non-indigenous species as eradication is only likely to be feasible at the earliest founding stages of the invasion process.

New Zealand's geographic isolation presents the opportunity to protect its unique biodiversity and economy. Knowledge of existing non-indigenous and indigenous biodiversity is required to identify new species threats, detect new species introductions, and undertake effective management of marine biosecurity (Hewitt *et al*. 2004). New Zealand has, therefore, implemented a number of baseline port surveys to determine non-indigenous and indigenous marine species diversity within its ports, marinas and in regions that are relatively unaffected by human activities and regarded as pristine (Campbell *et al*. 2007).

Between 8 and 13 February 2007, Golder Associates (NZ) Ltd (Golder) and the Australian Maritime College's National Centre for Marine and Coastal Conservation undertook a non-indigenous marine species baseline survey at the Chatham Islands, New Zealand. The aim of the survey was to undertake a port and marine baseline survey to detect non-indigenous species using the Australian Centre for Research on Introduced Marine Pests (CRIMP) protocols (Hewitt & Martin 1996, 2001) and adhering to the survey design provided by the Ministry of Agriculture and Forestry – Biosecurity New Zealand (MAFBNZ). Marine biodiversity of the sites was also evaluated. This document presents the outcomes of this baseline survey of the Chatham Islands, the potential impacts of non-indigenous marine species and assesses the risk of new introductions to the marine area.

2. Description of the Port

2.1. GENERAL FEATURES OF THE CHATHAM ISLANDS

The Chatham Islands lie 700 km from Cape Turnagain on the Wairarapa coast and about 860 km from Banks Peninsula (Nelson *et al*. 1991; Figure 1). The island group consists of two inhabited islands, Chatham Island (Rekohu, 90 038 ha) and Pitt Island (Rangiauria, 6325 ha), and several smaller islands, the largest being South-East Island (Rangitira) and Mangare Island (Allan 1928). Several rock outcrops and reefs surround the islands, most notably Western Reef and the Star Keys.

The eastern and western coasts of Chatham Island have two large embayments, Petre Bay and Hanson Bay, respectively. Harbours are located at Waitangi (south-eastern corner of Petre Bay), Owenga (southern end of Hanson Bay), and within several smaller embayments along the northern shore of Petre Bay, e.g., Ocean Bay, Whangaroa (Port Hutt), Whangamoe and Whangatete. Kaingaroa, situated on the north-eastern tip of Chatham Island, is the only harbour along the north coast. Whangaroa (Port Hutt) is considered the only safe harbour in the island group (Allen 1928).

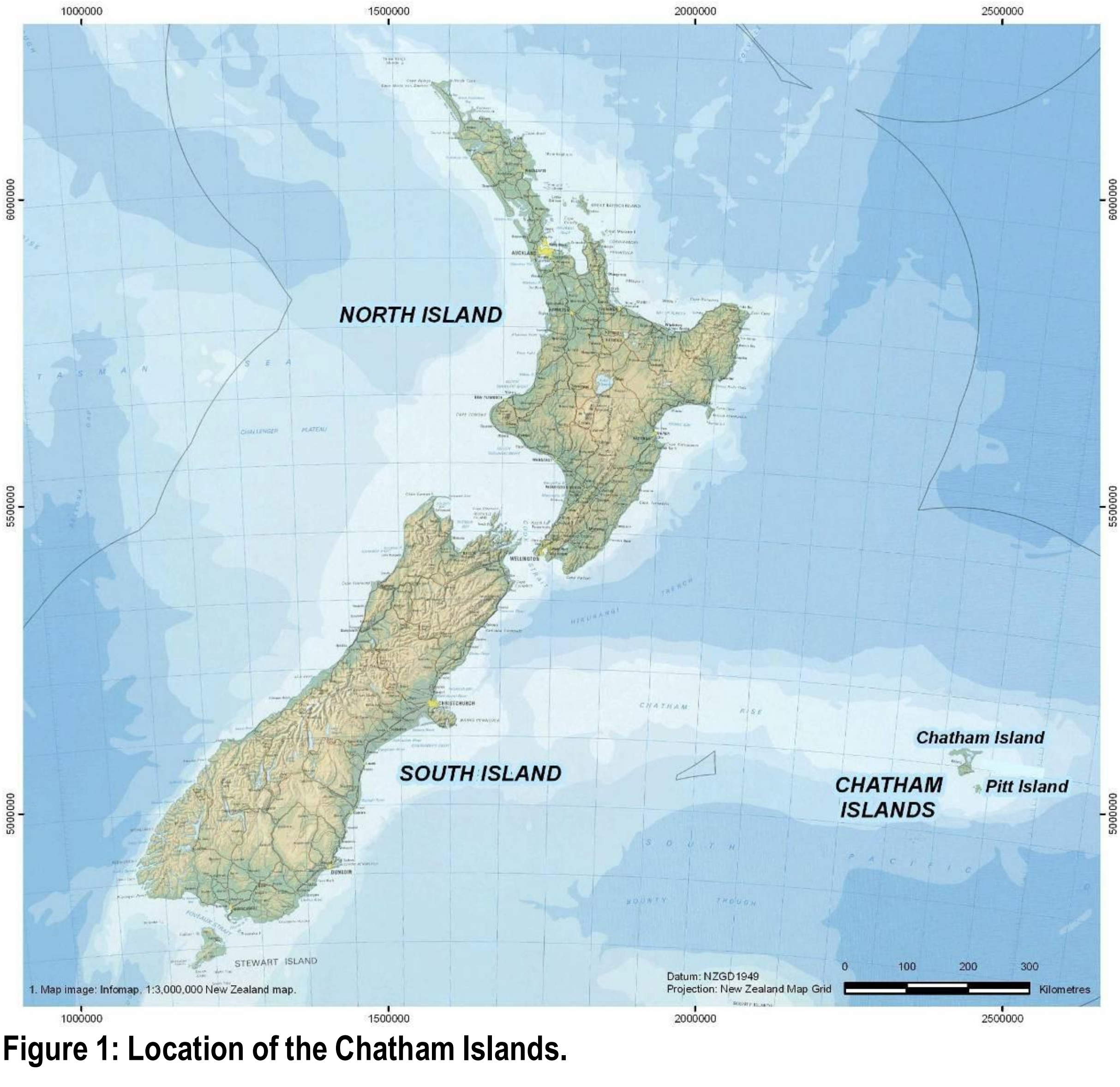


Figure 1: Location of the Chatham Islands.

Prevailing oceanic currents to the Chatham Islands are eastward from mainland New Zealand along the Chatham Rise to the Islands. The Southland Current carries cooler water along the east coast of South Island as far north as Cape Turnagain, where it is diverted southward by the warmer waters of the East Cape Current and flows eastward along the Chatham Rise to the Chatham Islands (Parsons 1985).

The Chatham Islands presently support a declining population of approximately 620 people and an economy based on tourism, fishing, agriculture and forestry (Taylor Baines & Associates 2002, Statistics New Zealand 2006). Much of the land is deforested and the remaining forested areas are protected by covenants and reserves (nature, historic and scenic reserves). The marine ecosystems of Chatham Island, however, have no formal protection (such as Marine Protected Areas).

2.2. HISTORICAL INFORMATION – PORT DEVELOPMENT, MAINTENANCE AND SHIPPING MOVEMENTS

2.2.1. Colonising expeditions

The original inhabitants of the Chatham Islands were Moriori, voyaging to the islands from New Zealand sometime between the 12th and 16th centuries AD and, more probably, from the South Island during the 13th and 14th centuries (King 2000). The first European contact occurred when the brig, *Chatham* sighted the northern coast of Chatham Island in 1791 (McNab 1908). The vessel put ashore briefly at Kaingaroa but left shortly after the fatal shooting of a native Moriori (King 2000, McNab 1908). The islands to the south of Chatham Island were later charted by *HMS Cornwallis* in 1807.

In 1835, two related New Zealand Maori tribes, Ngati Mutunga and Ngati Tama, sailed to the Chatham Islands from Wellington in two voyages on the brig *Rodney*. The first voyage carried principally Ngati Tama, some of whom immediately settled at Waitangi and Kaingaroa. When the remaining Ngati Mutunga arrived in early December, they stayed at Whangaora (Port Hutt). Once settled, the Maori proceeded to ‘walk the land’, killing and enslaving the Moriori inhabitants. In May 1838, Maori seized the French whaling vessel *Jean Bart*, ran her ashore at Ocean Bay and set her alight (Butterfield & Pryce 2002), with the crew being killed by Maori or perishing in their efforts to escape to Pitt Island and mainland New Zealand (King 2000). When news of the *Jean Bart*’s capture reached the Bay of Islands with the American whaler *Rebecca Sims*, the French warship *Heroine* sailed to the Chatham Islands, accompanied by the *Adele* and *Rebecca Sims*, and destroyed villages at Waitangi, Ouira, Ocean Bay and Whangaroa in retaliation (King 2000, Holmes 1993, Ingram & Wheatley 1936). Fear of further reprisals contributed to the decision by the Ngati Mutunga chief, Matioro, to lead a colonising expedition to the Auckland Islands in 1842.

2.2.2. Shipping Movements

Sealing

Sealers from Hobart, Sydney and America frequented the Chatham Islands from 1805 onwards (Butterfield & Pryce 2002) with foreign sealing reaching an initial peak around November 1808 (Richards 1982). The main period of sealing activity was reported to have occurred over the decade from 1825 to 1835, although some records indicate that the volume of vessel traffic was still considered to be low in the early 1830s with only three or four sealers visiting each year from 1831 to 1835 (Dieffenbach 1841). In later years, sealers were reported to have visited Chatham Island and neighbouring islets and reefs in considerable numbers, with Ocean Bay indicated as their principal resort (Dieffenbach 1841). Sealing persisted as a seasonal activity that complemented bay whalers from Sydney and Hobart and subsistence agriculture until 1843.

Whaling

The first pelagic whalers to visit the Chatham Islands arrived in 1835 and the south-east spread of American and British sperm whaling from grounds around the Kermadec Islands led to a pelagic whaling bonanza around 1840 (Butterfield & Pryce 2002, Richards 1982, 2002). Ocean Bay was the port-of-call for sealers and whalers in the early 1830s, but was later supplanted by Whangaroa (Port Hutt), and then by Waitangi in the late 1830s (King 2000).

Thirty shore visits by vessels at Waitangi are reported in the 1839-40 whaling season (Richards 1982, McNab 1908). By the 1840-41 season, however, only 16 American vessels were recorded at or off the Chatham Islands, compared to 30 listed vessels at the Bay of Islands. This reflected the general decline in pelagic whaling after 1840 as the industry became less profitable (Richards 1982).

In the half decade from 1845 to 1850, the pattern of American pelagic whaling vessels exhibited a growing trend away from concentrated whaling off the Chathams toward merely cruising slowly through the area on their way to the right whaling grounds off Japan, the Okhotsk Peninsula, and the north-west coast of America. Thirty-four vessels were recorded in the area from 1846 to 1850, with only a small number spending more than a few days in passing, and even fewer landing on the Islands (Richards 1982).

In the mid-1850s, the Chatham Islands became a major base for smuggling dutiable goods into New Zealand and several colonial vessels were likely only part-time whalers also pursuing the lucrative trading and smuggling ventures. Incidentally, 17 recorded wrecks occurred among whalers and traders from 1849 to 1868, and is indicative that most vessels calling around this time were as much interested in onshore provisions as they were in offshore whaling. This compares to seven recorded wrecks during the previous 20 years of sealing and whaling, and three wrecks in the proceeding 20 years.

By the 1860s, sperm whaling was a firmly established industry with individual ships returning to the grounds situated thirty to forty miles south of Pitt Island. Most American whalers operating in this period adopted seasonal routes that included southern summers at the Chatham Islands and northern summers in the Arctic, Oskhotsk and Japan Seas. In the course of a single four-year voyage, a typical whaling vessel could have made four distinct cruises to the Chatham Islands, four in the Arctic and made up to eight calls each at Monganui, Russell or Auckland, Lahaina and Honolulu (Richards 1982).

Whaling vessels were provisioned at Waitangi, Owenga, Whangaroa, Waikeri (Okawa), Matarakau, South-East Island and Pitt Island (Richards 1982). Kaingaroa was established as the port of entry to Chatham Island in 1857 until 1863 (King 2000). A decline in the number of vessels visiting Chatham Island over this period was commensurate with an increased number visiting neighbouring Pitt Island, which had captured the bulk of the American trade by 1860 when nine vessels are reported to have visited the island (King 2000, Richards 1982).

Permanent shore stations were established at Waikeri (1840~1843) and Owenga (1840-1861) (Prickett 2002), but the activities at Waikeri were also later shifted to Owenga in 1844, where the station remained active until 1855. Other whaling stations were established at Kaingaroa (in 1841), Te Whakaru Island, Te Awapatiki, Whangaroa, Te Roto and South-East Island (Richards 1982). As pelagic whaling ceased off the Chatham Islands, attempts at shore whaling were unsuccessful, despite revival of the station at Owenga in 1861 and the establishment of a small station at Whangaroa in 1882 (Richards 1982). The last non-American whaling visitor to the Chatham Islands was the *Othello* of Hobart in 1885, and American whaling at the Chatham Islands ended in 1888 with the departure of the *Alaska* after visits to Owenga and Pitt Island (Richards 1982). Figure 2 indicates sites on the Chatham Islands that were most frequently visited by whaling vessels during 1807 to 1885.

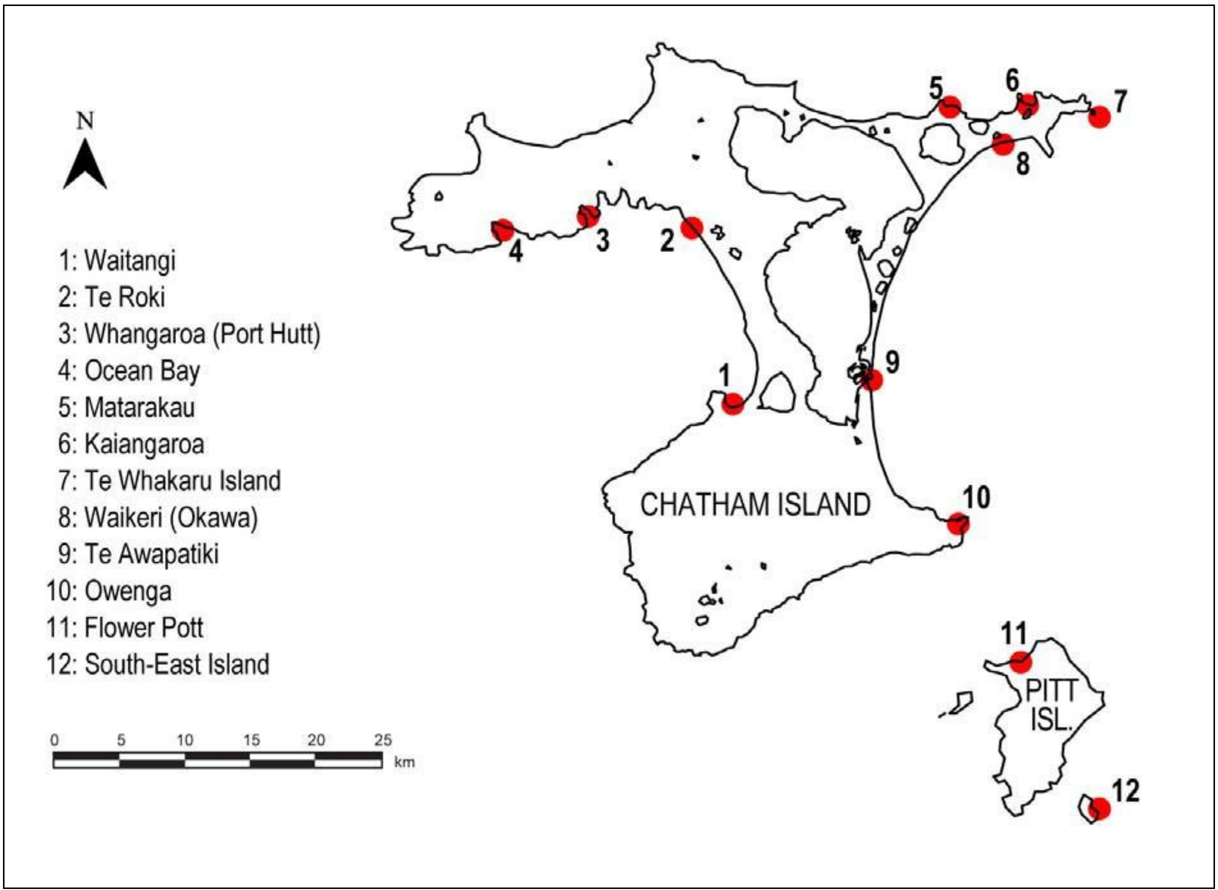


Figure 2: Sites at the Chatham Islands that were known to be frequented by whaling vessels between 1807 to 1885.

Other fisheries

In addition to whaling, a few other fisheries have established at the Chatham Islands. A cod fishery was established in 1911 following promising returns from an exploratory cruise by the Wellington fishing vessel *Nova Niven*, during which time she fished and trawled from Okawa (Waikeri) to Owenga (Holmes 1993, Johnson & Haworth 2004). At this time the Chatham Island Fishing Company Ltd also purchased the steamer *Himitangi* and commenced a service between Lyttelton and Chatham Island.

By the mid-1960s crayfish stocks in New Zealand were severely depleted overall. When the Wellington-based vessel *Miro* returned from the Chatham Islands with its freezer full of crayfish in 1966, it sparked a crayfish boom. Vessels travelled to the Chatham Islands from Bluff, Port Chalmers, Timaru, Nelson, Napier, Gisborne and North Auckland, with records indicating up to 30 vessels anchored at Kaingaroa alone (Ingram 1990). Crayfish catches rose to a peak in 1969, but declined rapidly until 1971 when little stock was left. The *Thomas Currell* was sent to Chatham Island in 1966 to act as a freezer depot at the time of the crayfish boom. This vessel was deliberately run ashore at Port Hutt in 1968 when a processing plant was built onshore and the vessel was of no further use (Butterfield & Pryce 2002; Figure 3).

Figure 3: The wreck of the *Thomas Currell* at Port Hutt, Chatham Island.

Cargo and passenger services

By 1843 there was a thriving trade in produce from Chatham Island, supplying not only whalers but also settlements on mainland New Zealand, and by 1848 suppliers were delivering to Wellington, Auckland, Sydney and San Francisco (Richards 1982, King 2000).

Sheep were established on Chatham Island by 1840, but sheep farming did not begin in earnest until 1867-1868 when most Maori returned to Taranaki on the mainland and leased their land to Canterbury settlers (King 2000, Holmes 1993). Before 1893 small shipments of live sheep from Chatham Island were landed at various ports about New Zealand, but a regular shipping service between mainland New Zealand and Chatham Island began in 1863 with 1600 sheep being transported to Lyttelton on the Ohau (Holmes 1993, Butterfield & Pryce 2002).

Over the next thirty years several companies supplied vessels for charter from Chatham Island to Lyttelton, including the *Kahu*, *Toroa*, *Himitangi* and *Ripple* (Butterfield & Pryce 2002, Holmes 1993). The voyages of the *Kahu* to the Chatham Islands included four or five wool-trips in January 1891, as well as trips in October 1891, March 1893 and January 1895

(Gascoyne 1916). The *Star of the South* was the first steamer to visit the Chatham Islands in 1864 (Butterfield & Pryce 2002). The *Ripple* was additionally fitted with accommodation to take passengers in 1906 (Butterfield & Pryce 2002).

From 1910 to 1920, the larger cargo vessels *Ngatoro*, *Ngahere* and *SS Taviuni* were chartered to provide greater carrying capacity (Holmes 1993). The last voyages to be chartered specifically with stock were two trips by the *Kamo* in November 1922 and four voyages by the *SS Flora* in early 1923 (Butterfield & Pryce 2002, Holmes 1993).

