Davidson Environmental Limited

Trial indicators for an ecological integrity assessment (EIA), Abel Tasman coast

Research, survey and monitoring report number 772

A report prepared for:
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2013

Bibliographic reference:

Davidson, R.J.; Freeman D. 2013: Trial indicators for an ecological integrity assessment (EIA), Abel Tasman coast. Prepared by Davidson Environmental Limited for Department of Conservation, Wellington. Survey and Monitoring Report No. 772.

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2013

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Summary

The Department of Conservation is currently developing a new framework for monitoring and reporting in the marine environment. Based on the concept of ecological integrity, the framework will provide the ability for the Department of Conservation to monitor and report on the effectiveness of its marine conservation management, in particular in marine reserves. This report presents a case study assessment of the ecological integrity of the Tonga Island Marine Reserve and wider Abel Tasman coastline. Based on a series of field surveys and desktop based research, we assessed a suite of candidate indicators of ecological integrity for the New Zealand marine environment. Ecological integrity indicators we assessed for this region related to a range of pressures, states and impacts in the marine environment, including marine habitat extent and diversity, abundance and size of particular species of interest (such as protected species and harvested species), levels of environmental contaminants and litter, sedimentation, invasive species, physical benthic disturbance, and land-use and land-cover in the adjacent terrestrial environment. For these indicators it was possible to provide an assessment for both the marine reserve and the wider Abel Tasman coastline. Three key pressures were identified that if reduced, would contribute to enhancing the ecological integrity of this area. These were: physical damage of benthic habitats, sedimentation and invasive species.

The new data collected in November 2011, including remote video imagery, contribute to a snapshot in time of the environmental status of this region and provide a permanent record for not only more detailed analysis of biological attributes at this time, but also for assessment of future changes in aspects such as species diversity and habitat extent and condition.

1.0 INTRODUCTION

The Department of Conservation (DOC) is developing a programme of work that will enable it to monitor and report on the state of New Zealand's marine environment and how the Department's conservation management actions may influence the marine environment. The work is based around the concept of ecological integrity. Ecological integrity is a holistic term that seeks to capture our sense of nature, its functionality and self-maintenance (Thrush *et al*., 2011). This is dependent on human values and our perception of nature, which in our society are wide ranging. For DOC, ecological integrity has been defined in the context of terrestrial and freshwater ecosystems, however, it has not yet been expanded to form an integrated management network across ecosystems.

The Department's marine ecological integrity programme involves the following main components.

- Describe and understand factors that influence the health of the marine environment.
- Develop and trial indicators of "ecological integrity" for the New Zealand marine environment.
- Develop a framework for (a) collecting data, and (b) reporting on ecological integrity in the marine environment including the development criteria that will enable standardised assessment of "ecological integrity" for any section of coast throughout New Zealand, including marine protected areas.

The Department proposed three levels of indicators – some measured at the national scale, others measured at a range of sites around New Zealand, and some that will only be measured at key sites that are the subject of long-term research.

In 2011, NIWA developed a range of candidate indicators of ecological integrity (Thrush *et al*., 2011). A variety of biological data were collected during field work in Port Pegasus, Stewart Island in 2011 (i.e. representative of a relatively pristine location in New Zealand) (D'Archino 2012; Freeman and Chilvers in prep.). During this field work, the Department prioritized the collection of data that represented good candidates for integrity indicators as outlined in Thrush *et al*. (2011). Some examples of data collected in that study by the Department included:

- The number and diversity of marine mammals; sea and shore birds; large predatory fish and invertebrates.
- The presence of large and old animals.
- Levels of contaminants in marine animals and sediments.
- Sediment draping on the seabed.
- Presence/absence of large brown algal species.
- Species richness.
- The foraging ranges and condition of seabirds and marine mammals.

The present study compiles existing data and collects new data for the Abel Tasman coast, including the Tonga Island Marine Reserve, an area that has been studied for over 20 years.