A general freight, stock and passenger service, comprising monthly calls to Waitangi and annual visits elsewhere about the Chatham Islands, was established in April 1923 with the *Tees*. Shortly after being renamed *Holmwood*, she was scuttled by German raiders en route to Lyttlelton in November 1940. After the loss of the *Holmwood*, the Holm shipping company chartered the *Port Waikato* and ran a monthly service from 1940 to 1958. The time between 1939 and 1940 were bad years for sheep farming, but the industry was on its way to recovery by April 1943 when the *Kopua* made four voyages to Lyttelton in 20 days (Holmes 1993). The 1950s were boom years for sheep farming and in 1954 the *Port Waikato* made a record 19 voyages to Lyttelton carrying stock (Butterfield & Pryce 2002, Holmes 1993). A meat-works was built on Chatham Island in 1964, and shipping of livestock reduced thereafter (Holmes 1993).

The purpose-built *Holmburn* replaced the *Port Waikato* in 1958 providing a monthly service to the Chatham Islands until 1968, at which time the *Holmdale* was chartered by the New Zealand government to undertake at least ten voyages to the Islands, including two to Pitt Island, per annum. The *Holmdale* continued a monthly service until 1972. Services supplementary to the *Holmdale* were provided by the *Kopua* and the Government steamer *Matai* in August 1951 and 1954. More recently, the New Zealand government supported a barge service operated by Seatow Ltd from October 1990 to 1991 (Butterfield & Pryce 2002).

The Cook Island National Line's *Ngamaru III* then commenced a service between Napier and Waitangi in November 1991 (Butterfield & Pryce 2002). In the first eight years of this service, *Ngamaru III* made over 170 voyages to the Chatham Islands, in addition to regular trips between mainland New Zealand and the Pacific Islands (Butterfield & Pryce 2002). She was sold in late 2002, re-named as the *Southern Motu*, and resumed services between Napier and Chatham Island, but without regular passage to the tropics (Tony Skelton, March 2003, pers. comm. M. Stuart). The *Southern Motu* was then sold offshore in May 2004 (Pryce 2005) and is no longer in service at the Chatham Islands. The *Southern Tiare* resumed a monthly service between mainland New Zealand and the Chatham Islands in June 2004 (Pryce 2004), although this service was discontinued in June 2006 (Owen Pickles, March 2007, pers. comm. M. Stuart).

In late 1996, Chatham Shipping Services Ltd chartered the *Sitka II* and later the *Sami II* to conduct a service to the Islands in competition with the *Ngamaru III*. Collectively, these vessels made seven voyages between Napier and Chatham Island plus five to Pitt Island in four months. The service was later continued by the *Acoriano*, which made seven voyages between Napier and the Islands between May 1997 and March 1998.

In March 2000, the *Jenka* began a ten-day service between Timaru and Chatham Island. This vessel was renamed *Rangatira* in early 2002 and continues to voyage between Timaru and the Chatham Islands and to Napier as required (Owen Pickles, June 2009, pers. comm. M. Stuart). In May 2009 a second vessel began servicing the Chatham Islands with the converted fishing trawler *Baldur*, owned by 44 South Shipping Company Limited, making three voyages between Napier and Chatham Island. Two more voyages from Napier were planned for June 2009, followed by a two month hiatus while the vessel voyaged to the Pacific Islands (Owen Pickles, June 2009, pers. comm. M. Stuart).

Naval and government shipping

Over the period from 1892 to 1906, several naval vessels and government steamers visited Chatham Island, including *HMS Goldfinch* (1892), *HMS Ringdove* (1893, 1895), *HMS Lizard* (1893, 1903), *HMS Rapid* (1894), *SS Hinemoa* (1895), *HMS Psyche* (1904), and *SS Tutanekai* (1906) (Butterfield & Pryce 2002, Gascoyne 1916). The *HMSS Britannia* carrying the Duke of Edinburgh also visited Chatham Island on 20 December 1956 (Butterfield & Pryce 2002).

Scientific expeditions

The first scientist to visit the Chatham Islands was Ernst Dieffenbach, on the *Cuba* in 1840 (Dieffenbach 1841, King 2000). Visits by scientists continued during the 18th century with Henry Travers (1863-64, 1871), Charles Traill (1866-67) Professor Hugo Schauinsland (1897) and Henry Forbes (1892) (Nelson *et al*. 1991, Godley 2002, Tennyson & Millener 1994). In the early part of the 19th century visits by individual scientists such as Leonard Cockayne (1901) gave way to multi-disciplinary and marine expeditions such as the *Nora Niven* New Zealand Government trawling expedition (1907), the Otago Institute Expedition to the Chatham Islands (1924-25) and the Chatham Islands 1954 Expedition (Jennings 1914, Young 1930, Dell 1960a and b, Glasby & Read 1998).

3. Review of Existing Biological Information

The most detailed synopsis of the Chatham Islands marine fauna is the result of the Chatham Islands 1954 Expedition, undertaken by members of the New Zealand Oceanographic Institute (Jennings 1914, Young 1930, Dell 1960a and b, Glasby & Read 1998). The expedition was conducted from the *HMS Challenger* and was the first major oceanographic expedition beyond the shelf edge around New Zealand. Prior to this, Young's (1929) synopsis of marine fauna of the Chatham Islands provides some information on the marine communities of the area. There is also a limited range of recently published biological information describing the Chatham Islands marine fauna. The most common publications involve research on particular species, such as algae (Nelson *et al*. 1991, Naylor 1954), rock lobster (Kensler 1967) and a variety of commercial fish species (Francis 1996, Ministry of Fisheries 2007, Paulin & Roberts 1992, 1993, Roberts 1991, Roberts *et al.* 1991). Figure 4 illustrates the number of records of marine taxa found at the Chatham Islands prior to the current survey and Table 1 lists the most commonly recorded species of the major taxonomic groups mentioned in these records.

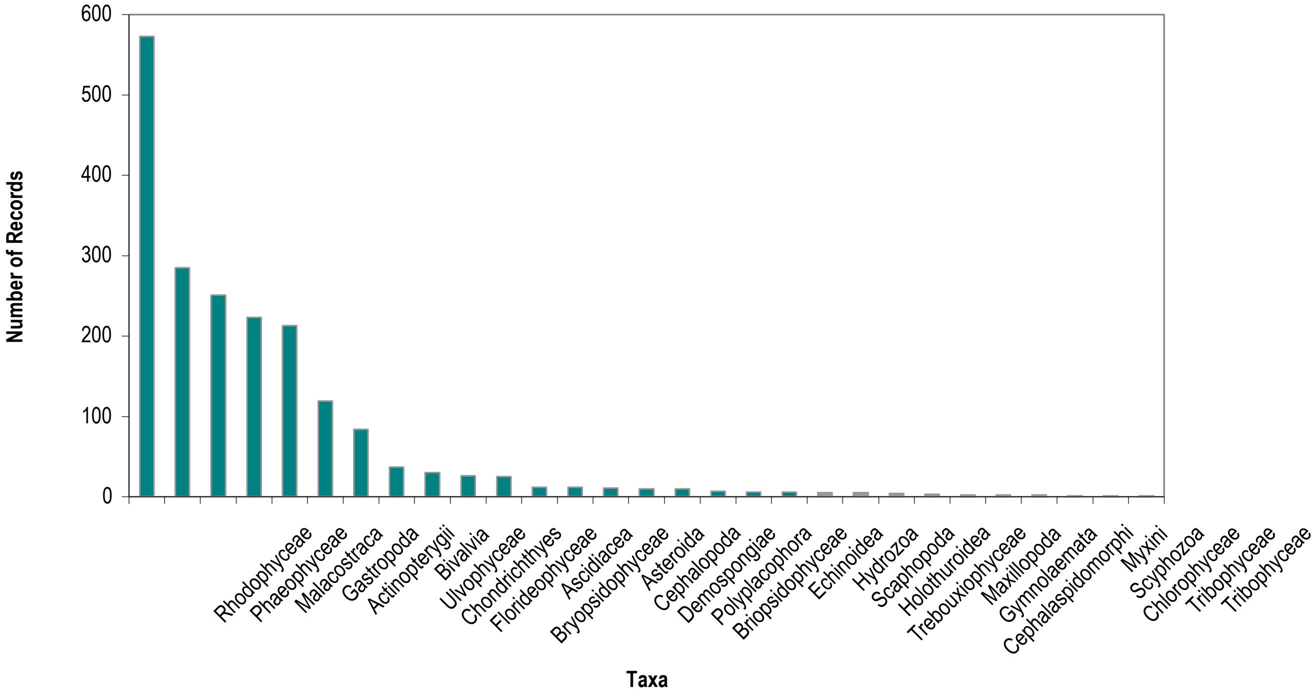


Figure 4: Number of records for marine taxa found at the Chatham Islands prior to the Chatham Islands port survey.

Of the marine species reported in the vicinity of the Chatham Islands, algae were the most frequently recorded taxa, with approximately 274 species reported from a total of approximately 998 records for the area (e.g., Saunders & Bailey 1999, Adams 1994, Nelson *et al*. 1991, Hay 1989, Nelson 1987, Naylor 1954, Chatham Islands 1954 Expedition). The majority of these were members of the Rhodophyta (red algae), which are ecologically significant as primary producers and providers of structural habitat for other marine organisms.

Table 1: The most commonly recorded marine fauna and flora from the main taxonomic groups found at the Chatham Islands prior to the Chatham Islands non-indigenous marine species survey.

Kingdom	Phylum	Class	Order	Lowest taxonomic identification	No. of Records
Animalia	Arthropoda	Malacostraca	Decapoda	*Cancer novaezelandiae*	4
				Elamena producta	6
				Eurynolambrus australis	8
				Halicarcinus cookii	4
				Heterozius rotundifrons	4
				Jasus edwardsii	134
				Nectocarcinus antarcticus	4
				Notomithrax ursus	13
				Pinnotheres novaezelandiae	4
	Chordata	Actinopterygii	Anguilliformes	*Conger verreauxi*	3
			Beryciformes	*Paratrachichthys trailli*	3
			Gadiformes	*Lotella rhacinus*	3
				Pseudophycis bachus	3
			Perciformes	*Dellichthys morelandi*	3
				Diplocrepis puniceus	4
				Forsterygion varium	3
				Latridopsis ciliaris	5
				Latris lineata	3
				Nemadactylus macropterus	5
				Notolabrus fucicola	4
				Odax pullus	4
				Parapercis colias	3
				Polyprion oxygeneios	3
				Pseudolabrus miles	4
				Thrysites atun	4
			Scorpaeniformes	*Helicolenus percoides*	4
			Syngnathiformes	*Hippocampus abdominalis*	3
				Solegnathus spinosissimus	3
			Tetraodontiformes	*Parika scaber*	4
	Cnidaria	Hydrozoa	Leptothecata	*Amphisbetia trispinosa*	2
	Echinodermata	Echinoidea	Camarodonta	*Evechinus chloroticus*	2
			Cassiduloida	*Apatopygus recens*	4
	Mollusca	Bivalvia	Veneroida	*Paphies subtriangulata*	3
		Cephalopoda	Incirrata	*Argonauta nodosa*	3
			Octopoda	*Octopus huttoni*	3
				Pinnoctopus cordiformis	2
		Gastropoda	Archaeogastropoda	*Haliotis iris*	2
Chromista	Ochrophyta	Phaeophyceae	Dictyotales	*Glossophora kunthii*	10
				Zonaria turneriana	11
			Ectocarpales	*Myriogloea intestinalis*	10
			Laminariales	*Lessonia tholiformis*	10
Plantae	Rhodophyta	Florideophyceae	Hildenbrandiales	*Apophlaea lyallii*	11
		Rhodophyceae	Ceramiales	*Chondria macrocarpa*	11
				Laurencia thyrsifera	12
			Gelidiales	*Pterocladia lucida*	10
			Rhodymeniales	*Champia novae-zelandiae*	10

The mollusc record has also been well documented including the records of Powell (1979). A total of 362 mollusc species including bivalves, gastropods, cephalopods, scaphopods and polyplacophorans have been recorded in the Chatham Islands region. Gastropods are relatively well-studied and abundant at the Chatham Islands with over 200 previous records (e.g., paua, *Haliotis iris*; Figure 5 left), while the bivalve taxa were approximately half as numerous with a little over 100 records.

Of the fishes, the most common type recorded are the ray-finned fishes (Actinopterygii) with 128 species recorded near the Islands, in addition to the 29 species of cartilaginous fishes (e.g., spiny dogfish *Squalus acanthias*; Figure 5 right) reported from the region (Francis 1996, Roberts 1991, Young 1929). Fish fauna were similar to records elsewhere in New Zealand and included eels, flounder, triplefins, blue cod and a range of estuarine species.

Sixty-one crustacean taxa have been recorded from the Chatham Islands prior to the current survey. These taxa included ten amphipods, 32 decapods and 15 isopods and four species of barnacle (e.g., Breen & Booth 1989, Wear & Fielder 1985, Annala & Bycroft 1985, McKoy 1983, Melrose 1975, Kensler 1969, 1967, Griffin 1966, Bennett 1964, Young 1929). Decapod taxa included several camouflage spider crabs and smaller shore crab species; isopod taxa mainly comprised four genera including *Amphoroidea*, *Dynamenella*, *Exospaeroma* and *Isocladus* spp., while the amphipods included several genera.

The marine biota of the Chatham Islands is characterised by a high degree of endemism. Species endemic to the Chatham Islands include several algae (such as *Pyrophyllon cameronii*, *Lessonia tholiformis*, *Grateloupia prolifera*, *Durvillaea chathamensis* and *Landsburgia myriofolia*; Hay 1989, Nelson *et al.* 1991, Nelson *et al*. 2003), molluscs and sponges (Dell 1960, Berquist 1961, Roberts 1991). In terms of macroalgae, the Chatham Islands are noted by the absence of the laminarian kelp *Ecklonia radiata* (Schiel *et al*. 1995), which is prevalent throughout mainland New Zealand.

4. Survey Methods

4.1. SURVEY DESIGN AND SAMPLING METHODS

4.1.1. Survey design

The survey design was provided by Ministry of Agriculture and Forestry – Biosecurity New Zealand (MAFBNZ) and developed using the protocols of the Centre for Research on Introduced Marine Pests (CRIMP) (Hewitt & Martin 1996, 2001) with the aim of maximising the detection of non-indigenous species. Site selection concentrated on habitats and sites within the port and adjacent areas that were near a point of inoculation, or were most likely to have been influenced by ballast water discharge, mariculture, and hull fouling transfers (including fishing and recreational vessels).

Sampling methods were selected to ensure comprehensive coverage of habitats and were intended to provide presence/absence information or semi-quantitative indices of abundance only. Typically, non-indigenous species are rare (at least initially), having both limited distribution and abundance. Thus, to detect a rare species, sampling concentrated on maximising coverage within a site with minimal sampling replication. Replicate sampling was only undertaken in situations where small-scale heterogeneity was likely to influence detection of non-indigenous species, such as dinoflagellates.

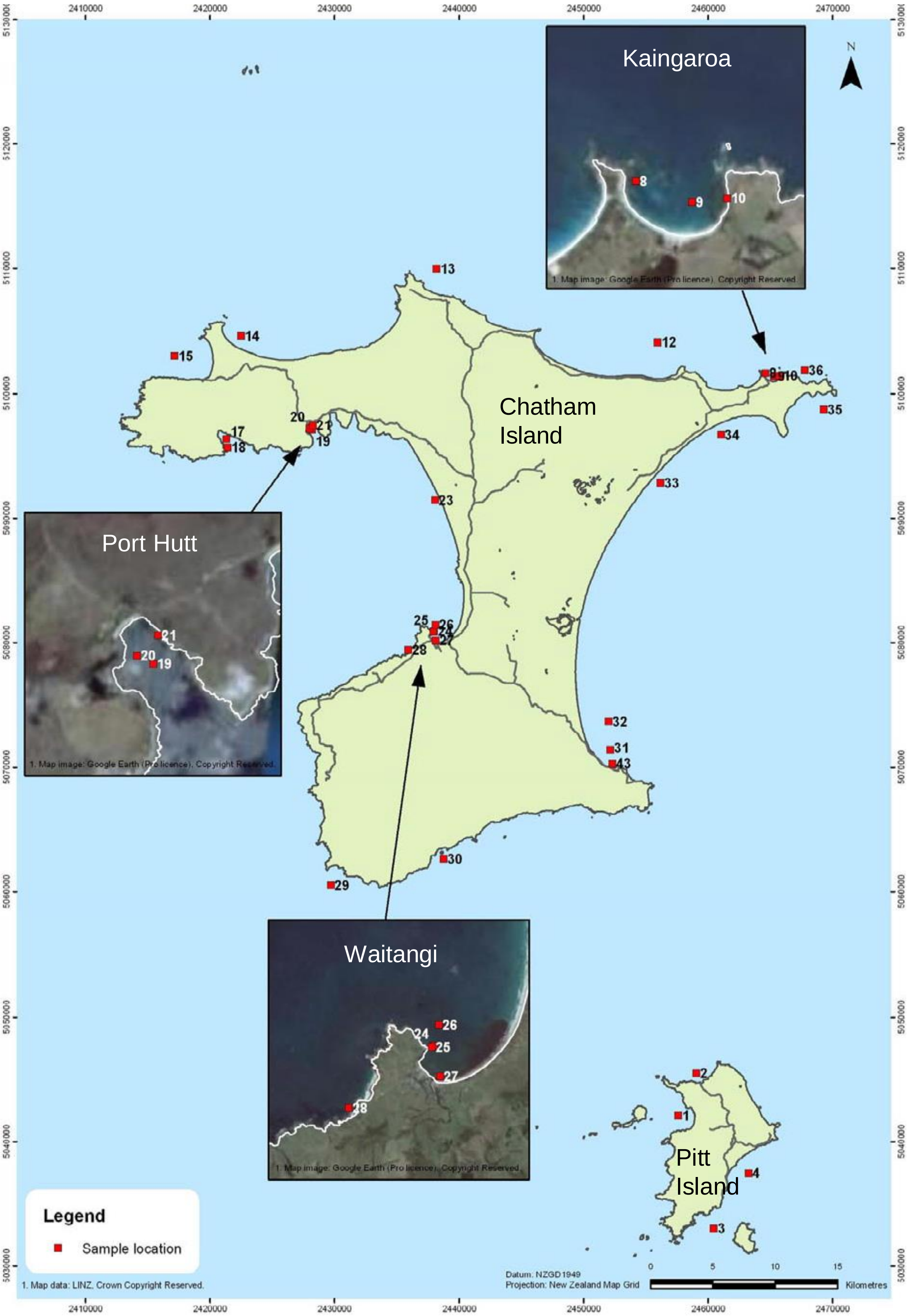
The survey was conducted from 8 to 13 February 2007. The sampling strategy used for the Chatham Islands marine biosecurity survey relied on the detection thresholds determined for non-indigenous species in Australia (see Hewitt & Martin 2001). Hewitt & Martin (2001) cite the previous work of Green & Young (1993), which indicates approximately 13 samples are required to detect a rare species (i.e., species with a mean Poisson density of 0.1 individuals per sample unit) at a 95% probability. Hence, the sampling strategy used for the Chatham Islands was based on a suggested minimum sample size of at least seven sites to detect rare species.

Sampling targeted three regions including:

- Potential inoculation sites within the port;
- The adjacent area; and
- Port approaches.

4.1.2. Sampling methods

Visual surveys, pile scraping and coring were undertaken by scuba divers, and trapping and plankton sampling were carried out from the research vessel. Photographic records were taken where visibility was adequate. Areas specifically targeted included shipping berths, anchorage areas, the shipping approach channels, and other potential sink areas where non-indigenous species may be deposited due to currents and geographic position. The distribution of sampling sites visited during the survey is illustrated in Figure 6. Data records for each site are provided in Appendix A.



Kaingaroa
Chatham Island
Port Hutt
Waitangi
Pitt Island
Legend
Sample location
1. Map data: LINZ, Crown Copyright Reserved.
1. Map image: Google Earth (Pro licence). Copyright Reserved.
Datum: NZGD1949
Projection: New Zealand Map Grid
Kilometres

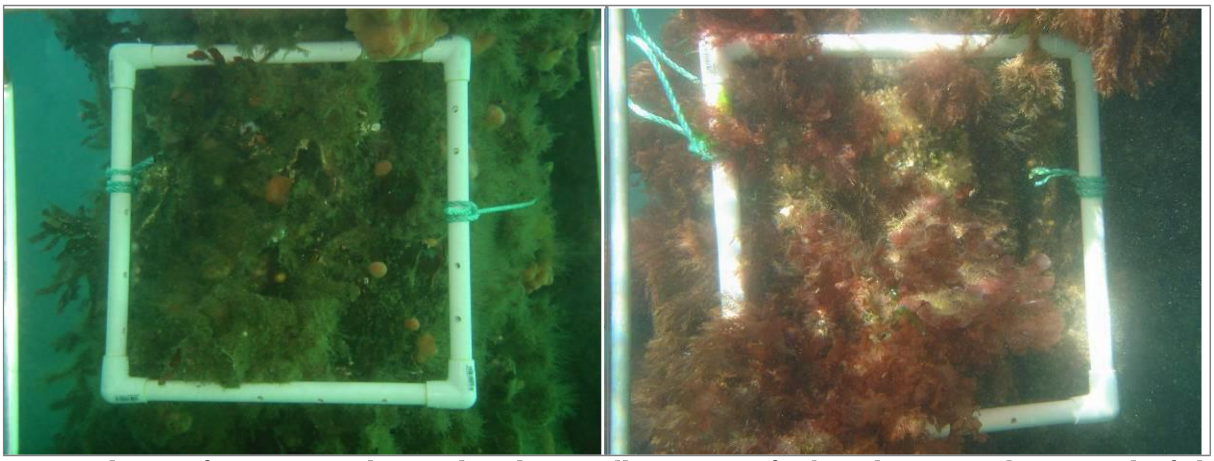
Sampling methods used during the survey included:

- Pile scraping.
- Poison stations.
- Qualitative visual surveys.
- Benthic coring (large cores).
- Dinoflagellate cyst sampling (small cores).
- Plankton netting (phyto- and zooplankton).
- Trapping (crab and shrimp traps).
- Beach seining.
- Beach wrack searches.
- Collection of photographs and video footage (where visibility allowed).

Pile scraping

Fouling assemblages on wharf pilings and other hard substrates (i.e., channel markers) were collected by pile scraping. Quantitative samples were removed from 0.1 m^2 (32 cm x 32 cm quadrats; Figure 7) using plastic scrapers. A series of piles were selected along the wharf from which samples were collected. Where depths were greater than 7 m, three samples were collected from four piles at 0.5 m, 3.0 m and 7.0 m below the mean low water (MLW) level. Where depths were less than 7 m, two samples were collected from eight piles at 0.5 m and 3.0 m below MLW. Where depths were much less than 3 m or the hard surface was not large enough to appropriately sample using quadrats (i.e., chain-link channel markers, narrow struts on small wharves), qualitative visual surveys were undertaken as an alternative sampling method.

Prior to scraping, still photographs were taken of each quadrat (where visibility allowed). Scraped samples were collected in a 1 mm mesh collection bag or large plastic bag, returned to the research vessel and rough-sorted prior to preservation according to protocols provided by the Marine Invasives Taxonomic Service (MITS).



An emulsion of seawater, clove oil and a small amount of ethanol was used to sample fish found near breakwaters and around the base of piles and facings. The solution was dispensed by divers from a plastic bottle and the affected organisms were collected using hand nets (Figure 8). Specimens were handled according to MITS protocols.

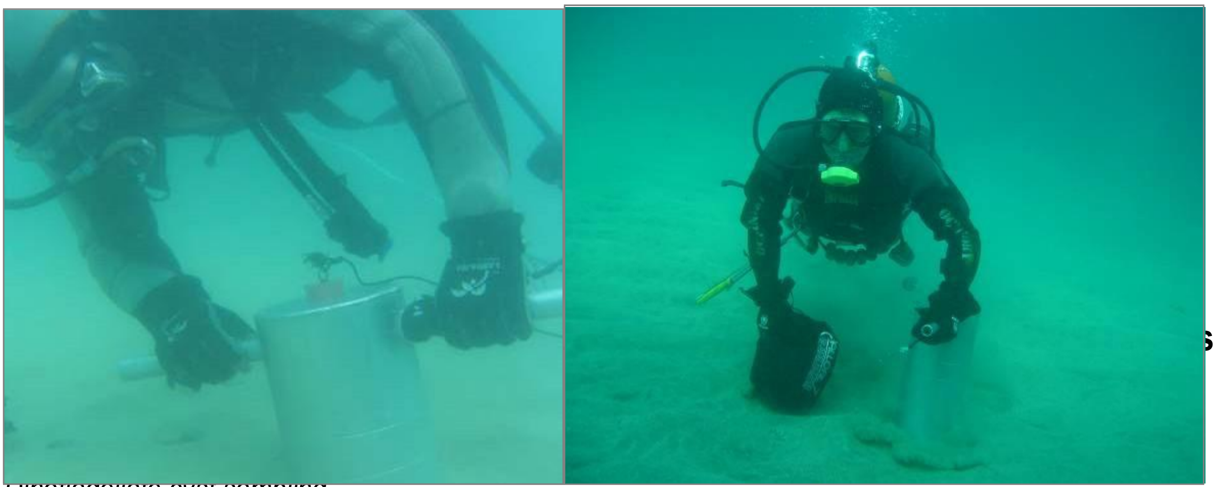
sampling methods. Divers swam along the length of the wharf, seawall or structure and examined the vertical extend of wharf piles, channel markers or other submerged hard substrates. Visual searches were conducted for at least 30 minutes but were extended relative to the size of the area to be examined. Photographic records were taken where appropriate and when visibility allowed. Samples and specimens were processed according to MITS protocols.

Benthic coring

Benthic infauna were collected by scuba divers using a specifically designed and manufactured aluminium 0.025 m^2 corer devised to sample soft-sediments ranging from fine mud and sand to hard-packed clay and small cobbles. The corer was 180 mm in diameter and 400 mm in length, with marked grooves at 200 mm and 250 mm from the bottom to indicate the appropriate sampling depth (Figure 9). The top of the corer had an aperture (80 mm diameter) that was sealed with a rubber bung after insertion into the substrate, to aide in the retention of the sample when the corer was withdrawn from the sediment.

Samples were transferred underwater to purpose-made, drawstring bags then relayed to the surface. On board the research vessel each sample was sieved through 5 mm graded sieves and stored in sample bags or jars according to MITS protocols.

When sampling sites were located in the vicinity of wharves and boat ramps, three replicate cores were collected within 2 m of the wharf piles or ramp and a further three cores collected at a distance of 50 m from the structure. At sites without berthing or other such structures, three replicate cores were collected in the vicinity of the selected sampling location.



Dinoflagellate cyst sampling

A gravity or 'javelin' corer was used to collect small sediment cores for dinoflagellate cysts (Figure 10). The corer consisted of a 1.0 m long hollow stainless steel shaft with a detachable 0.5 m long head. The shaft was 150 mm in diameter and a perspex core tube (12 mm diameter) was inserted into the head to retain the sediment sample. Four fins were attached to the end of the shaft to aid in directing the javelin corer vertically through the water so that the device penetrated the sediment from an upright position. The javelin was weighted with lead internally and the head was tapered for penetration of unconsolidated sediments to a depth of 200 to 300 mm. On retrieval, the perspex tube was removed from the spearhead and retained for analysis according to MITS protocols.

In many situations the javelin corer was not effective at collecting samples; for undetermined reasons the sediment samples were not adequately retained within the perspex tube on retrieval. The corer was weighted with additional lead flashing to ensure that the spearhead penetrated the substrate in an upright position, although this still did not always ensure the collection of a suitable sample (see Figure 10, right). Samples were transferred to plastic containers and handled according to MITS protocols. In situations when the javelin corer repeatedly failed to collect a sample, sediment samples were collected using small core tubes (200 mm length, 50 mm diameter) that were sealed with rubber bungs and handled according to MITS protocols.

Plankton netting

Phytoplankton samples were collected by vertical drops of a hand-deployed plankton net (20 µm mesh, 250 mm diameter aperture) (Figure 11, left). Zooplankton samples were collected by vertical drops of a hand-deployed zooplankton net (100 µm mesh, 700 mm diameter aperture) (Figure 11, right). The nets were weighted with lead to ensure the vertical direction was maintained in strong currents. The nets were released to within 1 m of the seafloor. Three replicate samples were collected using each net (i.e., three samples each for phytoplankton and zooplankton) and retained in plastic sampling jars. Samples were stored as required by MITS protocols.

Trapping

Mobile epibenthos such as benthic scavengers (crabs and seastars) and fishes were sampled using two types of baited traps. Opera house traps (Figure 12) were used to collect large organisms such as paddle crabs and fish. These oval-shaped collapsible traps were 640 mm x 470 mm and 200 mm in height, with a mesh size of 20 mm. The entrance funnel of the trap was circular with a diameter of 90 mm. Collapsible shrimp (or minnow) traps were used to collect small and juvenile crustaceans and other taxa. These traps were 450 mm x 250 mm and 250 mm in height, with a mesh size of approximately 5 mm.

Traps were attached to leadline and a marker buoy attached to one end. Trap lines were comprised of three opera house traps and two shrimp traps. Traps were baited with frozen pilchards (*Sardinops neopilchardus*) and fresh fish offal (when available from local fishermen), which was contained in mesh bags suspended in the centre of the trap. Trap lines were deployed parallel to the dominant current flow (where possible) and left overnight (~12 hrs) before retrieval.

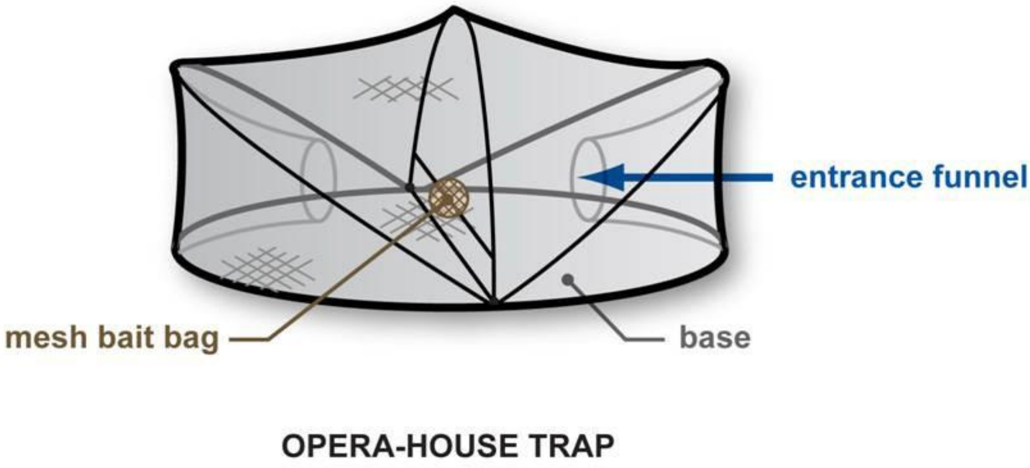


Figure 12: Diagram of an opera house crab trap.

Beach seining

A beach seine was used to sample nearshore fish over sandy and muddy substrates on beaches and in estuaries. A 25 m seine with 15 mm mesh was hauled for approximately 5 m parallel to the shoreline (Figure 13, foreground). All species of fish and invertebrate collected in the seine nets were recorded and representative samples of each species was retained and stored according to MITS protocols.

Beach wrack

Qualitative searches of beach wrack were made along the shoreline in the region between the low and high tide marks (e.g., Figure 13, background). Items that were searched for included crab exuviae, sponges and remnants of unusual or rare species.

Sediment texture sampling

Sediment samples (~100 g wet weight) were collected for each site (where soft sediments occurred) for analysis of particle size and organic content. Samples were collected to a depth of 500 mm into the sediment using sealable plastic sample containers of 150 mm x 80 mm and 500 mm in height. Sediments were transferred to double-bagged plastic sampling bags and frozen or keep on ice for transport to the analytical laboratory.

Environmental data collection

A submersible data logger (SDL) was used to measure water temperature, salinity (or conductivity), and dissolved oxygen at the water's surface, at mid-depths (< 5m) and/or the seafloor. Water clarity (visibility) was estimated using a secchi disk. Air temperature, wind speed and direction were recorded from local weather reports, and sea state, tidal height and extent of cloud cover were recorded based on fieldworker's observations. The maximum depth at each site was recorded using the research vessels depth sounder or a scuba divers depth gauge. This information was recorded on boat data sheets at each site.

4.2. TAXONOMIC IDENTIFICATION

Rough-sorting and preservation of specimens occurred soon (~12 hr) after sampling as prescribed by the Marine Invasives Taxonomic Service (MITS) protocols (NIWA 2006). The samples were then transferred to MITS for taxonomic identification of specimens. MITS is a taxonomic identification service provided to MAFBNZ by the National Institute of Water and Atmospheric Research (NIWA) and draws on taxonomic expertise within NIWA and around the world.

Taxonomic data was cross-referenced with a number of different web-based databases such as the Integrated Taxonomic Information System (ITIS), World Porifera Database, Australian Faunal Directory, Algaebase, and the National Introduced Marine Pest Information System (NIMPIS). Biological and distribution information for the non-indigenous species collected during the survey is presented in Appendix B.

Species rarity was expressed relative to the site occupancy of all taxa as the inclusion of higher taxa would skew the data distribution toward higher site occupancy.

Species rarity was defined as follows:

- Rare – species occurring at fewer sites than occupied by 25% of all taxa (i.e., less than the lower quartile).
- Occasional – species occurring at the same number of sites occupied by 25% percent of all taxa, but fewer sites than occupied by 50% of all taxa (i.e., from the lower quartile up to and including the median).
- Common – species occurring at the same number of sites similar or greater than the median, and no greater than was occupied by 75% of all taxa (i.e., from the median up to and including the upper quartile).
- Abundant – species occurring at more sites than occupied by 75% of all taxa (i.e., greater than the upper quartile).

4.3. CRITERIA FOR DETERMINATION OF SPECIES AND BIOSECURITY STATUS

Carlton (1996) commented that the classical view of species' origins meant that native species comprised indigenous or endemic taxa and included prehistoric invasions, whereas exotic species comprised historical invasions including both natural range extensions and human-mediated introductions. Carlton (1996) also observed that the default to this view was to classify species without any obvious record of introduction as native.

For the purpose of determining the status of species collected during this survey, the following criteria were used to determine whether a species is non-indigenous or native. These criteria were amended by Cranfield *et al*. (1998) from Chapman & Carlton (1991) and were largely based on historical information of a species' native range and range extension.

- Has the species appeared locally where it has not been found before?
- Has the species spread subsequently?
- Is the species distribution associated with human mechanisms of dispersal?
- Is the species associated with, or dependent on, other non-indigenous species?
- Is the species prevalent in or restricted to, new or artificial environments?
- Is the species distribution restricted compared to natives?
- Does the species have a disjunctive worldwide distribution?
- Are dispersal mechanisms of the species inadequate to reach New Zealand, and is passive dispersal in ocean currents unlikely to bridge ocean gaps to reach New Zealand?
- Is the species isolated from the genetically and morphologically most similar species elsewhere in the world?

There are, however, species that cannot be assigned to either category owing to a lack of adequate data to reliably determine their native range. Such species have been called 'cryptogenic' to reflect their unknown origin (i.e., *crypt*- Greek, kryptos, secret; -*genic*, New Latin, genic, origin; Carlton 1996). Species are, therefore, assigned to three categories and six sub-categories to better reflect the available information on which species and biosecurity status were determined (Table 2).

Table 2: Species and biosecurity status (adapted from Inglis *et al*. 2006a-m).

Species status	Biosecurity status	Explanation
Non-indigenous	Known introduced	Non-indigenous species already established in New Zealand.
	Unknown introduced	Non-indigenous species not previously recorded in New Zealand.
Cryptogenic	Cryptogenic Category 1	Species established in New Zealand, whose identity as native or non-indigenous is ambiguous owing to a cosmopolitan distribution or unknown native distribution. This class also includes newly described species that exhibit invasive behaviours, but for which there are no known records outside of New Zealand.
	Cryptogenic Category 2	New or undescribed species for which there is insufficient taxonomic or biogeographical information to determine whether New Zealand is within their indigenous range.
Indigenous	Native	Species whose indigenous range includes, but is not confined to New Zealand.
	Endemic	Species whose indigenous range is confined to New Zealand.

4.3. PUBLIC AWARENESS PROGRAMME

Prior to undertaking the survey, a programme was designed to inform the general public and stakeholders (notably regulatory agencies) of the nature and goals of MAFBNZ's port survey of the Chatham and Pitt Islands area. The following organisations were contacted as part of this programme:

1. Ministry of Fisheries – notification of sampling under the conditions of a Special Permit.
2. Chatham Island Regional Harbourmaster – preliminary notification of activities around Chatham and Pitt Islands.
3. Department of Conservation – contact with the Chatham Islands area office in Te One.
4. Chatham Islands Council – advanced notification of the survey
5. Informal discussions with local residents.

5. Survey Results

5.1. PORT ENVIRONMENT

Environmental data collected during the Chatham Islands survey included measurements of water temperature, salinity, dissolved oxygen, substrate type, visibility and maximum depth at each site. This information is summarised in Table 3.

Water temperatures ranged between 14.3 to 20.4°C. There was no stratification between sea surface temperatures and water temperatures closer to the seafloor, which differed by approximately 0.4°C (Figure 14).

Salinity ranged from 24.7 to 30.6 psu with an average of 30.2 psu (Figure 15). There was no stratification between surface and bottom salinity measurements, although salinity was often slightly higher (in the order of 1.0 psu) closer to the seafloor. The lowest readings for salinity were recorded at the Kaingaroa wharf (Site 8) and in Ocean Bay and Port Hutt (Sites 17-21), as well as the mouth of the Nairn River (Site 27). These areas may experience higher input of freshwater, which is likely owing to their proximity to human activities (i.e., residential sites) and freshwater river outflow.

Dissolved oxygen ranged from 5.30 to 10.57 mg/L, with an average of 8.18 mg/L (Figure 16). Dissolved oxygen was slightly higher at Cape Young (Site 13), Hanson Bay (Site 33 and 34), Ocean Bay (Sites 17 and 18), Cascade Gorge (Site 30) and Tapuarange Reef (Site 31), while relatively low dissolved oxygen was recorded at French Reef (Site 12), Kaingaroa Harbour (Sites 8-10), Omatuku Rock (Site 36) and in the vicinity of the *Seafresh 1* wreck (Site 32).

Seafloor sediments were analysed for total organic carbon (TOC) content and proportions of mud (<63 µm), sand (63 µm to 2 mm) and gravel (>2 mm) (Figure 17). Sediments with the highest TOC content occurred beneath the wharves at Kaingaroa Harbour (Sites 8 and 10) and Port Hutt (Sites 19-21), while sites located at Waihere Bay (Site 1), Kaingaroa Harbour (Site 9), Cascade Gorge (Site 30) and Hanson Bay (Sites 33 and 34) had relatively low TOC content. Sites with high proportions of muddy sediments included areas beneath the Port Hutt wharf (Site 24) and the *Thomas Currell* shipwreck (Site 20, also in Port Hutt), while areas of Kaingaroa Harbour (Site 8 and 9), the Port Hutt anchorage (Site 21) and Cascade Gorge (Site 30) had mostly gravel substrates. Overall, sandy sediments were the dominant soft shore substrate throughout the Chatham Islands; although some sites had predominantly rocky bottoms where sediment samples could not be collected (i.e., Cape Young, Cape L'Eveque).

Table 3: Physical data (water temperature, salinity, dissolved oxygen, visibility, maximum depth and substrate type) recorded during the Chatham Islands survey, February 2007.