2.0 AIMS OF THE PRESENT STUDY

The present study compiled a combination of existing and new data for use as potential indicators in the Ecological Integrity Assessment (EIA). In particular, we aimed to document the benthic habitats within and adjacent to the marine reserve, for the purposes of habitat mapping and to gather video imagery for future detailed analysis of aspects such as functional diversity. The Abel Tasman coast was ideal for this project as 20 years of data had been collected from the Tonga Island Marine Reserve (MR) and adjacent coast. Further, the coast has been and still is intensively visited by humans and therefore is subject to a range of pressures. Historically, human use was primarily for resources with activities such as catchment land clearance, farming and commercial fishing occurring over large areas of this coast. Since that time most of the land is administered by DOC in the Abel Tasman National Park and part of the marine environment is protected within the Tonga Island MR. More recently, human pressures have come from tourism and recreational fishing.

As part of the present study, existing data collected in relation to the Tonga Island MR was augmented to include biological aspects that had not been thoroughly investigated previously.

The following new data were collected and presented in the present report.

- Underwater video and still camera imagery from soft sediments of the Tonga Island MR and adjacent (alongshore and offshore) coast.
- A soft sediment habitat map for Tonga Island MR and immediate adjacent coast. The soft sediment habitat map plots major soft substratum types (e.g. mud, shell hash).
- Description of important soft bottom surface dwelling biological communities (e.g. horse mussel beds, bryozoan beds, rhodolith beds, red algae beds).
- Diver spot dives to ground truth video and photographic imagery and fill video and drop camera knowledge gaps
- Diver collected data on the subtidal vertical extent of macroalgae and documentation of the dominant species within and outside the reserve.
- Collect field data photographs of subtidal sedimentation present on rock.
- Collection of soft sediment and biota samples contaminant analysis (i.e. heavy metals).

The aims of the present study were to:

1. Present existing data likely to be useful in an EIA.
2. Present new data collected during the present study likely to be useful for an EIA.
3. Compile data in 1 and 2 into a format easily integrated and used in an Ecological Integrity Assessment (EIA). (Note: a comprehensive list of potential EIA candidates were listed in Table 3 In: Thrush *et al*., 2011).

2.0 STUDY AREA

The Abel Tasman coastline, including the Tonga Island Marine Reserve, is located centrally within Tasman and Golden Bays, Nelson. Tonga Island Marine Reserve was established in November 1993. The reserve is 1835 hectares in size and extends one nautical mile, or 1.852 km, offshore from mean high water (Figure 1). The marine reserve boundaries extend from the headland immediately north of Bark Bay to Awaroa Head, and include the shoreline of all islands and stacks within its boundaries.

The Tonga Island MR and the adjacent coast from Marahau in the south to Wainui Inlet in the north are adjacent to the 22,530 ha Abel Tasman National Park (see Dennis, 1985, for review). This coastline is sheltered from large ocean swells, rather being influenced by wind-generated waves that quickly subside with a drop or change in wind direction. High sediment input from the hill catchments both within and adjacent to this coast (i.e. Motueka River), combined with regular sea-breezes and large tides (4.7 m extreme high tide), maintain water clarity at low levels (approximately 2-8 m horizontal distance). In 2013, after a prolonged dry period and no floods, water visibility along some of the coast increased to an all time high of approximately 12 m horizontal distance. Water temperatures range from 10^{o} C to 22^{o} C (Dix, 1970).

Rocky reefs may extend to a depth of approximately 4-14 m and are bordered by gently sloping soft sediment shores. Shallow soft shores are primarily characterised by broken shell and sands. With increasing depth they grade to finer substrata and eventually silt and clays. Granite boulder and bedrock substrata dominate the Abel Tasman coast. Less than 1% of rocky shores along the Abel Tasman coast is composed of limestone, all being located north of Separation Point and outside the marine reserve (Davidson 1992, Davidson and Chadderton, 1994).