Site No.	Site Name	Temperature (°C)		Salinity (psu)		Dissolved Oxygen (mg/L)		Visibility (% Depth)	Depth (m)	Substrate Type
		Surface	Bottom	Surface	Bottom	Surface	Bottom			
1	Pitt Island, Waihere Bay anchorage	15.5	15.5	30.5	30.6	9.30	9.31	33	24	sand
2	Pitt Island, Flowerpot anchorage	15.8	15.7	30.6	30.6	8.81	8.40	73	13	rock, sand
3	Pitt Island, Canister Cove	15.6	15.2	30.6	30.6	9.70	8.93	70	10	rock, boulder
4	Pitt Island, Waipaua	15.6	15.3	30.6	30.7	9.18	8.30	61	18	sand
8	Kaingaroa Harbour wharf	14.3	14.4	30.7	30.7	7.05	6.90	100	5	sand
9	Kaingaroa Harbour 1	14.6	14.4	30.7	30.7	8.78	7.45	38	9	-
10	Kaingaroa Harbour 2	14.7	14.6	30.7	30.7	7.55	7.11	70	5	sand
12	French Reef	14.7	14.7	30.9	30.9	5.31	5.30	26	17	rock
13	Cape Young	15.4	15.4	30.8	30.8	10.17	9.46	60	10	rock, sand
14	Maunganui Beach	15.2	15.3	30.9	30.8	8.59	8.24	70	6	-
15	Waitangi West Beach	-	-	-	-	-	-	100	intertidal	sand
17	Ocean Bay anchorage 1	14.8	14.8	30.7	30.7	9.06	9.02	39	16	shelly sand
18	Ocean Bay anchorage 2	17.2	14.6	28.8	30.8	9.51	9.42	52	16	rock
19	Port Hutt wharf	15.2	15.2	29.2	30.8	7.88	7.53	40	10	-
20	*Thomas Currell* shipwreck	15.2	15.2	29.2	30.8	7.88	7.53	40	10	-
21	Port Hutt anchorage	15.2	15.2	29.2	30.8	7.88	7.53	40	10	-
23	Long Beach – Petre Bay	-	-	-	-	-	-	100	intertidal	sand
24	Port Waitangi wharf 1	18.2	16.8	24.7	30.2	7.86	7.82	40	5	sand
25	Port Waitangi wharf 2	18.2	16.8	24.7	30.2	7.86	7.82	40	5	sand
26	Port Waitangi moorings	16.4	16.2	30.2	30.2	7.96	7.68	61	12	sand, reef
27	Nairn River mouth	20.4	18.3	26.8	30.1	9.03	8.73	80	2.5	sand
28	Point Weeding Bay	17.4	16.9	29.9	30.4	7.48	7.35	100	6	sand, gravel
29	Cape L'Eveque	15.4	15.3	30.5	30.2	7.63	7.68	80	15	reef, boulders
30	Cascade Gorge	15.1	14.9	30.6	30.7	9.00	7.88	85	17	rock, shell
31	Tapuarange Reef	15.6	15.4	30.4	30.6	9.02	7.68	40	5	shelly sand
32	*Seafresh 1* shipwreck	15.6	15.4	30.6	30.6	7.10	6.85	11	22	vessel hull
33	Hanson Bay anchorage 1	14.9	15.0	30.8	30.8	10.57	10.32	28	13	sand
34	Hanson Bay anchorage 2	14.9	14.8	30.8	30.8	9.00	9.43	48	12	-
35	Blind Reef	14.9	14.9	30.8	30.8	8.80	8.55	60	15	reef
36	Omatuku Rock	15.1	15.1	30.8	30.8	6.06	6.01	58	12	rock
43	Owenga jetty	-	-	-	-	-	-	100	intertidal	rock

Site No.	Site Name	Temperature (°C)		Salinity (psu)		Dissolved Oxygen (mg/L)		Visibility (% of Depth)	Depth (m)	Substrate Type
		Surface	Bottom	Surface	Bottom	Surface	Bottom			
	Average	**15.8**	**15.4**	**29.8**	**30.6**	**8.36**	**8.01**	**55**	**11**	
	Minimum	**14.3**	**14.4**	**24.7**	**30.1**	**5.31**	**5.30**	**11**	**3**	
	Maximum	**20.4**	**18.3**	**30.9**	**30.9**	**10.57**	**10.32**	**100**	**24**	

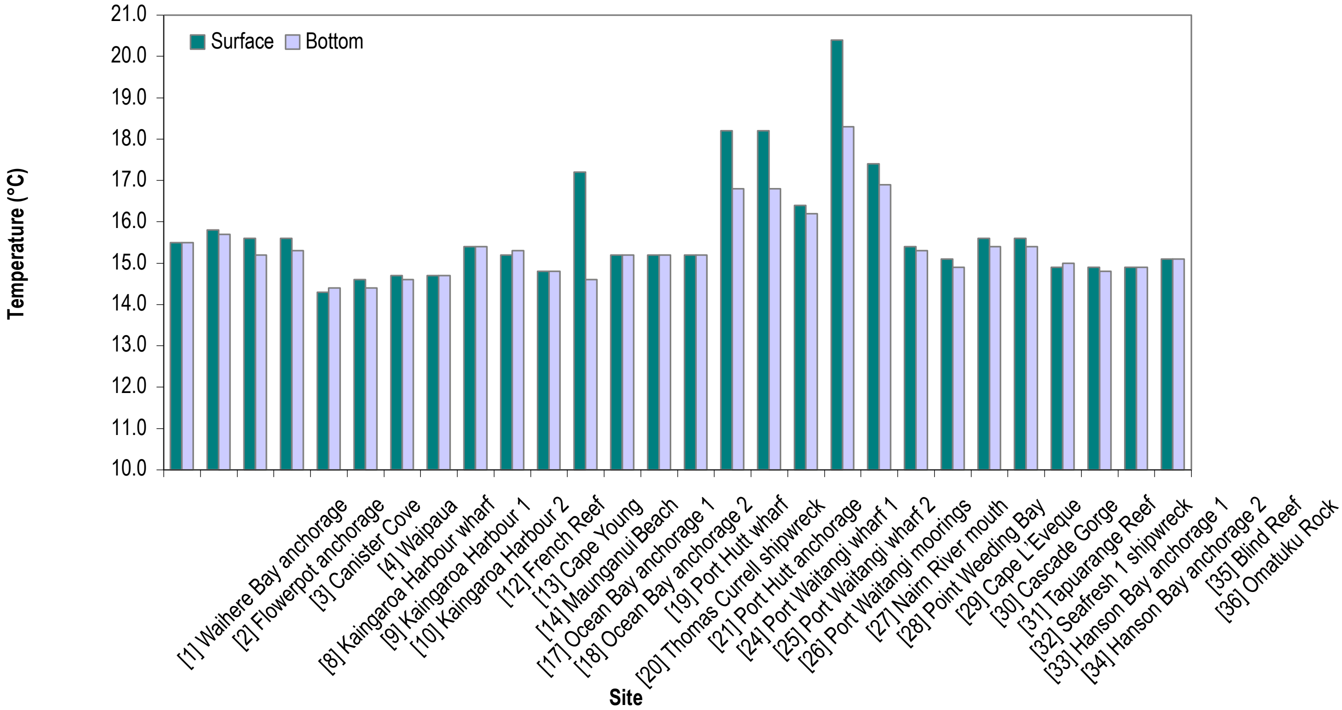


Figure 14: Water temperatures recorded during the Chatham Islands survey, February 2007. Dark shading denotes sea surface readings and light shading demotes readings taken near the sea floor.

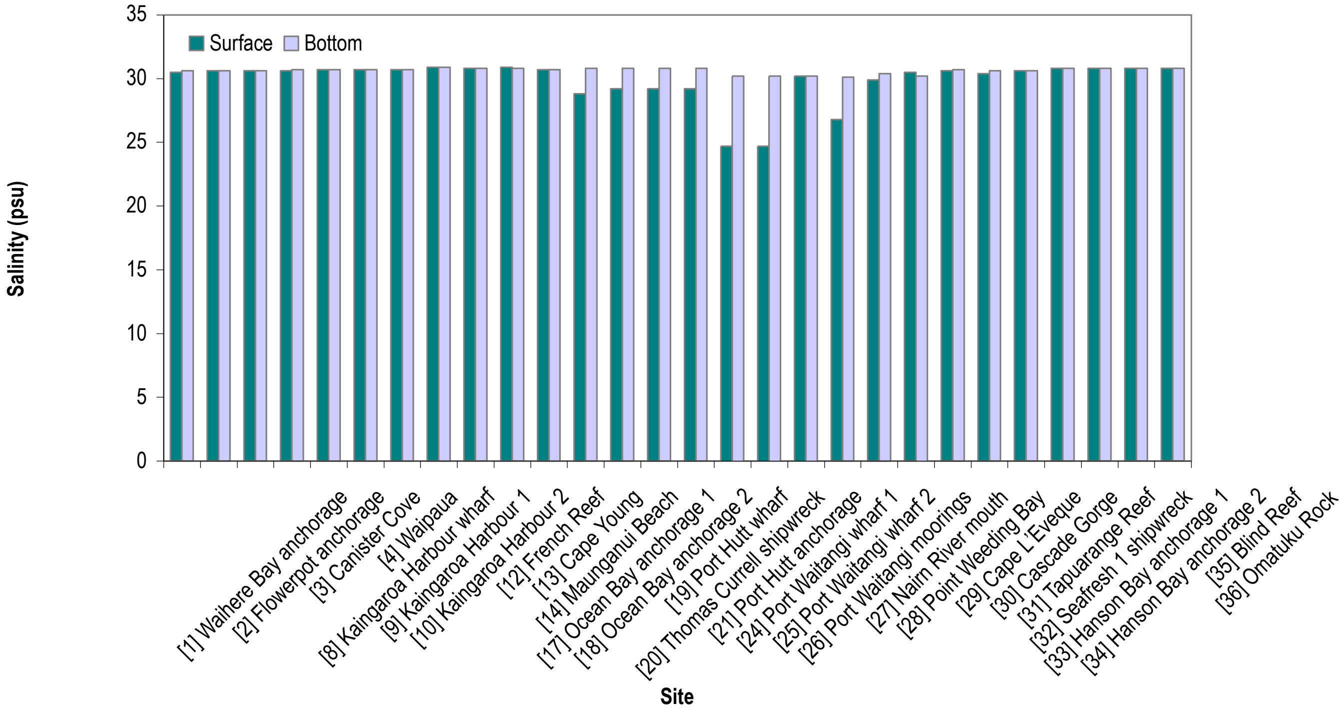


Figure 15: Salinity recorded during the Chatham Islands survey, February 2007. Dark shading denotes sea surface readings and light shading demotes readings taken near the sea floor.

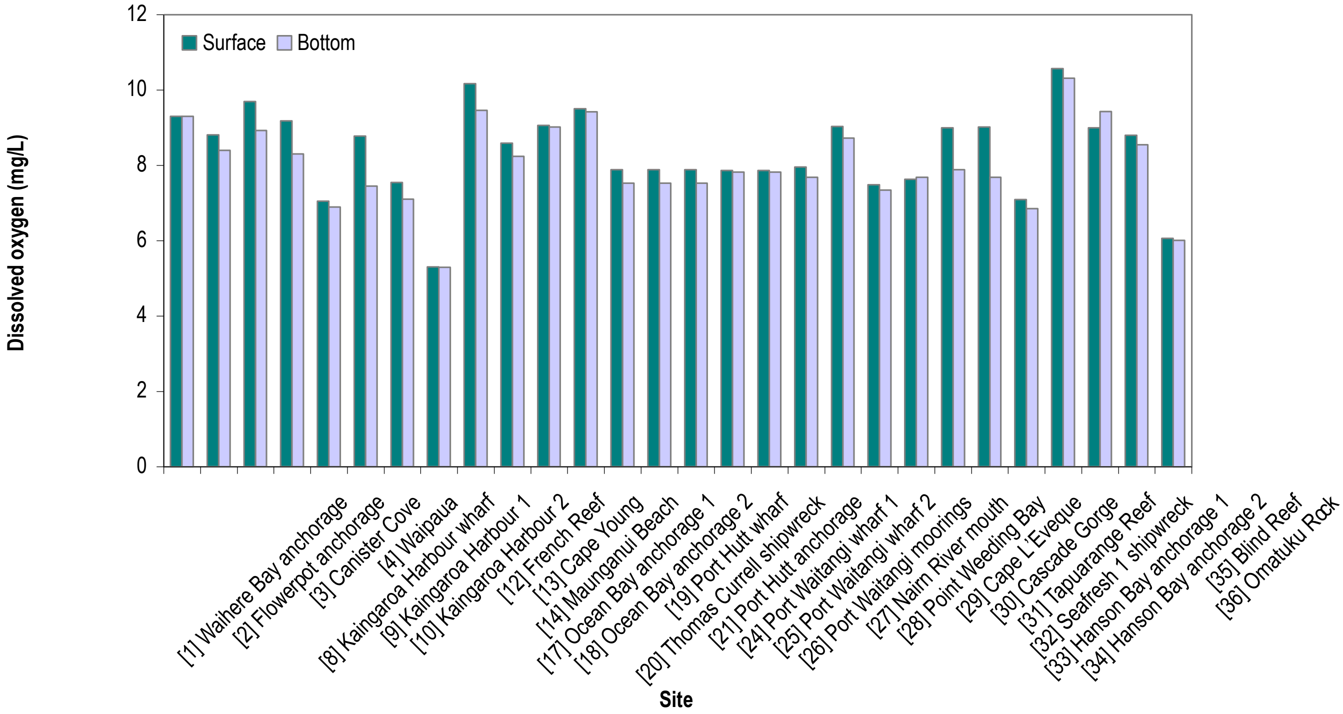


Figure 16: Dissolved oxygen levels recorded during the Chatham Islands survey, February 2007. Dark shading denotes sea surface readings and light shading demotes readings taken near the sea floor.

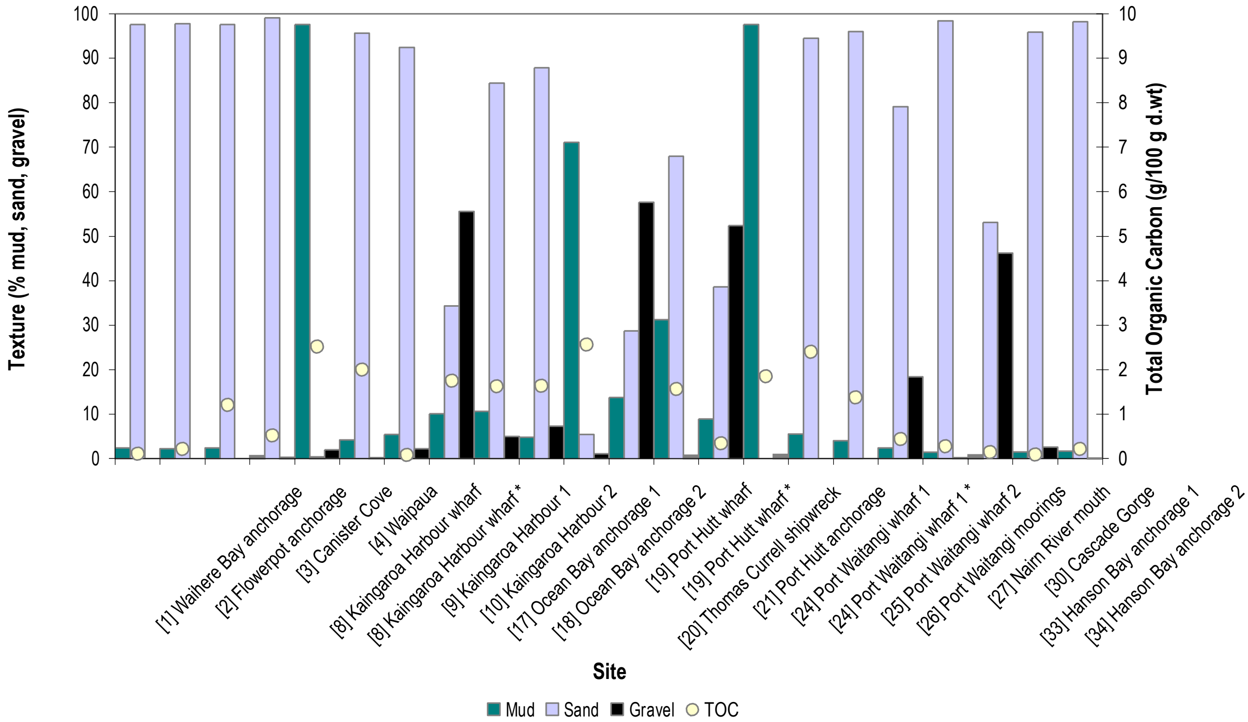


Figure 17: Proportion of mud (<63 µm grain size), sand (63 µm – 2 mm) and gravel (> 2 mm) and total organic carbon from sediment samples collected during the Chatham Islands port survey, February 2007. (Note that hard substrates were present at Sites 12-14, 28, 29, 31, 32, 35 and 36. * denotes samples that were collected at 50 m from the site).

5.2. NATIVE BIODIVERSITY

A total of 534 taxa (determined to Class level or below) were identified from the Chatham Islands survey collection, of which 62% (n = 330) were determined to be indigenous or endemic to New Zealand (Figure 18). Of the native fauna, the Rhodophyta were the most diverse with 19% of the native species collected during the survey from this group. Other dominant faunal and floral taxonomic groupings included Arthropoda (15%), Bryozoa and Mollusca (14% each), and Annelida (10%). Other taxonomic groups of species collected during the survey included (in order of highest to lowest taxonomic diversity) Ochrophyta (9%), Ascidiacea (5%), Actinopterygii, Echinodermata and Porifera (3% each) Cnidaria (2%), Chlorophyta and Bacillariophyta (1% each), and Brachiopoda, Entoprocta and Dinophyta (0.3% each).

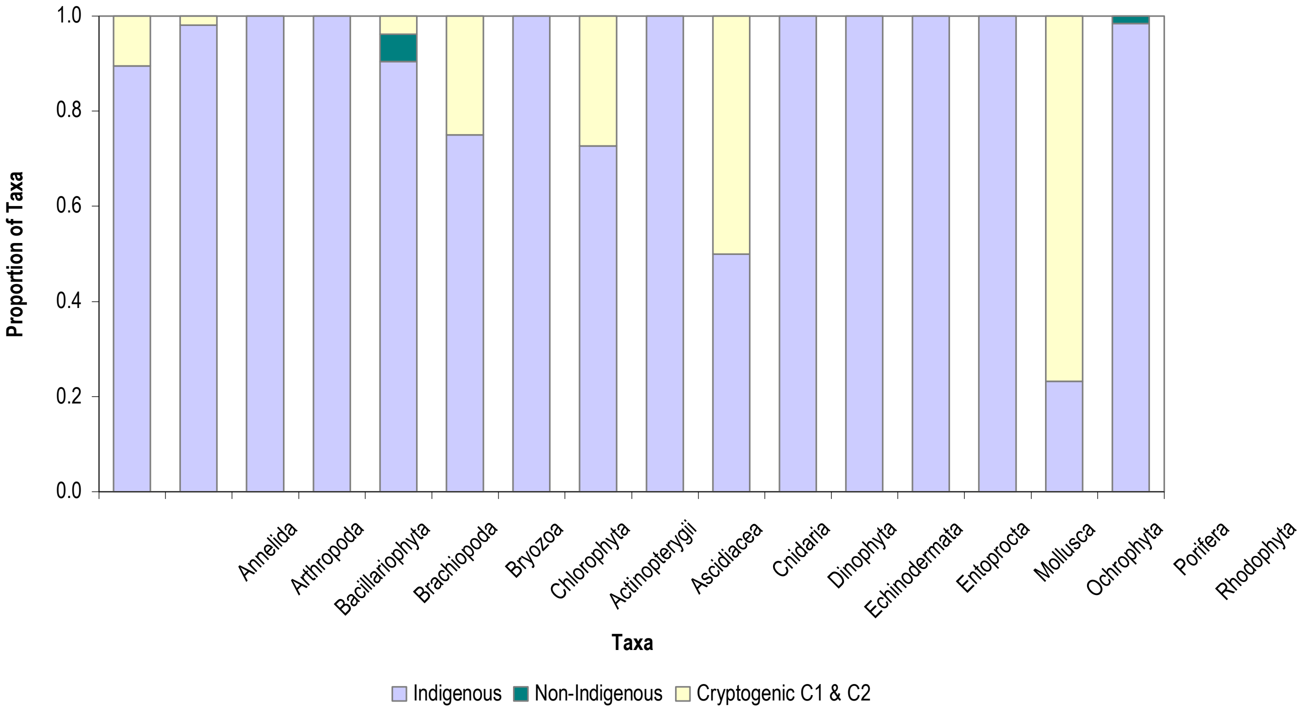


Figure 18: Proportion of species diversity for taxonomic groups detected during the Chatham Islands port survey.

5.3. NON-INDIGENOUS SPECIES IN THE PORT

Four non-indigenous species and twenty-seven cryptogenic species (category 1) were detected during the present survey representing 0.7% and 5.1%, respectively, of the total taxa collected from the Chatham Islands. Of the non-indigenous or cryptogenic species already known at the Islands, *Aplidium phortax*, *Botrylloides leachii*, *Corella eumyota*, *Cystodytes dellechiajei* and *Neosiphonia subtilissima* were detected in the present survey. The failure to detect other known introduced species during the survey, including *Colpomenia durvillaei*, *Apocorophium acutum*, *Didemnum* cf. *candidum* and *Polysiphonia sertularioides*, could relate to the seasonality of ephemeral species or to a restricted and patchy distribution (e.g., *durvillaei*). Sites frequented by shipping were targeted in the survey, and non-indigenous and cryptogenic species were consequently detected at 58.1% of the sites sampled (n = 31 sites) (Figure 19). Twenty non-indigenous or cryptogenic species detected in the survey occurred occasionally, nine cryptogenic species were considered common, and the remaining two cryptogenic species were considered to be abundant (Figure 20).

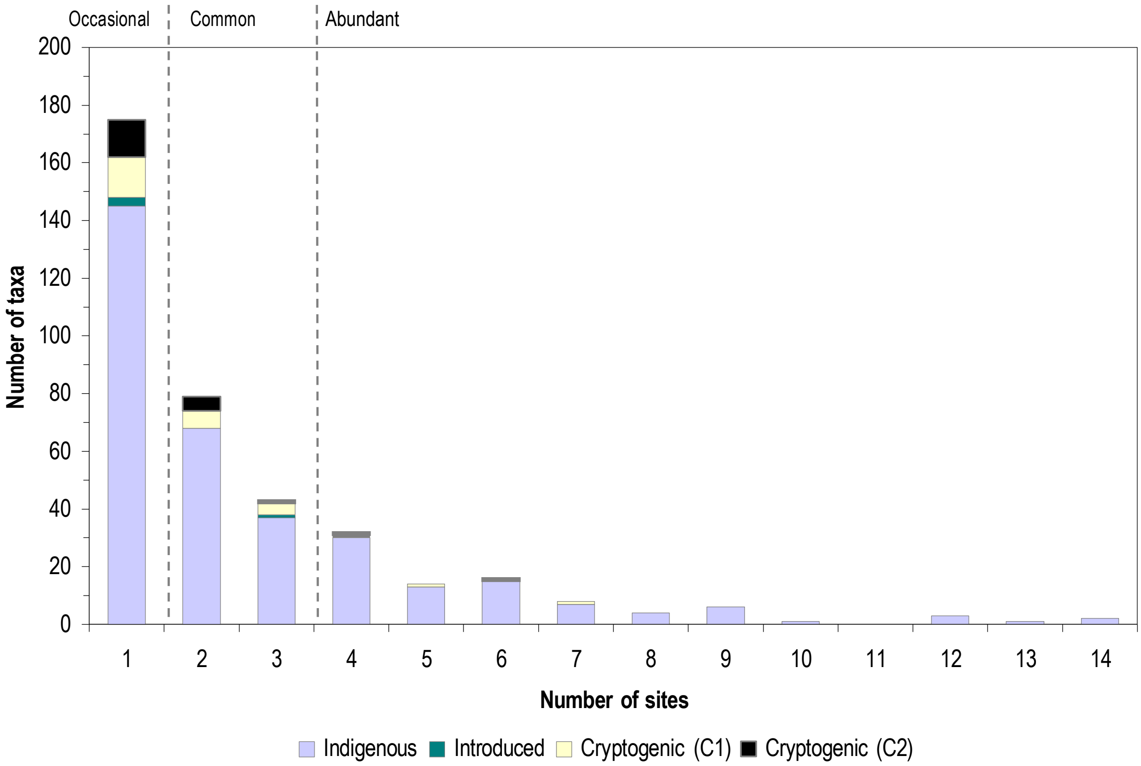


Figure 19: Site occupancy of indigenous, non-indigenous and cryptogenic taxa at the Chatham Islands.

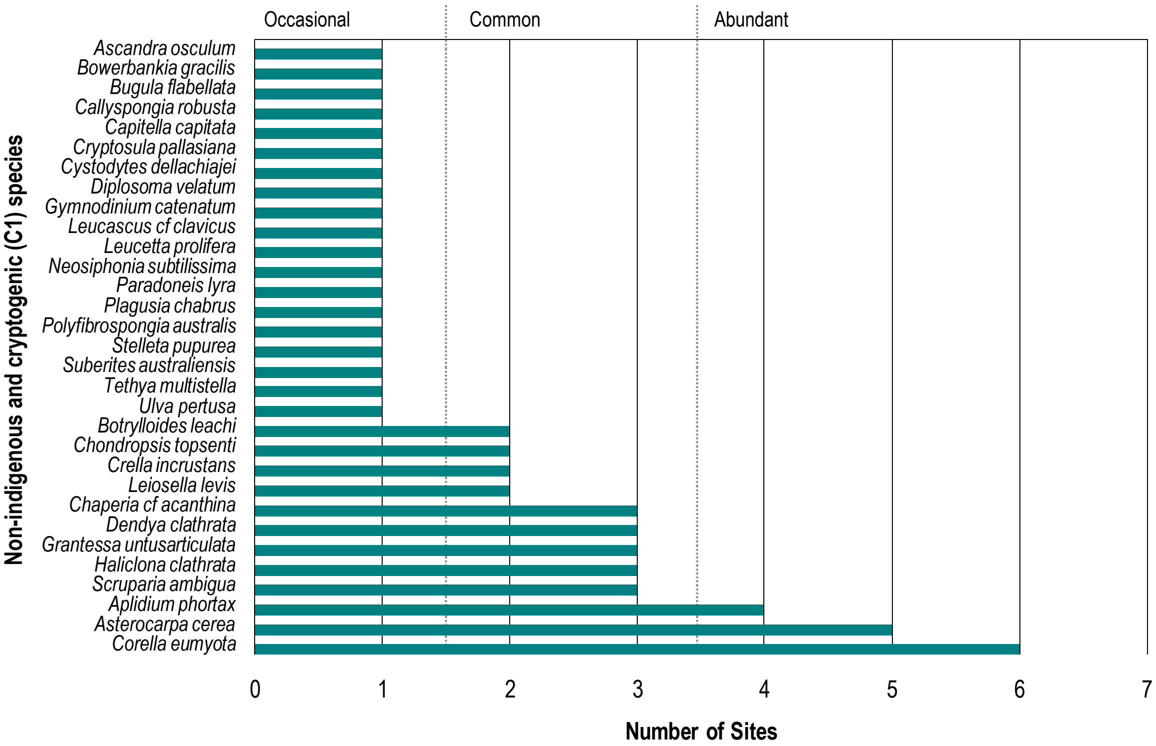


Figure 20: Site occupancy of non-indigenous and cryptogenic (C1) species relative to measures of rarity based on percentage quartiles of total taxa site occupancy (i.e., Figure 19).

Several non-indigenous or cryptogenic species are known to occur at the Chatham Islands, including the ascidians *A. phortax*, *B. leachii*, *C. eumyota*, *C. dellechiajei* and *C.* cf. *candidum*, and the amphipod, *A. acutum* (Cranfield *et al*. 1998). Bruce (2003) discredited an earlier record of the Australian isopod *Cirolana australiense* from Chatham Island, and later re-described the record as a new native species, *Cirolana kokoru* sp. nov. (Bruce 2004). The non-indigenous red algae, *P. sertularioides* and *N. subtilissima* are also recorded previously at the Chatham Islands (Nelson 1999), and the non-indigenous brown alga, *C. durvillaei* was collected from a slipway at Kaingaroa, Chatham Island in October 2001 (Figure 21). Vessel traffic to the Chatham Islands, firstly with exploration and exploitation for sealing and whaling and later for agriculture and settlement, is the likely mode of introduction by ship wrecks, hull fouling and possibly via dry ballast.

Four non-indigenous species were detected at the Chatham Islands during the survey, comprising *Bowerbankia gracilis*, *Bugula flabellata*, *Cryptosula pallasiana* and *N. subtilissima*. The red seaweed *N. subtilissima* is recorded previously from the Chatham Islands as *Polysiphonia subtilissima* (Nelson *et al*. 1991), but the bryozoans *B. gracilis*, *B. flabellata* and *C. pallasiana* have not been recorded previously from Chatham Islands (i.e., Gordon 1986). No unwanted organisms or pests were detected during the survey.

5.3.2. Cryptogenic Species

Forty-eight cryptogenic species (categories 1 and 2) were recorded from the Chatham Islands during this survey. Twenty-one of these species were new or undescribed for which there was insufficient taxonomic or biogeographical information to determine whether New Zealand is within their indigenous range (i.e., cryptogenic category 2).

Twenty-seven category 1 cryptogenic species were recorded form the Chatham Islands during this survey. Most species in this category included species or species complexes with a cosmopolitan distribution and undetermined indigenous range (i.e., *B. leachii*, *Calyspongia robusta, Capitella capitata, Chaperia acanthina, C. eumyota, C. dellachiajei, Gymnodinium catenatum, Haliclonia clathrata, Paradoneis lyra, Plagusia chabrus, Scruparia ambigua, Stelletta purpurea* and *Ulva pertusa*).

Other species have been previously recorded from Australia and New Zealand but have a disjunctive distribution in either country, such as *Diplosoma velatum, Leiosella levis, Chondropsis topsentii, Crella incrustans, Leucascus clavatus* and *Leucetta prolifera*. Similarly, some species appear restricted in distribution to Australia and New Zealand, such as *Ascandria osculum, Dendya clathrata, Polyfibrospongia australis, Suberites australiensis* and *Tethya multistella*. These species could be indigenous to either New Zealand and Australia or both countries depending on the availability and interpretation of historical records or other evidence (i.e., genetic, morphometric or paleological information).

Aplidium phortax and *Grantessa intusarticulata* occur in Australia and New Zealand, with reports of a disjunctive distribution based on reports from Japan (*G. intusarticulata*) and the Solomon Islands (*A. phortax*). These species could be indigenous to New Zealand and Australia, and introduced to other regions; but are considered cryptogenic on the basis of the uncertainty concerning their indigenous range.

In the present survey, *C. eumyota*, *H. clathrata* and *Leucosolenia clathrata* were widespread about Chatham Island indicating that they are either indigenous or represent early introductions that have spread extensively about the Islands. Another four cryptogenic species (*C. incrustans*, *L. prolifera*, *P. chabrus* and *S. purpurea*) were found exclusively at remote reefs and embayments suggesting they are uncommon or absent from sites in close proximity to shipping and could be indigenous to the Chatham Islands or introduced directly to remote areas by mechanisms such as shipwrecks. Further examination of their distribution about Chatham Island could indicate that they are more widespread than suggested by the present survey. *Tethya multistella* was located exclusively at Point Weeding Bay, an embayment immediately to the east of Waitangi and in relative proximity to vessel traffic.

A number of cryptogenic species were only detected in harbours or on shipwrecks, indicating a possible association with shipping and a proclivity for fouling of artificial substrates such as wharf pilings and vessel hulls. Such species included *A. phortax*, *B. leachii, C.* cf. *acanthia, C. topsentii, C. pallasiana, G. intusarticulata, L.* cf. *clavatus* and *S. ambigua*.

The cryptogenic sponges *L. levis* and *P. australis* were detected in the port survey as moribund specimens in beachcast. Although this indicates that these species are present in the region, it does not suggest that they are established in the near-shore areas of the Chatham Islands and they are excluded from subsequent analysis.

5.4. PUBLIC AWARENESS PROGRAMME

Preliminary notification of the survey to the Chatham Islands Council resulted in much discussion amongst local residents on topics of the survey and biosecurity management. The survey was conducted from a conspicuously large vessel, the 30 m *Clan MacLeod* (Figure 22), which resulted in local interest on arrival at Port Waitangi.

Discussion with the General Manager of the Council, Mr Owen Pickles indicated that marine biosecurity is a topic of particular concern for local residents. This is a consequence of the relatively high proportion of the local economy that is dependent on marine-based activities (commercial and recreational fishing, tourism). The General Manager indicated the Councils keen interest in protecting the area from exotic species, in particular the unwanted organism *Undaria pinnatifida*. At the time of the survey (February 2007) the Council was very interested in coming to some arrangement for continuing to support the *Undaria* vector management programme that had been in place since 2003.

A meeting with Mayor Patrick Smith was also held to discuss the survey and broader marine biosecurity management.

6. Potential Impacts of Non-Indigenous Species Found in the Port

The majority of non-indigenous species detected at Chatham Island are not known to impact significantly on indigenous communities. The detection of the biofouling bryozoans *B. gracilis*, *B. flabellata* and *C. pallasiana*, are new records for the Chatham Islands. These species possibly represent more recent introductions than *N. subtilissima*, which is widespread about the Chatham Islands (Nelson *et al* 1991). The occurrence of *B. gracilis*, *B. flabellata* and *C. pallasiana* exclusively within Port Hutt and occurrence of *B. gracilis* and *B. flabellata* only on the wreckage of the *Thomas Currell* suggests that the impacts of these species is presently restricted to these sites. These species are typically found on artificial substrates such as wharves and jetties and the impacts of these species are therefore likely to be localised and confined.

Assessing the potential impacts of non-indigenous species requires adequate knowledge of the species' ecology and how its presence may affect the structure and composition of indigenous species assemblages. However, specific research is presently lacking on the effect of these species and other non-indigenous species, such as *C. durvillaei*, on biological diversity and community function. Information on some species with demonstrable impacts elsewhere can inform on the likely impacts when they are introduced to a new location, but the marine assemblages at the Chatham Islands are unique in the absence of key species that are indigenous to mainland New Zealand (i.e., *Durvillaea willana*, *Ecklonia radiata* and *Lessonia variegata*) and the endemism of closely-related species (i.e., *Durvillaea chathamensis* and *Lessonia tholiformis*). The potential impacts of non- indigenous species on marine assemblages at the Chatham Islands are, therefore, extremely difficult to predict, even if there is some precident from mainland New Zealand.

For example, *U. pinnatifida* has shown itself to be capable of colonising a wide range of environments throughout mainland New Zealand (Russell *et al*. 2007) and, although successfully eradicated from the Chatham Islands, it could impact on algal assemblages at the Islands if it were re-introduced. Similarly, Schiel *et al*. (1995) indicated that *E. radiata* is likely to extensively occupy middle and deeper portions of subtidal reef that currently have a sparse cover of *L. tholiformis* and some fucalean species if it were to occur at the Chatham Islands. Unlike *U. pinnatiifda*, which has an annual sporophyte, the sporophyte of *E. radiata* is perennial and could therefore impact more significantly on marine assemblages at the Chatham Islands than would be expected for *U. pinnatifida* because of its ability to establish and maintain a permanent algal canopy. The discovery of the Mediterranean fan worm, *Sabella spallanzianii*, in Lyttelton Harbour in March 2008 (NIWA 2008) also presents a significant risk of introduction should efforts fail to prevent its establishment and spread in mainland New Zealand.

In summary, most of the non-indigenous species present at the Chatham Islands are not known to greatly affect indigenous marine communities. The cumulative effect of known and new species introductions from mainland New Zealand could, however, potentially affect the structure and composition of indigenous species assemblages if they were introduced or spread to natural substrates at the Chatham Islands. Species of most concern are possibly *E. radiata, S. spallanianzii* and *U. pinnatifida.*

7. Origin and Potential Vectors for the Introduction of Non-Indigenous Species Found in the Port

7.1. OVERVIEW

Non-indigenous species detected at the Chatham Islands could have arrived via five mechanisms:

- Natural range extension of species introduced to other parts of New Zealand.
- Directly to the port by international shipping using the port, either in ballast water or by hull fouling.
- Domestic translocation from fishing, charter and recreational vessels.
- Activities associated with marine farming and fisheries enhancement.
- Hull cleaning.

7.2. NATURAL RANGE EXTENSION

Natural range extension occurs primarily via dispersal of larvae by currents, although motile adults of some species may disperse under their own locomotion. Typically, species that have planktonic life history phases are capable of some degree of natural dispersal via currents and water movement; the distance of dispersal depend largely on local hydrodynamics and the length of time spent as plankton. Bryozoans, polychaetes and ascidians generally have planktonic life history phases capable of natural dispersal, as evident by their broad distributions throughout New Zealand.

There is little opportunity for species to naturally disperse to mainland New Zealand against the prevailing currents that run eastwards along the Chatham Rise to Chatham Island (Heath 1985). However, natural dispersal along the Southland Current and to Chatham Island along the Chatham Rise is possible. Pelagic species and those life history stages that spend a long time as plankton are most likely to naturally disperse from mainland New Zealand to the Chatham Islands.

Rafting of species can occur provided they have some means of buoyancy, species may attach to driftwood and other naturally buoyant substrates. Anecdotal evidence that rafts of buoyant algae and biofouling species could reach the Chatham Islands from mainland New Zealand can be found in the recovered flotsam and jetsom from the shipwrecked barque *Assaye* thought to have run aground at the Snares Islands, and the recovery of road signage from Otago Peninsula at Chatham Island by beachcombers (Ingram & Wheatley 1936, M. Stuart pers. obs.). The relatively high degree of endemism of marine life at the Chatham Islands and absence of some significant mainland New Zealand species (i.e., *E. radiata*) indicates that only the most buoyant and resilient of species are likely to survive the journey. For instance, the establishment of *Durvillaea antarctica* at Chatham Island would have been aided by the buoyancy of its lamina due to their honey-comb internal structure, whereas the lamina of the New Zealand congeneric *D. willana* are not buoyant and this species is not present at the Chatham Islands (Hay 1979). Nevertheless, the absence of *D. willana* at the Chatham Islands has led to the evolution of the non-bouyant endemic bull-kelp, *D. chathamensis* which fills a similar niche to *D. willana*, occurring subtidally below *D. antarctica* to a depth of approximately 2 m (Hay 1979, Adams 1994).

The bladder-kelp, *Macrocystis pyrifera*, is another algal species that is likely to have rafted to the Chatham Islands with the aid of the gas-filled bladders that buoy its fronds. However, the stipitate kelps *E. radiata* and *U. pinnatifida* do not have any such buoyancy aids that would facilitate natural dispersal to the Chatham Islands, and which is likely to prevent their natural dispersal to the Chatham Islands by any means other than as biofouling organisms.

7.3. BALLAST WATER AND HULL FOULING

Few, if any, water-ballasted vessels have visited the Chatham Islands, although solid ballast was a feature of early shipping and would have been jettisoned as sailing vessels loaded oil, skins and produce destined for domestic and overseas markets. Ballast water discharge is therefore unlikely to have introduced non-indigenous species to the Chatham Islands. The detection of cysts of a toxic dinaoflagellate in samples taken from the northern end of Hanson Bay is therefore an anomoly with known dispersal mechanisms, translocation pathways and invasion history for toxic dinoflagellates (e.g., Hallegraeff 1993). A shore-whaling station was established at the northern end of Hanson Bay at Waikeri for three years in the early 1840s, but any introduction of *G. catenatum* in dry ballast at this time would predate the earliest sediment core recorded of *G. catenatum* in New Zealand by almost a century and the first blooms of this species in New Zealand by 140-160 years (Smayda 2007). *Gymnodinium catenatum* would therefore appear to be indigenous to the Chatham Islands.

After the decline in sealing and whaling at the Chatham Islands, shipping to Whangaroa (Port Hutt), Waitangi, Owenga and Kaingaroa increased from late 1830s through the establishment of agrarian trade, which has continued to the present time (Butterfield & Pryce 2002, King 2000). International and domestic shipping to these ports and harbours is reflected in the distribution of non-indigenous and cryptogenic species detected in the present survey, with 19 of the 28 non-indigenous and cryptogenic species detected in this survey occurring exclusively within current ports and harbours, and 12 species occurring on wharf pilings (Table 4).

The recently described ascidian *D. velatum* and bryozoans *C. pallasiana* and *S. ambigua* were all recorded for the first time at the Chatham Islands as biofoulers of wharf pilings in ports and harbours frequented by modern shipping (Table 4). *C. pallasiana* and *S. ambigua* are particularly widespread in ports throughout mainland New Zealand whereas *D. velatum* is widespread about the South Island (Cranfield *et al*. 1998, Gordon 1986, Inglis *et al* 2008d). This suggests they are not indigenous to the Chatham Islands and have been introduced as biofouling on the hulls of domestic vessels traffic.