The distribution of habitats and associated communities on the granite shores of the Abel Tasman are relatively homogeneous (Davidson, 1992). The exception is the community associated with limestone substrata. Davidson and Chadderton (1994) reported that subtidal communities on limestone were dramatically different to communities on granite.

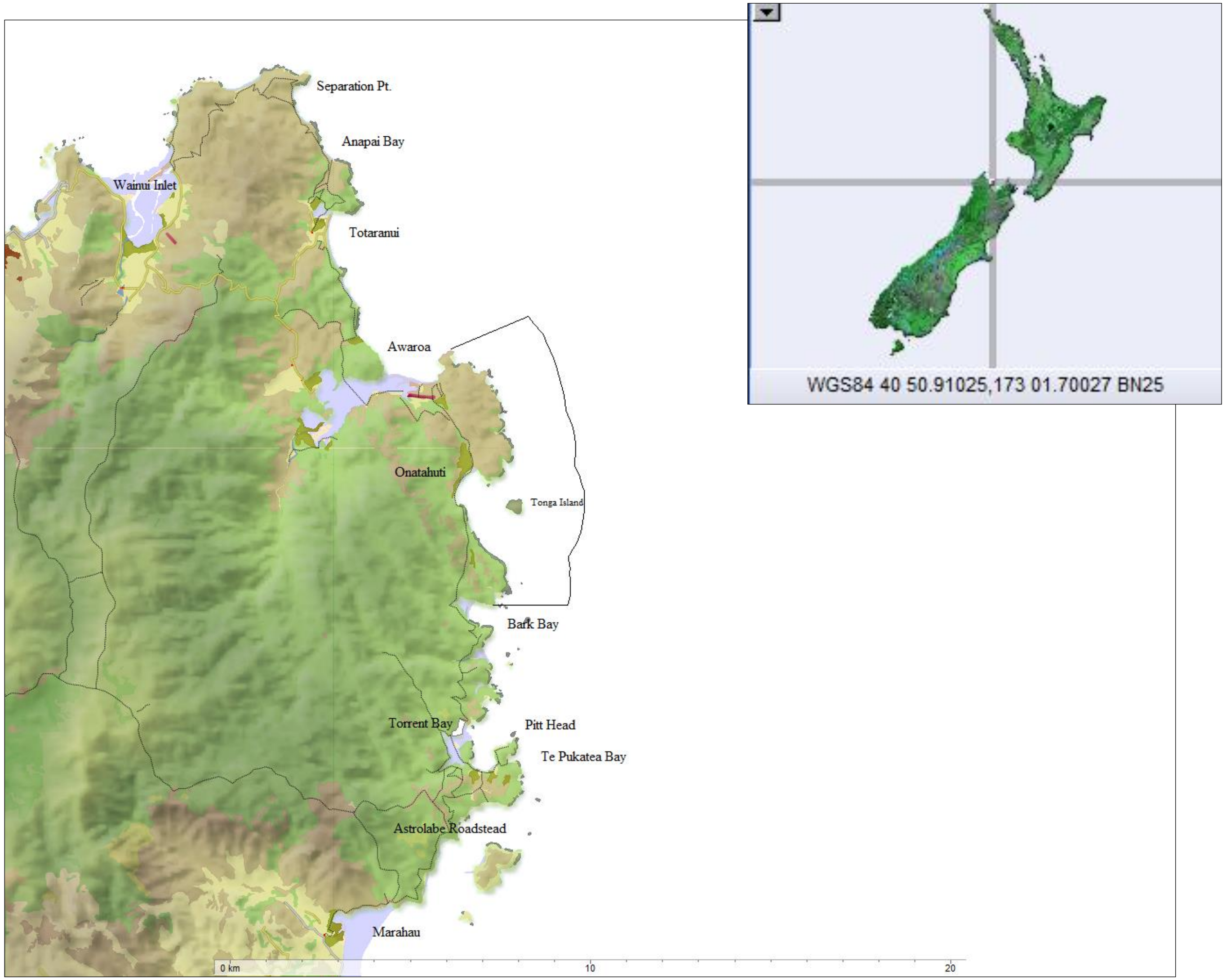


Figure 1. Location of Tonga Island Marine Reserve (black line) along the Abel Tasman coast.