Foreign vessels regularly foundered at the Chatham Islands up until the early 1900s and shipwrecks have been identified as a likely source of marine species introductions over this period (Stuart & McClary 2008). Cryptogenic species detected during the present survey that may represent introductions by early shipping are *C. eumyota, H. clathrata, L. clathrata, C. incrustans, L. prolifera, P. chabrus* and *S. purpurea*. However, determination of the origin and possible mechanisms of introduction of these species is confounded by a lack of historical data on their distribution and spread about the Chatham Islands. Nevertheless, the importance of intentional and accidental shipwrecks as a mechanism for the introduction and persistence of biofouling organisms is demonstrated by the high proportion (36%) of non-indigenous and cryptogenic species detected in this survey that were recorded from the *Thomas Currell* and *Seafresh 1*.

Table 4: Location of non-indigenous and cryptogenic species detected during port survey.

Species	Current ports and harbours	Wharf pilings	Historical ports and anchorages	Extant shipwrecks	Remote exposed reefs and embayments
Aplidium phortax	✓	✓		✓	
Ascandra osculum	✓	✓			
Botrylloides leachi	✓	✓		✓	
Bowerbankia gracilis	✓			✓	
Bugula flabellata	✓			✓	
Callyspongia robusta	✓	✓			
Capitella capitata	✓				
Chaperia cf *acanthina*	✓	✓		✓	
Chondropsis topsentii	✓			✓	
Corella eumyota	✓	✓		✓	✓
Crella incrustans					✓
Cryptosula pallasiana	✓	✓			
Cystodytes dellachiajei	✓				
Diplosoma velatum	✓	✓			
Grantessa intusarticulata	✓	✓		✓	
Gymnodinium catenatum			✓		
Haliclona clathrata	✓				✓
Leucascus cf *clavatus*	✓	✓			
Leucetta prolifera					✓
Leucosolenia clathrata	✓	✓			✓
Neosiphonia subtilissima				✓	
Paradoneis lyra	✓			✓	
Plagusia chabrus					✓
Scruparia ambigua	✓	✓			
Stelletta purpurea					✓
Suberites australiensis	✓				
Tethya multistella	✓				
Ulva pertusa	✓				

The documented history of the *Seafresh 1* as a vector for the introduction of *U. pinnatifida* to Chatham Island and the incidence of several non-indigenous and cryptogenic species on shipwrecks further emphasise the importance of shipwrecks in the introduction and persistence of marine species to the Chatham Islands (Table 4). The detection of *B. gracilis* and *B. flabellata* on the wreckage of the *Thomas Currell* represent new records for the Chatham Islands, and their absence from samples collected elsewhere around the Chatham Islands strongly suggests that they were introduced as biofouling ON the vessel's hull when it arrived at Chatham Island in 1966 and was subsequently run aground in 1968. This timing fits well with the indicated dates of introduction of *B. gracilis* and *B. flabellata* to New Zealand as occurring before 1967 and 1949, respectively (Cranfield *et al*. 1998).

Genetic analysis of *U. pinnatifida* from the wreck of the *Seafresh 1* indicated that the introduction of this species most likely occurred from ports on the eastern coast of the South Island. The haplotype that was removed from the *Seafresh 1* corresponded with that present at Lyttelton Harbour, Taylor's Mistake, Timaru, Oamaru, Moeraki, and Big Glory Bay, and Stewart Island, but was absent from Otago Harbour, Bluff, Halfmoon Bay (Stewart Island) and locations north of Banks Peninsula (Uwai *et al*. 2006).

7.4. MARINE FARMING ACTIVITIES AND FISHERIES ENHANCEMENT

Currently there are no marine farms at the Chatham Islands. A small number (<5) of mussel buoys were moored in Whangamoa Inlet from 2000 to 2003 (M. Stuart pers. obs.), but activities at this site have since ceased (Owen Pickles pers. comm. 25 May 2009). The probability that non-indigenous species have been introduced to the Chatham Islands by marine farming is low and there is no evidence to associate any of the detected non-indigenous species with the large-scale experimental and commercial seeding of hatchery-reared abalone that has occurred repeatedly at the Chatham Islands since 1990.

7.5. HULL CLEANING

The slipway situated at Kaingaroa has no containment facility and discharges directly onto the sandy foreshore and associated rocky reef (Figure 23, left). Unless collected by hand, any fouling organisms removed during cleaning are deposited directly into the marine environment. The slipway is immediately adjacent and above rock reef providing suitable substrate for colonisation by fouling organisms. As indicated previously, *C. durvillaei* (Bory) Ramirez was collected from a slipway at Kaingaroa in October 2001. The first published record of *C. durvillaei* in New Zealand was from the Cape Rodney-Okakari Point Marine Reserve at Leigh in 1980, recorded under the synonym *C. bullosa* (Saunders) Yamada (Parsons 1982). It has been reported subsequently on the east coast of Northland, at Mahia Peninsula, Napier and Wellington Harbour (Adams 1994). The presence of *C. durvillaei* in Wellington and Napier and at the Kaingaroa slipway suggests that it may have been translocated to Chatham Island on a vessel from either of these mainland ports and introduced to Kaingaroa by the disposal of hull scraping directly into the marine environment.

Figure 23: Slipway at Kaingaroa (left) and haulout area at Waitangi (right), Chatham Island.

Vessels are regularly hauled ashore in cradles and cleaned on the sandy foreshore at Waitangi (Figure 23, right). This presents a mechanism for the introduction of fouling organisms if biofouling is deposited or washed into the marine environment. However, the release of biofouling onto the sandy beach at Waitangi is likely to present a barrier to the establishment of most biofouling organisms that generally attach to hard substrates. Biofouling organisms or propagules may, however, disperse to rock reef and outcrops that occur immediately offshore and further along the beach from the haul-out area.

8. Influences of the Port Environment and Port Practices on Colonisation and Survival of Non-Indigenous Species

The marine environment and communities about the Chatham Islands are relatively intact and unmodified by human impacts associated with urbanisation. This may provide a degree of resistance and resilience to the establishment and localised spread of some non-indigenous species. Reclamation and the construction of seawalls wharves, boat ramps and moorings have, however, created artificial substrates suitable for colonisation by biofouling organisms. Vessels regularly move between moorings and wharves throughout Chatham Island, which creates opportunity for the translocation and establishment of non-indigenous species at new sites about the Chatham Islands. The greatest concentration of permanent moorings occurs at Waitangi and Kaingaroa, moorings also occur at Owenga and Port Hutt.

Hull cleaning practices at the Kaingaora slipway and haulout facilities at Waitangi could result in further introductions of non-indigenous species, particularly if efforts are not taken to prevent the release of biofouling directly to the marine environment (e.g., by establishing containment facilities). The disposal of derelict shipwrecks could also introduce non-indigenous marine species by creating permanent hard substrate for colonisation by biofouing species that spread to the wreck from other locations or are already attached to the vessel's hull. This appears to be the mechansism of introduction and spread of *B. gracilis, B. flabellata* and *C. pallasiana* on the *Thomas Currell*, and for *U. pinnatifida* and *N. subtilissima* on the *Seafresh 1*.

9. Assessment of the Risk of New Introductions to the Port

9.1. OVERVIEW

Biofouling of domestic shipping and international cruise ships present the greatest risk of new introductions to Chatham Island with a number of non-indigenous and cryptogenic species recorded as biofouling of vessels voyaging to the Chatham Islands (Table 5, Stuart & McClary 2008).

It is also possible that species native to mainland New Zealand but absent from the Chatham Islands may pose a biosecurity risk to these offshore areas. One such example is *E. radiata,* which is not present at the Chatham Islands but has been observed to foul vessels servicing the area (M. Stuart, pers. obs.). Most recently, a seaweed specimen though to be *U. pinnatida* was removed from the hull of a Napier-based fishing vessel that had been hauled out for cleaning at Waitangi on 12 June 2009 (O. Pickles, pers. comm.). The vessel had been present in Kaingaroa Harbour for several months prior to cleaning and had since returned to Napier. The sample was subsequently identified by the Marine Invasives Taxonomic Service (MITS) as *E. radiata* (J. McDonald, pers. comm.); a species indigenous to mainland New Zealand but non-indigenous to the Chatham Islands.

If *E. radiata* were to be introduced to the Chatham Islands it could exclusively occupy middle and deeper portions of subtidal reef that are presently occupied by a sparse cover of the Chatham Island endemic, *L. tholiformis*, and some fucalean species (Schiel *et al.* 1995).

Table 5: Non-indigenous and cryptogenic species recorded as biofouling of vessels voyaging to Chatham Islands (Stuart & McClary 2008).

Phylum/Class	Order	Family	Genus and Species	Status
Arthropoda	Amphipoda	Caprellidae	*Caprella mutica*	Known introduced
		Ischyroceridae	*Jassa falcata*	Unknown introduced
			Jassa marmorata	Cryptogenic
	Sessilia	Balanidae	*Amphibalanus amphitrite*	Known introduced
			Megabalanus coccopoma	Unknown introduced
			Amphibalanus variegatus	Cryptogenic
			Balanus trigonus	Cryptogenic
Bryozoa	Cheilostomata	Bugulidae	*Bugula neritina*	Known introduced
		Cryptosulidae	*Cryptosula pallasiana*	Known introduced
		Watersiporidae	*Watersipora subtorquata*	Known introduced
		Schizoporellidae	*Schizoporella errata*	Cryptogenic
Chordata	Pleurogona	Styelidae	*Styela plicata*	Cryptogenic
		Pyuridae	*Pyura stolonifera*	Unknown introduced
Cnidaria	Leptothecata	Campanulariidae	*Hartlaubella gelatinosa*	Known introduced
Mollusca	Mytiloida	Mytilidae	*Mytilus galloprovincialis*	Cryptogenic
Ochrophyta	Laminariales	Alariacaea	*Undaria pinnatifida*	Known introduced
Rhodophyta	Ceramiales	Rhodomelaceae	*Polysiphonia brodiei*	Known introduced

9.2. AQUACULTURE VECTORS

The transfer of farm-reared juvenile paua from mainland New Zealand to the Chatham Islands and re-seeding of paua fisheries could also introduce parasites and pathogens to indigenous fisheries. No non-indigenous species or pathogens are present in New Zealand aquaculture stock and the current risk of new introductions by this pathway can thus currently be considered low. However, the herpes-like viral disease of abalone, Abalone Virus Ganglioneuritis (AVG), caused high mortalities on Australian abalone farms in 2005 and was detected in natural abalone populations in Victoria, Australia a year later (Hills 2007). Although the origin of this pathogen is unclear, its introduction to New Zealand would pose a significant threat to paua fisheries and paua cultivation.

9.3. VESSEL VECTORS

Historical interest in international shipping to the Chatham Islands as the source of seals, whales and agrarian produce diminished over the mid to late 1800s and the size and range of the domestic fleet grew in response to reduced international shipping (Stuart & McClary 2008). However, a rise in the popularity of modern ecotourism has resulted in increased numbers of international shipping visits to the Chatham Islands. International cruise liners began to visit the Chatham Islands in the late 1960s and are the main, and possibly the only, source of modern international shipping that voyages directly to the region. Cruise liners are known to contain a far greater number of non-indigenous biofouling species than domestic shipping (Stuart & McClary 2008). However, the biosecurity risk presented by cruise liners to the Chatham Islands is moderated by the fact that these vessels anchor offshore and ferry passengers to shore in smaller vessels.

The occurrence of known introduced marine species on domestic shipping indicates that secondary transport of non-indigenous marine species established on mainland New Zealand is an important mechanism by which non-indigenous species are introduced to the Chatham Islands (Stuart & McClary 2008, Wasson *et al*. 2001). Domestic vessels from Timaru, Lyttelton, Wellington and Napier have regularly serviced the Islands, and these ports contain a number of non-indigenous species not known to occur at the Chatham Islands (Table 6).

Domestic vessels are known or are suspected to have introduced *U. pinnatifida* and *C. durvillaea* to the Chatham Islands in recent times (Wotton *et al*. 2004, M. Stuart unpublished data). Oceanic fishing vessels that operate around the Chatham Rise intermittently enter the near-shore waters of Chatham Island to obtain vessel parts, to change crew, or for medical emergencies, but the biosecurity risk presented by oceanic fishing vessels is moderated by the short duration of their visits. Vessels domiciled at the Chatham Islands could introduce new species to the Island during intermittent voyages to mainland New Zealand for maintenance and servicing. Similarly, new vessels purchased or manufactured in mainland New Zealand could also introduce new species when making their maiden voyage to the Islands. However, the biosecurity risk of such voyages to Chatham Island is difficult to assess due to their intermittent and unpredictable occurrence.

Napier and Timaru are the primary ports from which vessels regularly service the Chatham Islands but only two vessels, the *Baldur* and *Rangatira*, presently service the Islands. Data on the biofouling of the *Rangatira* is available (i.e., Stuart & McClary 2008), although no data is presently available for the *Baldur* due to the recent establishment of this service in May 2009. It is also extremely difficult to compare the likelihood of non-indigenous species being introduced by such vessels that berth frequently at the Chatham Islands for short periods to vessels that are permanently moored at the Chatham Islands and make intermittent return voyages from the Islands to mainland New Zealand.

Table 6: List of non-indigenous marine species recorded at New Zealand mainland ports that have vessels voyaging to the Chatham Islands (Inglis *et al*. 2008a-c, Nelson 1999, Cranfield *et al*. 1998, Nelson & Maggs 1996, Adams 1983).

Phylum/Class	Genus and species	Location	Time of introduction or first discovery (d) in NZ
Anthozoa	*Haliplanella lineata*	Lyttelton	Mar 2002 d
Ascidiacea	*Ascidiella aspersa*	Lyttelton, Napier	1900s
Ascidiacea	*Asterocarpa cerea*	Timaru, Lyttelton, Wellington, Napier	Pre 1900
Ascidiacea	*Ciona intestinalis*	Timaru, Lyttelton, Napier	Pre 1950
Ascidiacea	*Styela clava*	Lyttelton	Nov 2004 d
Ascidiacea	*Styela plicata*	Lyttelton, Wellington	Pre 1948
Bivalvia	*Theora lubrica*	Wellington, Lyttelton, Napier	1971
Bryozoa	*Bugula neritina*	Timaru, Lyttelton, Napier	1949
Bryozoa	*Bugula stolonifera*	Timaru	1962
Bryozoa	*Celleporaria nodulosa*	Timaru	Jan 2002 d
Bryozoa	*Conopeum seurati*	Lyttelton	Pre 1963
Bryozoa	*Cyclicopora longipora*	Wellington	Unknown
Bryozoa	*Tricellaria inopinata*	Lyttelton	Pre 1964
Bryozoa	*Watersipora subtorquata*	Timaru, Lyttelton, Wellington, Napier	Pre 1982
Hydrozoa	*Eudendrium capillare*	Wellington	Nov 2001 d
Hydrozoa	*Eudendrium generale*	Wellington, Napier	Jan 2003 d
Hydrozoa	*Halecium delicatulum*	Lyttelton	Pre 1876
Hydrozoa	*Plumularia setacea*	Timaru, Lyttelton	Pre 1828
Hydrozoa	*Monotheca pulchella*	Timaru, Lyttelton, Wellington	1928
Hydrozoa	*Sertularia marginata*	Wellington	1930
Hydrozoa	*Symplectoscyphus subdichotomus*	Timaru, Lyttelton	1930
Hydrozoa	*Synthecium subventricosum*	Timaru	1955
Malacostraca	*Apocorophium acutum*	Timaru, Lyttelton	Pre 1921
Malacostraca	*Cancer gibbosulus*	Timaru, Lyttelton, Wellington	Nov 2001 d
Malacostraca	*Caprella mutica*	Timaru	Feb 2002 d
Malacostraca	*Crassicorophium bonnellii*	Lyttelton	Nov 2004 d
Malacostraca	*Jassa slatteryi*	Timaru, Lyttelton	Unknown
Malacostraca	*Jassa staudei*	Timaru	Dec 2004 d
Malacostraca	*Monocorophium acherusicum*	Timaru, Lyttelton, Wellington	Pre 1921
Malacostraca	*Monocorophium sextonae*	Lyttelton	Pre 1921
Malacostraca	*Stenothoe* sp. aff. *gallensis*	Lyttelton	Unknown
Phaeophyta	*Cutleria multifida*	Lyttelton, Wellington	Pre 1870
Phaeophyta	*Dictyota furcellata*	Lyttelton	2000 d
Phaeophyta	*Punctaria latifolia*	Wellington	Pre 1947
Phaeophyceae	*Striaria attenuata*	Wellington	Pre 1957
Phaeophyceae	*Undaria pinnatifida*	Timaru, Lyttelton, Wellington, Napier	Pre 1987
Polychaeta	*Euchone limnicola*	Timaru	Unknown
Polychaeta	*Barantolla lepte*	Timaru, Napier	Unknown
Polychaeta	*Dipolydora armata*	Wellington	~1900
Polychaeta	*Euchone limnicola*	Timaru	Unknown
Polychaeta	*Polydora hoplura*	Timaru, Lyttelton, Wellington	Unknown
Polychaeta	*Sabella spallanzanii*	Lyttelton	Mar 2008
Polychaeta	*Spirobranchus polytrema*	Timaru, Lyttelton, Wellington	Nov 2001 d
Porifera	*Halisarca dujardini*	Lyttelton, Wellington	Pre 1973
Florideophyceae	*Antithamnionella ternifolia*	Timaru	Pre 1904
Florideophyceae	*Griffithsia crassiuscula*	Timaru, Lyttelton, Wellington	Pre 1954
Florideophyceae	*Polysiphonia brodiaei*	Timaru, Lyttelton, Wellington	Pre 1940
Florideophyceae	*Polysiphonia senticulosa*	Lyttelton, Wellington	Pre 1993

10. Assessment of the Risk of Translocation of Non-Indigenous Species Found in the Port

Natural dispersal of non-indigenous marine species from Chatham Island to mainland New Zealand or other landmasses is most unlikely, as prevailing oceanic currents are eastward along the Chatham Rise and onward into the Pacific Ocean (Heath 1985). To date, all non-indigenous species discovered at the Chatham Islands are known previously from mainland New Zealand suggesting that they have been introduced to the Chatham Islands by domestic shipping. Although considered unlikely, it is possible that international shipping to the Chatham Islands (i.e., cruise ships; Stuart & McClary 2008) could directly introduce non-indigenous species from overseas, which could then be spread to mainland New Zealand by domestic shipping. Similarly, populations of non-indigenous species already established at mainland New Zealand and the Chatham Island could be spread to other locations on mainland New Zealand as hull fouling on domestic vessels servicing the Chatham Islands. The likelihood of this is relatively low owing to the low volume of vessel traffic to mainland New Zealand. It is more likely that non-indigenous marine species are introduced directly to mainland New Zealand and are translocated between mainland ports and marine farming areas.

Species endemic to the Chatham Islands which are not indigenous to mainland New Zealand could be translocated from the Chatham Islands to mainland New Zealand by vessel biofouling. For example, the red seaweed, *G prolifera* J. Agardh is endemic to the Chatham Island and was introduced to mainland New Zealand (Wellington Harbour) by shipping (Adams 1994). The Chatham Island endemic brown seaweed, *L tholiformis*, has been observed fouling local vessels and wharf pilings at Chatham Island (M. Stuart, pers. obs. 2001-2003, present survey) and could be translocated to mainland New Zealand by vessel biofouling.

11. Recommendations

11.1. OVERVIEW

This report represents the first comprehensive survey for non-indigenous marine species at the Chatham Islands, and therefore provides information that can inform appropriate actions for MAFBNZ to manage existing non-indigenous marine species and prevent new species from being introduced to the Chatham Islands. The geographic isolation of the Chatham Islands and the high degree of endemism amongst marine species presents a situation where the likelihood of introduction is relatively low when compared to mainland New Zealand, but the potential effect of these introductions on such unique marine assemblages could be substantial.