3.0 HISTORIC BIOLOGICAL STUDIES ALONG THE ABEL TASMAN COAST

Dix (1969, 1970, 1970a, 1972)

Dix produced a variety of papers on the urchin *Evechinus chloroticus*. His work was conducted at a variety of location in New Zealand including the Abel Tasman.

Saxton (1980)

Provided a historical account documenting the destruction of approximately 160 km^2 of bryozoan “coral” by commercial fishermen towing chains. The extent, composition and location of bryozoan beds were reportedly located offshore of Torrent Bay and dominated by lace corals.

Bradstock and Gordon (1983)

Produced a report describing the Separation Point bryozoan 'corals'. The authors stated these beds were dominated by two species of bryozoan with another 92 species being recorded. They stated this area was an important juvenile fish and supported a high diversity of invertebrates.

Dennis (1985)

Produced a hand-book outlining the history, biological features and values along the Abel Tasman coast. The book was focused on the terrestrial environment, but makes mention of marine features.

Rushton (1987)

A Ministry of Fisheries report outlining the merits of establishing a marine reserve along the Abel Tasman coast.

Elliott (1989, 1990)

Outline of locations and numbers of banded rail in Tasman and Marlborough estuaries including the Abel Tasman coast.

Davidson (1992)

This report presented a biological inventory of the Abel Tasman coast. The author collected a wide variety of biological information from intertidal and subtidal areas. A habitat map for the estuaries along this coast was also produced outlining major substratum types and vegetated areas. Some data was collected from rocky intertidal and subtidal shores. A small amount of data was collected from soft subtidal shores located adjacent to rocky areas or in shallow locations. No offshore soft substrata data were collected. Known information on fish, estuarine habitat maps, birds and human modification were also included.

Nelson *et al*. (1992).

Collected algae species form a variety of sites along the Abel Tasman Coast and other areas in the northern South Island.

Taylor (1992)

A report summarizing the public submissions received relating to the proposed marine reserve along the Abel Tasman coast.

Davidson and Chadderton (1994)

Produced a journal paper investigating the subtidal community types associated with granite and limestone substrata along the ATNP coast. The authors provided quantitative data and reported a dramatic difference in the macroalgal cover and invertebrate communities between the two substratum types.

Taylor *et al.* (1995)

These authors surveyed the fur seal population in the Nelson-Marlborough region.

Davidson et al. (1995)

Provided an assessment of the biological values of the Abel Tasman coast and estuaries. The authors stated: “the Abel Tasman National Park coastline is renowned for its attractive combination of coastal vegetation, sandy estuaries, golden sand beaches and sculptured granite headlands. The coast represents New Zealand's largest and most northern area of sheltered granite coastline. There are 15 estuarine areas located along this coast. They are excellent examples of relatively coarse substratum estuaries and provide important habitat for various wetland birds, notably banded rail and fernbird. Scattered along the coast are a variety of marine communities which are of biological interest. These include the internationally recognised coral-like bryozoans (Separation Point), localised areas of limestone, high current habitats, and rhodolith and horse mussel.

Davidson *et al*. (1995) also commented "As many as 100,000 people visit the Park each year. Many gather shellfish (eg. mussels: *Perna canaliculus* and *Mytilus* sp.), however, recreational and commercial fishers have had by far the biggest impacts on the coastal environment. Much of the Park has been dredged for scallops (*Pecten novaezelandiae*), netted for fish or potted for crayfish (*Jasus edwardsii*). Recreational fishers have undoubtedly had an impact as up to 100 runabouts leave Kaiteriteri every day in the summer months, many of which fish along the park."

Smith (1997)

Smith provided a summary of human related history and activities including land clearance, farming and resource use along the coast and catchments.

Thrush *et al.* (2003)

Produced a report investigating the use of multi-resolution sampling strategies for mapping soft sediment habitats in marine reserves. The authors used Tonga Island MR to test sonar, acoustic techniques and video imagery.

Davidson (2000, 2001) and Davidson *et al.*, (2002, 2007, 2013)

Reported on the Department of Conservation marine reserve monitoring that has been conducted since in December 1993 Data collected included reef fish density and selected species size, spiny lobster size, sex and density, and kina and cats-eye size and density, scallop size and density and horse mussel density from selected reserve and control sites at particular years between 1993 and 2013.

Davidson (2001) produced a marine reserve monitoring protocol report outlining suggested monitoring protocols including suggested sites and number of replicates.

Davidson *et al*. (2002) produced a journal paper on the size, abundance and sex of spiny lobsters from the marine reserve and adjacent coast. The authors reported lobsters were larger and more abundant form inside the marine reserve.

Davidson and Richards (2005) conducted a study comparing results baited underwater video data collected at Tonga Island MR and Long Island-Kokomohua MR. Authors reported larger blue cod inside the reserves compared to areas outside the protected zone.

Forrest *et al*. (2007)

Subtidal sediments and associated biota were sampled in April 2005 at 15 sites in Tasman Bay along three transects (Fig. 1). Motueka River plume transect sites (M) were positioned in 5 m depth increments from the river mouth to just beyond the outer boundary of the plume. Reference transects (beyond known riverine influences) near The Glen (G) in eastern Tasman Bay and in the Tonga Island (T) marine reserve to the north were included for comparison, but locations ≤15 m depth within these areas consisted of coarse sediments or rock and hence were not sampled. Sediments were analyses for Carbon(C)/N ratios and δ13C and δ15N isotope values, percentage N and δ15N, % N and % C, and 15N/14N and 13C/12C ratios, trace metal suite comprising cadmium (Cd), copper (Cu), chromium (Cr), lead (Pb), nickel (Ni), and zinc (Zn). Epibenthic bivalves were also collected from most of the sediment sampling sites for determination of δ 13C and δ15N isotope signatures. The infaunal community was also described. The authors stated that during flood flows the Motueka River plume can extend several tens of kilometres offshore and in a northerly direction, with an associated depositional footprint of fine (2–20 μm particle size) river-derived sediment predicted to largely follow the plume boundaries under these conditions

Pande *et al.* (2008)

Published paper on the effects of marine reserves in New Zealand producing data from the Tonga Island MR.

Willis *et al.* (2008)

Report on the diet of fur seals along the Abel Tasman coast. The authors stated: The diet of the New Zealand fur seal *Arctocephalus forsteri* was examined at the Tonga Island (Abel Tasman National Park) rookery through analysis of scats and regurgitations from June – November 2007. The arrow squid *Notodarus sloanii*, anchovy *Engraulis australis*, pilchard *Sardinops neopilchardus*, and jack mackerel *Trachurus* spp. were the dominant prey species taken. Dietary composition did not vary markedly between winter and spring, when the colony was dominated by lactating females and their pups, and large territorial males, respectively. The dominance of certain prey species in the diet at different times probably reflects their local availability. Lanternfishes (Myctophidae), described as important fur seal prey in other locales, were absent. This is likely to be a function of the distance to the continental shelf edge from Tonga Island. Low numbers of some benthic coastal species were also taken. These may have been taken by pups learning to hunt in the immediate vicinity of the colony.

Guisado *et al.* (2012)

Produced a journal paper investigating marine reserve monitoring methodologies around New Zealand MR's including the Tonga Island MR.