We recommend that a regional partnership (or similar) approach to marine biosecurity management be adopted for the Chatham Islands, whereby stakeholders actively participate toward the development of a specific Chatham Islands Marine Biosecurity Plan. Owing to the isolation of the Chatham Islands from mainland New Zealand and the inherent difficulties and costs involved in the local community or its representatives travelling to the mainland, we also recommend that the development of this plan occur through a series of face-to-face meetings held at the Chatham Islands. Specific components of such a plan to manage existing non-indigenous marine species and prevent new introductions are presented below. These could provide the basis for discussions with stakeholder representatives and the wider Chatham Island community toward the development of a Chatham Islands Marine Biosecurity Plan.

11.2. MANAGEMENT OF EXISTING NON-INDIGENOUS SPECIES IN THE PORT

11.2.1. Overview

Management of existing non-indigenous marine species at the Chatham Islands could comprise five main components:

- Social marketing – to educate people of the presence of non-indigenous marine species and actions they can take to reduce the rate of spread and impacts of non-indigenous marine species;
- Pathways and vector management – to reduce the risk of human-mediated vectors spreading non-indigenous marine species about the Chatham Islands;
- Surveillance – to detect non-indigenous marine species that are introduced to the Chatham Islands;
- Population management – to reduce or avoid the spread and negative effects of non-indigenous marine species through population control or localised eradication; and
- Performance monitoring – to assess and improve the efficacy of management measures.

11.2.2. Social marketing

While outside support will be required in the management of existing non-indigenous marine species at the Chatham Islands, community involvement and participation will be crucial to management success. The small, isolated and close-knit community of the Chatham Islands is far more amenable to managing their own affairs than it is to adopting management initiatives that are imposed on them from mainland New Zealand. In the same manner as the regional partnership approach seeks to obtain stakeholder participation in the management of marine pests on mainland New Zealand, the participation of the Chatham Island community could be easily gain through a similar approach. The willingness of local residents and council officers to engage with the field team prior to this survey is suggestive of the success of such an approach.

We recommend that the Chatham Islanders are actively engaged in this process at the outset to ensure that the management of existing non-indigenous marine species at the Chatham Islands is in line with community expectations and a realistic appreciation of the possible outcomes. Given the relative isolation of the area and lack of daily air service to all major centres (the location rotates between Auckland, Wellington, Christchurch and New Plymouth), the greatest degree of community participation is accomplished through face-to-face meetings held on the Chatham Islands. These can be used to identify and discuss community expectations, present and emerging marine biosecurity threats, and possible management options.

11.2.3. Pathways and vector management

The translocation and introduction of existing non-indigenous marine species to new locations about the Chatham Islands is most likely through hull fouling and the translocation of fouled marine equipment such as mooring blocks, chain, rope and buoys. Improvement of hull cleaning facilities, procedures for the disposal of derelict and disused vessels, and the location and maintenance of vessel moorings are issues that could be addressed independently by the Chatham Islands Council, in consultation with MAFBNZ, or through a regional partnership approach.

11.2.4. Surveillance

Regular surveillance for non-indigenous marine species at the Chatham Islands is necessary to enable prompt actions in response to new species introductions and inform management decisions. We recommend that surveillance is not only targeted for conspicuous and unwanted species present at mainland New Zealand (i.e., *S. spallanzanii, Styela clava, U. pinnatifida, Eudistoma elongata, Charybdis japonica*), but also includes the collection of samples that are subsequently identified by the Marine Invasives Taxonomic Service (MITS) to detect less conspicuous non-indigenous species that are entrained by biofouling pathways. Collection of such data is crucial to providing robust assessments of on-going biosecurity risks and the efficacy of management activities (i.e., performance monitoring).

11.2.5. Population management

The non-indigenous red seaweed *N. subtilissima* is widespread about the Chatham Islands and eradication or management of this species would not be feasible. The non-indigenous bryozoans, *B. gracilis* and *B. flabellata* occur only on the wreckage of the *Thomas Currell*, whereas *C. pallasiana* occurs on wharf pilings and the wreckage of the *Thomas Currell.* Thus, these species appear to be restricted to Port Hutt, and population control or eradication could be feasible. Population management of other non-indigenous species at the Chatham Islands could also be feasible (e.g., for *A. acutum, C. durvillaei* and *P. sertularioides*). We recommend that the Chatham Island community is involved in any decision-making process toward marine pest management through a regional partnership approach.

11.2.6. Performance monitoring

Regular assessment and improvement of management measures will be required to enable reporting to funding agencies and to incorporate changes to management that allow for the discovery of new species and changes in species' distribution. A key element of this process is the collection and collation of relevant information from management activities, which can be rigorously compared to set objectives and management goals. This may involve independent and specialist oversight of the collection and analysis of samples to provide empirical data on changes in the incidence, abundance and distribution of non-indigenous species and vectors. Such data would allow management decisions and allocations of effort (i.e., funding and resources) to be made objectively and within the context of the specific management plan developed previously through a regional partnership approach.

11.3. PREVENTION OF NEW INTRODUCTIONS

11.3.1. Overview

Management to prevent new introductions of non-indigenous marine species to the Chatham Islands could comprise the following components:

- Risk Assessment – to identify and assess the risk of existing and new non-indigenous marine species, pathways and vectors to the biosecurity of the Chatham Islands;
- Vector control – to reduce the risk of human-mediated vectors spreading non-indigenous marine species to the Chatham Islands;
- Social marketing – to educate people of non-indigenous marine species threats to the Chatham Islands and actions they can take to reduce the likelihood of introductions;
- Surveillance – to detect non-indigenous marine species that could be introduced to the Chatham Islands;
- Incursion response and population management – to respond effectively to the detection of non-indigenous marine species at the Chatham Islands and to reduce or avoid the spread and negative effects of non-indigenous marine species through population control or local elimination; and
- Performance monitoring – to assess and improve the efficacy of management measures.

11.3.2. Risk assessment

Marine biosecurity risks to the Chatham Islands will vary over time as the incidence, abundance and distribution of non-indigenous marine species and vectors change. Repeat surveys of non-indigenous marine species at the Chatham Islands and mainland New Zealand ports, along with a re-evaluation of vector pathways and movements will be necessary to provide current information on which to assess risk, monitor performance and make risk-based management decisions.

11.3.3. Vector control

Biofouling of vessels voyaging to the Chatham Islands from Napier and Timaru have been identified as presenting the greatest biosecurity risk by virtue of regular shipping services from these ports. The recent detection of *U. pinnatifida* on a Napier-based vessel hauled out at Waitangi illustrates this risk.

New introductions to the Chatham Islands may be prevented through the management of vessel biofouling on the relatively small number of vessels that make regular voyages to the Chatham Islands. Management of biofouling has occurred previously through voluntary vector management of merchant and oceanic fishing vessels voyaging to the Chatham Islands (Kingett Mitchell 2006, McClary & Stuart 2006a, b). The efficacy of voluntary measures was subsequently assessed through hull inspections of vessels arriving at Chatham Islands. Inspections allowed for the mitigation of biosecurity risks either through the removal of non-indigenous biofouling species (i.e., *U. pinnatifida*) or the prompt return of vessels to mainland

New Zealand (Kingett Mitchell 2006). We recommend that the Chatham Islands are re-visited, with management approaches updated and widened to include unwanted organisms other than *U. pinnatifida* (e.g., *S. spallanzanii* and *S. clava*). We recommend that hull inspections of vessels arriving at the Chatham Islands are re-established and occur on a regular basis. This not only represents biosecurity best practice but will assess the efficacy of voluntary measures.

Current hull cleaning facilities at Chatham Island are not of a standard where they would be able to effectively clean vessels without releasing biofouling organisms to the marine environment (e.g., McClary & Nelligan 2003). The establishment of hull cleaning facilities that are capable of containing biofouling that is removed during cleaning would therefore contribute to the prevention of new introductions. We therefore recommend that improvements are made to the hull cleaning procedures at the Kaingaroa slipway and haul-out area at Waitangi to allow vessels to be cleaned in an environmentally safe manner.

The development and application of methods to contain, remove and collect non-indigenous marine species from vessels whilst they remain in the water would also provide an alternative means of cleaning vessels. The development of portable methods to encapsulate, chemically treat or clean small to medium-sized vessels would provide an operational system that could be deployed quickly in response to biosecurity threats without the need for vessels to return to the mainland for cleaning.

The release of hatchery-breed paua at the Chatham Islands for the purpose of fisheries enhancement is a possible mechanism by which new species may be introduced to the Chatham Islands. While management practices are in place to reduce the likelihood of non-indigenous marine species being spread by aquaculture, these require constant review and improvement in light of new biosecurity threats and changing aquaculture practice.

11.3.4. Social marketing

As previously discussed, community involvement and participation will be crucial to successful management of marine biosecurity at the Chatham Islands, including the prevention of new species introductions. We therefore re-iterate our recommendation that the participation of the Chatham Island community is gained through a regional partnership approach. This could include face-to-face meetings held on the Chatham Islands to discuss present and emerging marine biosecurity threats, determine community expectations and discuss possible management options.

11.3.5. Surveillance

Regular surveillance for non-indigenous marine species at mainland ports is necessary to enable the identification of new species that could be translocated and introduced to the Chatham Islands.

11.3.6. Incursion response and population management

Incursion response and population management are difficult to differentiate at an operational level as they differ only in the desired outcome (that being eradication or local elimination as opposed to control). If incursion response fails to eradicate or locally eliminate a founding population, then the management of established populations of non-indigenous species would require consideration on an individual basis and against other management priorities. In keeping with earlier discussions concerning the management of existing non-indigenous species at the Chatham Islands, we recommend that the Chatham Island community is involved in any decision-making process concerning incursion response and population management of any non-indigenous species introductions.

11.3.7. Performance monitoring

Regular assessment and improvement of management measures will be required to enable reporting to funding agencies, decisions on further funding appropriations, and to incorporate improvements to management that allow for changing risk profiles due to the incidence of new species and pathways, or changes in the volume of vector movements. A key element of this process is the collection and collation of relevant information from management activities, which can be compared to set objectives and management goals. Management decisions concerning changes to the programme and allocations of effort (i.e., funding and resources) can therefore be made objectively and within the context of the specific management plan developed previously through a regional partnership approach.

Acknowledgements

This project was funded by MAF Biosecurity New Zealand Contract ZBS2005-19. We wish to thank the Chatham Islands Council, and in particular Mr Owen Pickles (General Manager) and Mr Patrick Smith (Mayor) for their interest in and enthusiasm for protecting this unique marine environment. The authors also thank Ms. Coralie Dignan and Ms. Sandra Hinni of Golder Associates for their invaluable work in the field and Ms Debbie Gunn for her excellent GIS work. We are thankful to Dr Marnie Campbell (field team leader) and students of the Australian National Centre for Marine and Coastal Conservation for their assistance in the field. Otago Diving and Salvage Ltd. and Dr Franz Smith provided dive support during the survey. Appreciation also to Mr Alan MacLeod (Master) and the crew of the vessel *Clan MacLeod* for logistical support and superb seamanship in demanding conditions. Personnel and associated taxonomists with the Marine Invasives Taxonomic Service provided identification services, including Dr.'s Wendy Nelson and Roberta D'Archnino (algae), Mr. Mike Page and Ms. Anna Bradley (ascidia), Dr.'s Dennis Gordon (bryozoa), Shane Ahyong (cnidaria, crustacea) and Hoe Chang (dinoflagellates and cysts), Mr. Owen Anderson, Ms. Niki Davey and Ms. Kate Neill (echinoderms), Dr Malcolm Francis (fish), Ms. Jill Burnett (molluscs) and Dr's Geoff Read (polychaetes) and Michelle Kelly (sponges). This report has also benefited from helpful comments by Dr Justin McDonald (MAFBNZ) and Dr. Ian Boothroyd of Golder Associates.

References

Adams, N. M. (1983) Checklist of marine algae possibly naturalised in New Zealand. *New Zealand Journal of Botany* 21: 1-2.

Adams, N. M. (1991) The New Zealand species of *Polysiphonia* Greville (Rhodophyta). *New Zealand Journal of Botany* 29: 411-427.

Adams, N. M. (1994) Seaweeds of New Zealand: An Illustrated Guide. Canterbury University Press, Christchurch.

Agriculture, Fisheries and Forestry – Australia (2002) Introduced marine pests – Scoping the socio-economic impacts. Reports prepared by Hassall & Associates Pty Ltd. For Fisheries and Aquaculture Branch of Aquaculture, Fisheries and Forestry – Australia. 75 pp.

Allan, R. S. (1928) Chatham Islands. The Physical Features and Structure. *Transactions and Proceedings of the Royal Society of New Zealand* 59: 824-839.

Allen, F. E. (1953) Distribution of marine invertebrates by ships. *Australian Journal of Marine and Freshwater Research* 4: 307-316.

Annala, J. H., Bycroft, B. L. (1985) Growth rate of juvenile rock lobsters (*Jasus edwardsii*) at Stewart Island, New Zealand. *Journal of the Royal Society of New Zealand* 19: 445-455.

Bergquist, P. R. (1968) The marine fauna of New Zealand: Porifera, Demospongiae, Part 1 (Tetractinomorpha and Lithistida). *Bulletin of the N.Z. Department of Scientific and Industrial Research 188*. 105 p.

Bergquist, P. R., Fromont, P. J. (1988) The Marine Fauna of New Zealand: Porifera: Demospongiae, Part 4 (Poecilosclerida). *New Zealand Oceanographic Institute Memoir 96*. 197 p.

Breen, P. A., Booth, J. D. (1989) Puerulus and Juvenile Abundance in the Rock Lobster *Jasus edwardsii* at Stewart Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research* 23(4): 519-523.

Brewin, B. I. (1946) Ascidians in the vicinity of Portobello Marine Biological Station, Otago Harbour. *Transactions and Proceedings of the Royal Society of New Zealand*. 76: 87-131.

Brewin, B. I. (1948) Ascidians of the Hauraki Gulf. Part I. *Transactions and Proceedings of the Royal Society of New Zealand* 77: 115-138.

Brewin, B. I. (1951) Ascidians of New Zealand Part VI. Ascidians of the Hauraki Gulf. *Transactions and Proceedings of the Royal Society of New Zealand* 79: 104-113.

Brewin, B. I. (1952) Ascidians of New Zealand Part VII. Ascidians of Otago coastal waters. *Transactions and Proceedings of the Royal Society of New Zealand* 79: 452-458.

Brewin, B. I. (1956) Ascidians from the Chatham Island and the Chatham Rise. *Transactions and Proceedings of the Royal Society of New Zealand* 84: 121-137.

Brewin, B. I. (1958) Ascidians of New Zealand Part XI. Ascidians of the Stewart Island region. *Transactions and Proceedings of the Royal Society of New Zealand* 85: 439-453.

Brewin, B. I. (1960) Ascidians of New Zealand Part XIII. Ascidians of the Cook Strait region. *Transactions and Proceedings of the Royal Society of New Zealand* 88: 119-120.

Broom, J. E., Jones, W. A., Nelson, W. A., Farr, T. J. (1999) A new record of a marine macroalga from New Zealand – *Giraudyopsis stellifera*. *New Zealand Journal of Botany* 37(4): 751-753.

Butterfield, L., Pryce, M. (2002) Chatham Islands Shipping. *New Zealand Marine News* 50(3): 109-121.

Campbell, M. L., Gould, B., Hewitt, C. L. (2007) Survey evaluations to assess marine bioinvasions. *Marine Pollution Bulletin* 55: 360-378.

Carlton, J. T. (1989) Man's role in changing the face of the oceans: Biological invasions and implications for conservation of near-shore environments. *Conservation Biology* 3: 265-273.

Carlton, J. T. (1996) Pattern, process, and prediction in marine invasion ecology. *Biological Conservation* 78(1-2): 97-106.

Chapman, J. W., Carlton, J. T. (1991) A test of criteria for introduced species: The global invasion by the isopod *Synidotea laevidorsalis* (Miers, 1881). *Journal of Crustacean Biology* 11: 386-400.

Chilton, C. (1910) Notes on the dispersal of marine crustacea by means of ships. *Transactions and Proceedings of the New Zealand Institute* 43: 131-133.

Chilton, C., Bennett, E. W. (1929) Contributions for a revision of the Crustacea Brachyura of New Zealand. *Transactions and Proceedings of the New Zealand Institute* 59(4): 731-778.

Cohen, A. N., Carlton, J. T. (1995) Biological Study. Non-indigenous Aquatic Species in a United States Estuary: A Case Study of the Biological Invasions of the San Francisco Bay and Delta. United States Fish and Wildlife Service, Washington DC, and The National Sea Grant College Program, Connecticut Sea Grant. 246 p.

Cohen, A. N., Carlton, J. T. (1998) Accelerating invasion rate in a highly invaded estuary. *Science* 279: 555-558.

Cooney, R. (2004) Precaution and invasive alien species: challenges at the interface of trade and environment regimes. Paper given at 'Biodiversity loss and species extinction: Managing risk in a changing world.' World Conservation Forum, 18-20 November 2004, Bangkok, Thailand. www.iucn.org/congress/wcforum/forum_th_biodiversity-proceed.htm. Accessed 28 January 2006.

Cooney, R., Dickson, B. (2005) Precautionary principle, precautionary practice: lessons and insights. pp. 288-298. In Cooney, R., Dickson, B. (Eds). Biodiversity and the Precautionary Principle. Risk and Uncertainty in Conservation and Sustainable Use. Earthscan; London.

Cranfield, H. J., Gordon, D. P., Willan, R. C., Marshall, B. A., Battershill, C. N., Francis, M. P., Nelson, W. A., Glasby, C. J., Read, G. B. (1998) Adventive marine species in New Zealand. NIWA Technical Report 34. National Institute of Water and Atmospheric Research, Wellington. 48 p.

Dawson, E. W. (1993) The Marine Fauna of New Zealand: Index to the Fauna 2. Porifera. *New Zealand Oceanographic Institute Memoir 100*. 98 p.

Dell, R. K. (1960a) Chatham Island marine Mollusca based upon collections of the Chatham Islands Expedition 1954. In Biological Results of the Chatham Islands 1954 Expedition. DSIR Bulletin 139(4): 141-159.

Dell, R. K. (1960b) Crabs (Decapoda, Brachyura) of the Chatham Islands 1954 Expedition. In Biological Results of the Chatham Islands 1954 Expedition. DSIR Bulletin 139(1): 1-7.

Dell, R. K. (1963) Nature in New Zealand: Native Crabs. A H & A W Reed. 64 p.

Dieffenbach, E. (1841) An Account of the Chatham Islands. *Journal of the Royal Geographical Society of London* 11: 195-215.

Dupont, L., Viard, F., David, P., Bishop, J. D. D. (2007) Combined effects of bottlenecks and selfing in populations of *Corella eumyota* (Tunicata), a recent introduction to the English Channel. *Diversity and Distributions* 13: 808-817.

Francis, M. P. (1996) Geographic distribution of marine reef fishes in the New Zealand region. *New Zealand Journal of Mairne and Freshwater Research* 30: 35-55.

Gascoyne, F. J. W. (1916) Soldiering in New Zealand. T. J. S. Guilford and Company Limited. London. 164 p. www.nzetc.org/tm/scholarly/tei-GasSold.html. Accessed 2 March 2007)

Glasby, C. J., Read, G. B. (1998) A chronological review of polychaete taxonomy in New Zealand. *Journal of the Royal Society of New Zealand* 28: 347-374.

Godley, E. J. (2002) Biographical Notes (47): Charles Traill (1826-1891), Walter Traill (1850-1924), and Arthur William Traill (1852-1936). *New Zealand Botanical Society Newsletter* 69: 15-20.

Gordon, D. P. (1986) The Marine Fauna of New Zealand: Bryozoa: Gymnolaemata (Cheilostomata and Cheilostomata Anasca) from the Western South Island Continental Shelf and Slope. *New Zealand Oceanographic Institute Memoir 95.* 121 p.

Grosholz, E. D. (2005) Recent biological invasion may hasten invasional meltdown by accelerating historical introductions. *Proceedings of the National Academy of Sciences* 102: 1088-1091.

Gullett, W. (1997) Environmental protection and the "precautionary principle": A response to scientific uncertainty in environmental management. *Environmental and Planning Law Journal* 14(1): 52-69.

Gurevitch, J., Padilla, D. K. (2004) Are invasives species a major cause of extinctions? *Trends in Ecology and Evolution.* 19(9): 470-474.

Hallegraeff, G. M. (1993) A review of harmful algal blooms and their apparent global increase. *Phycologia* 32: 79-99.

Hay, C. H. (1979) Nomenclature and taxonomy within the genus *Durvillaea* Bory (Phaeophyceae : Durvillealles Petrov). *Phycologia* 18: 191-202.

Hay, C. H. (1989) *Lessonia tholiformis* sp. nov. (Pheophyta: Laminariales) from the Chatham Island, New Zealand. *New Zealand Journal of Botany* 27: 461-469.

Heath, R. A. (1985) A review of the physical oceanography of the seas around New Zealand – 1982. *New Zealand Journal of Marine and Freshwater Research* 19: 79-124.

Heath, E., Dell, R. K. (1971) Seashore Life of New Zealand. A H. & A. W. Reed. 72 p.

Hewitt, C. L., Martin, R. B. (1996) Port Surveys for Introduced Marine Species – Background Considerations and Sampling Protocols. CRIMP Technical Report 4. CSIRO Division of Fisheries, Hobart.

Hewitt, C. L., Martin, R. B. (2001) Revised Protocols for Baseline Port Surveys for Introduced Marine Species – Survey Design, Sampling Protocols and Specimen Handling. CRIMP Technical Report 22. CSIRO Marine Research, Hobart. 46 p.

Hewitt, C. L., Willan, J., Bauckham, A., Cassidy, A. M., Cox, C. M. S., Jones, L., Wotton, D. M. (2004) New Zealand marine biosecurity: delivering outcomes in a fluid environment. *New Zealand Journal of Marine and Freshwater Research* 38: 429-438.

Hills, J. (2007) A review of the Abalone Virus Ganglioneuritis (AVG). Ministry of Fisheries. November 2007. http://www.biosecurity.govt.nz/pests/paua-avg-virus. Accessed 30 March 2009.

Holmes, D. (1993) My seventy years on the Chatham Islands. Shoal Bay Press, Christchurch, New Zealand. 184 pp.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Hayden, B; Fenwick, G (2005a) Port of Bluff. Baseline survey for non-indigenous marine species. Research Project ZBS2000/04 Biosecurity New Zealand Technical Series Paper No: 2005/09. 57 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Hayden, B; Fenwick, G (2005b) Gulf Harbour Marina. Baseline survey for non-indigenous marine species. Research Project ZBS2000/04. Biosecurity New Zealand Technical Paper No: 2005/12. 53 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Hayden, B; Fenwick, G (2005c) Opua Marina. Baseline survey for non-indigenous marine species. Research Project ZBS 2000/04. Biosecurity New Zealand Technical Paper No: 2005/14. 50 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Hayden, B; Fenwick, G (2006a) Port of Lyttelton. Baseline Survey for non-indigenous marine species. Research project ZBS2000/04). Biosecurity New Zealand Technical Paper No. 2005/01. 64 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Hayden, B; Fenwick, G (2006b) Port of Nelson. Baseline survey for non-indigenous marine species. Research Project ZBS2000/04 Biosecurity New Zealand Technical Series Paper No: 2005/02. 56 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Hayden, B; Fenwick, G (2006c) Port of Picton. Baseline survey for non-indigenous marine species. Research Project ZBS2000/04 Biosecurity New Zealand Technical Series Paper No: 2005/03. 49 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Hayden, B; Fenwick, G (2006d) Port of Taranaki. Baseline Survey for non-indigenous marine species. Research project ZBS2000/04). Biosecurity New Zealand Technical Paper No. 2005/04. 60 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Hayden, B; Fenwick, G (2006e) Port of Tauranga. Baseline survey for non-indigenous marine species. Research Project ZBS2000/04. Biosecurity New Zealand Technical Paper No: 2005/05. 60 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Hayden, B; Fenwick, G (2006f) Port of Timaru. Baseline survey for non-indigenous marine species. Research Project ZBS2000/04 Biosecurity New Zealand Technical Series Paper No: 2005/06. 61 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Hayden, B; Fenwick, G (2006g) Port of Auckland. Baseline survey for non-indigenous marine species. Research Project ZBS 2000/04. Biosecurity New Zealand Technical Paper No: 2005/08. 58 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Hayden, B; Fenwick, G (2006h) Port of Wellington. Baseline survey for non-indigenous marine species. Research Project ZBS2000/04 Biosecurity New Zealand Technical Series Paper No: 2005/07. 61 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Hayden, B; Fenwick, G (2006i) Dunedin Harbour (Port of Otago and Port Chalmers). Baseline survey for non-indigenous marine species. Research Project ZBS2000/04 Biosecurity New Zealand Technical Series Paper No: 2005/10. 67 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Hayden, B; Fenwick, G (2006j) Port of Gisborne. Baseline survey for non-indigenous marine species. Research Project ZBS2000/04. Biosecurity New Zealand Technical Paper No: 2005/11. 56 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Hayden, B; Fenwick, G (2006k) Port of Napier. Baseline survey for non-indigenous marine species. Research Project ZBS2000/04. Biosecurity New Zealand Technical Paper No: 2005/13. 52 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Hayden, B; Fenwick, G (2006l) Whangarei Marina. Baseline survey for non-indigenous marine species. Research Project ZBS 2000/04. Biosecurity New Zealand Technical Paper No: 2005/15. 49 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Hayden, B; Fenwick, G (2006m) Whangarei Harbour (Whangarei Port and Marsden Point). Baseline survey for non-indigenous marine species. Research Project ZBS 2000/04. Biosecurity New Zealand Technical Paper No: 2005/16. 68 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Kospartov, M; Hayden, B; Fenwick, G (2008a) Port of Lyttelton: Second baseline survey for non-indigenous marine species (Research Project ZBS2000-04). MAF Biosecurity New Zealand Technical Paper No: 2008/02. 139 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Kospartov, M; Hayden, B; Fenwick, G (2008b) Port of Timaru: Second baseline survey for non-indigenous marine species (Research Project ZBS2000-04). MAF Biosecurity New Zealand Technical Paper No: 2008/03. 137 p.

Inglis, G; Gust, N; Fitridge, I; Floerl, O; Woods, C; Kospartov, M; Hayden, B; Fenwick, G (2008c) Port of Wellington: Second baseline survey for non-indigenous marine species (Research Project ZBS2000-04). MAF Biosecurity New Zealand Technical Paper No: 2008/06. 129 p.

Inglis, G; Gust, Kospartov, M; Peacock, L (2008d) Milford Sound: First baseline survey for non-indigenous marine species (Research Project ZBS2005-19). MAF Biosecurity New Zealand Technical Paper No: 2008/01. 220 p.

Ingram, C. W. N. (1990) New Zealand Shipwrecks: 195 Years of Disaster at Sea. 7th Edition. Beckett. 515 p.

Ingram, C. W. N., Wheatley, P. O. (1936) Shipwrecks: New Zealand Disasters 1795-1936. Coullls Somerville Welke Ltd, Dunedin, NZ. 502 p.

Johnson, D., Haworth, J. (2004) Hooked: The Story of the New Zealand Fishing Industry. Hazard Press Ltd, Christchurch, NZ. 551 p.

Kensler, C. B. (1967) The distribution of Spiny Lobsters in New Zealand waters (Crustacea: Decapoda: Palinuridae). *New Zealand Journal of Marine and Freshwater Research* 1: 412-420.

Keough, M., Ross, J. (1999) Introduced fouling species in Port Phillip Bay. pp. 193-226. In Hewitt, C. L., Campbell, M. L., Thresher, R. E., Martin, R. B. (Eds) Marine Biological

Invasions of Port Phillip Bay, Victoria. CSIRO Division of Marine Research, Centre for Research on Introduced Marine Pests, Technical Report No. 20.

King, M. (2000) Moriori: A people rediscovered. Revised edition. Penguin Books. 227 p.

Kingett Mitchell Ltd (2006) Chatham Islands Vector Management. Client Technical Report for Biosecurity New Zealand, Project ZBS2005-28. 7 p. + App.

Kott, P. (1963) The ascidians of Australia IV. Aplousobranchiata Lahille; Polyclinidae Verrill (continued). *Australian Journal of Marine and Freshwater Research* 14(1): 70-118.

Kott, P. (2001) The Australian Ascidiacea Part 4, Didemnidae. *Memoirs of the Queensland Museum* 47: 1-410.

Kott, P. (2005) Catalogue of Tunicata in Australian Waters. Australian Biological resources Study. 301 p. http://www.environment.gov.au/biodiversity/abrs/publications/electronic-books/tunicates.html. Accessed 26 October 2007.

Locke, A. (2009) A screening procedure for potential tunicate invaders of Atlantic Canada. *Aquatic Invasions* 4: 71-79.

Lubchenco, J., Olson, A. M., Brubaker, L. B., Carpenter, S. R., Holland, M. M., Hubbell, S. P., Levin, S. A., MacMahon, J. A., Matson, P. A., Melillo, J. M., Mooney, H. A., Peterson, C. H., Pulliam, H. R., Real, L. A., Regal, P. J., Risser, P. G. (1991) The sustainable biosphere initiative: an ecological research agenda. *Ecology* 72: 371-412.

McClary, D., Nelligan, R. J. (2003) Alternative Biosecurity Management Tools for Vector Threats: Technical Guidelines for Acceptable Hull cleaning Facilities. Unpublished client report prepared for the Ministry of Fisheries, September 2001. Project ZBS2000-03. 30 p.

McClary, D., Stuart, M. (2006a) Investigation of Vector Management Techniques to Reduce the Spread of *Undaria pinnatifida* around New Zealand. Objective 1, Final Report. Client Technical Report for the Ministry of Fisheries, Wellington. Project ZBS 2001/02. 9 p.

McClary, D., Stuart, M. (2006b) Investigation of Vector Management Techniques to Reduce the Spread of *Undaria pinnatifida* around New Zealand. Objective 2, Final Report. Client Technical Report for the Ministry of Fisheries, Wellington. Project ZBS 2001/02. 13 p. + App.

McKoy, J. L. (1983) Movements of rock lobsters, *Jasus edwardsii* (Decapoda: Palinuridae), tagged near Stewart Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research* 17: 357-366.

McNab, R. (1908) Journal of the “Chatham.” Historical Records of New Zealand Vol. II, Government Printer Wellington. pp. 496-508.

Meirs, E. J. (1876) Catalogue of the stalk- and sessile-eyed Crustacea of New Zealand. Colonial Museum and Geological Survey Department, London. 136 p.

Millar, R. H. (1982) The Marine Fauna of New Zealand: Ascidiacea. New Zealand *Oceanographic Institute Memoir 85.* 117 p.

Ministry of Fisheries (2007) Report from the Fishery Assessment Plenary, May 2007: Stock assessments and yield estimates. Ministry of Fisheries, Wellington. 1015 p.

Montgomery, S. K. (1931) Report on the Crustacea Brachyura of the Percy Sladen Trust Expedition to the Abrolhos Islands under the leadership of Prof. W. J. Dakin, D. Sc., F. L. S., in 1913, along with other crabs from Western Australia. *Journal of the Linnean Society of London, (Zoology)* 37(253): 405-465.

Morton, J. E. (2004) Seashore Ecology of New Zealand and the Pacific. David Bateman Limited, Auckland, New Zealand. 504 p.

Naylor, M. (1954) Occurrence of *Durvillea caepestipes* on Chatham Island. *Nature* 173:1099-1100.

Nelson, W. A., Maggs, C. A. (1986) Records of adventive marine algae in New Zealand: *Antithamnionella ternifolia*, *Polysiphonia senticulosa* (Ceramiales, Rodophyta), and *Striaria attenuata* (Dictyosiphonales, Phaeophyta). *New Zealand Journal of Marine and Freshwater Research* 30: 449-453.

Nelson, W. A. (1987) The New Zealand species of *Gracilaria* Greville (Rhodophyta, Gigartinales). *New Zealand Journal of Botany* 25: 87-98

Nelson, W. A., Adams, N. M., Hay, C. H. (1991) Marine Algae of the Chatham Islands. *National Museum of New Zealand Miscellaneous Series Number 23.* 58 p.

Nelson, W. A. (1999) A revised checklist of marine algae naturalized in New Zealand. *New Zealand Journal of Botany* 37: 355-359.

NIMPIS (2002a) *Bugula flabellata* species summary. National Introduced Marine Pest Information System. Hewitt, C. L., Martin, R. B., Sliwa, C., McEnnulty, F. R., Murphy, N. E., Jones, T., Cooper, S. (Eds.) http://crimp.marine.csiro.au/nimpis. Accessed 11 November 2006.

NIMPIS (2002b) *Cryptosula pallasiana* species summary. National Introduced Marine Pest Information System. Hewitt, C. L., Martin, R. B., Sliwa, C., McEnnulty, F. R., Murphy, N. E., Jones, T., Cooper, S. (Eds.) http://crimp.marine.csiro.au/nimpis. Accessed 11 November 2006.

NIWA (2006) Sample sorting and labelling of marine collections for Biosecurity New Zealand. Procedures developed by NIWA for the MAF-BNZ funded Marine Invasives Taxonomic Service. Version 1.4. 15 p.

NIWA (2008) Invasive fanworm discovered. Aquatic Biodiversity & Biosecurity Update 28. http://www.niwa.co.nz/news-and-publications/publications/all/abb/2008-28/fanworm. Accessed 4 June 2009.

Palomares, M. L. D., Pauly, D. (2009) SeaLifeBase. *Paradoneis lyra*. http://sealifebase.org/Summary/SpeciesSummary.php?id=40199, Accessed June 2009.

Parsons, M. J. (1985) New Zealand seaweed flora and its relationships. *New Zealand Journal of Marine and Freshwater Research* 19: 131-138.

Peel, J. (2005) The Precautionary Principle in Practice. Environmental decision making and scientific uncertainty. The Federation Press, Sydney. 244 p.

Porifera (2009) *Leucandra compacta* (Carter, 1886). In Van Soest, R. W. M., Boury-Esnault, N., Hooper, J. N. A., Rützler, K., De Voogd, N. J., Alvarez, B., Hajdu, E., Pisera, A. B., Vacelet, J., Manconi, R., Schoenberg, C., Janussen, D., Tabachnick, K. R., Klautau, M. (Eds) World Porifera Database. http://www.marinespecies.org/porifera/porifera.php?p=taxdetails&id=164294. Accessed 10 May 2009.

Paulin, C. D., Roberts, C. D. (1992) The rockpool fishes of New Zealand. Museum of New Zealand Te Papa Tongarewa, Wellington. 177 p.

Paulin, C. D., Roberts, C. D. (1993) Biogeography of New Zealand rockpool fishes. In Battershill, C. N., Schiel, D. R., Jones, G. P., Creese, R. G., MacDiarmid, A. B. (eds). Proceedings of the Second International Temperate Reef Symposium, p. 191-199. NIWA Marine, Wellington.

Prickett, N. (2002) The Archaeology of New Zealand Shore Whaling. National Historic Heritage Workshop, Wellington, September 2002. 15 p. http://www.doc.govt.nz/upload/documents/science-and-technical/NZShoreWhal.pdf. Accessed 29 February 2007.

Pryce, M. (2004) Southern Tiare. *New Zealand Marine News* 52(3): 148.

Pryce, M. (2005) Southern Tiare. *New Zealand Marine News* 53(1): 27.

Read, G. B. (2004a) Guide to New Zealand Shell Polychaetes: *Capitella capitata*. http://www.annelida.net/nz/Polychaeta/Family/Capitellidae/capitella-capitata.htm. Accessed 31 March 2009.

Read, G. B. (2004b) Guide to New Zealand Shell Polychaetes: About Family Paraonidae polychaetes in New Zealand. http://www.annelida.net/nz/Polychaeta/Family/F-Paraonidae.htm. Accessed 1 April 2009

Ribera, M. A., Boudouresque, C.-F. (1995) Introduced marine plants, with species reference to macroalgae: mechanisms and impacts. pp. 217-268. In Round, F. E., Chapman, D. J. Progress in Phycological Research. Volume 11. Biopress Ltd. Bristol.

Richards, R. (1982) Whaling and sealing at the Chatham Islands. Roebuck Society Publication No. 21. Canberra. 90 p.

Richer de Forges, B. (1983) Découverte d'une espèce de *Plagusia*, *P. chabrus* (Linné 1758) aux Iles Saint-Paul et Nouvelle-Amsterdam (Decapoda, Brachyura). *Crustaceana* 44(1): 94-102.

Roberts, C. D. (1991) Fishes of the Chatham Islands, New Zealand: a trawl survey and summary of the ichthyofauna. *New Zealand Journal of Marine and Freshwater Research* 25: 1-19.

Roberts, C. D. (1991) Fishes of the Chatham Islands, New Zealand: a trawl survey and summary of the ichthyofauna. *New Zealand Journal of Marine and Freshwater Research* 25: 1-19.

Ruiz, G. M., Carlton, J. T., Grosholz, E. D., Hines, A. H. (1997) Global invasions of marine and estuarine habitats by non-indigenous species: Mechanisms, extent and consequences. *American Zoololgist* 37: 621-632.

Russell, L. K., Hepburn, C. D., Hurd, C. L., Stuart, M. D. (2007) The expanded range of *Undaria pinnatifida* in southern New Zealand: distribution, dispersal mechanisms and the invasion of wave-exposed environments. *Biological Invasions* 10: 103-105.

Saunders, G. W., Bailey, J. C. (1999) Molecular systematic analyses indicate that the enigmatic *Apophlaea* is a member of the Hildenbrandiales (Rhodophyta, Florideophycidae). *Journal of Phycology* 35(1): 171-175.

Schiel, D. R., Andrew, N. L., Foster, M. S. (1995) The structure of subtidal algal and invertebrate assemblages at the Chatham Islands, New Zealand. *Marine Biology* 123: 355-367.

Skerman, T. M. (1960) Ship-fouling in New Zealand waters: A survey of marine fouling organisms from vessels of the coastal and overseas trade. *New Zealand Journal of Science* 3: 620-648.

Stuart, M. D., McClary, D. M. (2008) Vessel Biofouling Threat Mitigation. Research Project ZBS2005-16. Biosecurity New Zealand Technical Report prepared for MAF Biosecurity New Zealand. 51 p.

Tanita, S. (1965). Report on the sponges obtained from the adjacent waters of the Sado Island, Japan Sea. *Bull. Jap. Sea. Reg. Fish. Res. Lab.* (14): 43-66.

Taylor Baines and Associates (2002) Cooperation and Commitment: The Chatham Islands Economic Review, 2002. 29 p. www.nzte.govt.nz/common/files/ci-strategy-p1.pdf. Accessed 08 August 2007.

Statistics New Zealand (2006) 2006 Census of Population and Dwellings – Provisional Counts 2006. www.stats.govt.nz/NR/rdonlyres/E8AB724B-EF23-4C87-AE87-EA093DB89F70/0/**2006census**provisionalcounts**2006**hotp.pdf. Accessed 08 August 2007.

Tennyson, A. J. D., Millener, P. R. (1994) Bird extinctions and fossil bones from Mangere Island, Chatham Islands. *Notornis* 41: 165-178.

Uwai, S., Nelson, W., Neill, K., Wang, W. D., Aguilar-Rosas, L. E., Boo, S. M., Kitayama, T., Kawai, H. (2006) Genetic diversity in *Undaria pinnatifida* (Laminariales, Phaeophyceae) deduced from mitochondria genes – Origins and succession of introduced populations. *Phycologia* 45: 687-695.

Varela, M. M., De Matos-Pita, S. S., Ramil, F., Ramos-Espla, A. A. (2007) New Report of the Antarctic ascidian *Corella eumyota* (Tunicata:Ascidiacea) on the Galician coast (north-west Spain). *Journal of the Marine Biological Association of the United Kingdom* 87: 1791-1792.

Williams, R., Gould, B., Christian, S. (2008) Shipwrecks – an international biosecurity risk? *Surveillance* 35(1): 4-6.

Wotton, D., O'Brien, C., Stuart, M., Fergus, D. (2004) Eradication success down under: heat treatment of a sunken trawler to kill the invasive seaweed *Undaria pinnatifida*. *Marine Pollution Bulletin* 49: 844-849