Freeman *et al.* (2012)

Freeman and authors produced a journal paper investigating the recovery patterns of lobsters in New Zealand MR's including Tonga Island MR and adjacent control sites.

Robertson and Stevens (2012)

Provided a comprehensive report relating to estuarine value, threats and management including estuaries at each end, but not including, the Abel Tasman coast. The authors stated "developing an understanding of the distribution and risks to coastal and estuarine habitats is critical to the management of ecological resources. Recently, Tasman District Council (TDC) contracted Wriggle Coastal Management to identify the habitat vulnerability and monitoring priorities for coastal ecological resources in the Tasman region using an adaptation of an existing UNESCO methodology and a risk-based matrix developed for broad scale assessments of beaches, dunes, rocky shores, and estuaries. The approach targets the highest priority section of the coastline as the first step (i.e. the developed sections of the coast from Waimea Estuary to Marahau; Wainui Inlet to Puponga and, at a lesser level of detail, the West Tasman coast from Fossil Point to Kahurangi Point). Its three main components produce the following outputs: coastal habitat maps in GIS format, vulnerability assessments, and a recommended coastal monitoring programme for the management of coastline biological resources in the region.

The authors provided comment on Wainui Inlet located at the northern end of the Abel Tasman coast. They stated: "Wainui Inlet is a moderate-sized (215ha), shallow, well-flushed, seawater-dominated, tidal lagoon type estuary with one tidal opening, one main basin, and a small tidal arm. It has a large sand spit (1,100m long) much of which (750m, ~8ha) is covered in exotic weeds, including marram. Much of the estuary catchment is regenerating native forest (85%), with intensive pastoral use at 9%. The granite catchment is highly erodible and land disturbance has led to excessive fine sediment inputs to the estuary. The authors ranked Wainui Inlet:

Uses and Values

High use. It is valued for its aesthetic appeal, its rich biodiversity, shellfish collection, bathing, whitebaiting, fishing, boating, walking, and scientific appeal. It is the northern entrance to Abel Tasman National Park. Evidence of early Maori occupation is found throughout the area.

Ecological Values

Ecologically, habitat diversity is high and includes unvegetated tidal flats, saltmarsh, and herbfields. However, significant areas of saltmarsh and natural vegetated margin have been lost. In addition, the estuary is excessively muddy (13% is soft mud). The inlet is recognised as a valuable nursery area for marine and freshwater fish, an extensive shellfish resource, and is very important for birdlife.

Issues and Stressors

Excessive muddiness and moderate disease risk (bathing and shellfish) caused primarily by catchment runoff from intensive land use and an erosion prone catchment. Climate change (increased storms) is expected to exacerbate these issues. The estuary is generally safe for bathing, although disease risk indicators are elevated following rainfall, and shellfish consumption is not recommended after rainfall.

Loss of high value saltmarsh habitat caused by historical reclamations and seawalls. To maintain existing habitat in the face of impending sea level rise, inland migration of beds will need to be facilitated.

Changes in biological communities as a result of climate changes to sea pH and temperature (e.g. loss of larger shelled invertebrates).

> Other lesser stressors include; a modified terrestrial margin, increased population pressure and margin encroachment (wildlife disturbance, predator introductions, habitat loss), and invasive species (e.g. Pacific oyster, iceplant)."

4.0 PREVIOUS SUBTIDAL BIOLOGICAL DATA

Most biological data on the subtidal environment of the Tonga Island MR and adjacent coast has been collected as part of or in association with marine reserve monitoring (1993-2013). Data collected for the marine reserve and associated control sites include reef fish, spiny lobster, scallop, horse mussel, key rocky invertebrates, paua and habitat types (Table 1). Some data has been collected annually (e.g. reef fish, lobsters), some data has been collected occasionally (e.g. scallops and horse mussels), and some data has been monitored infrequently (e.g. gastropod densities, shore profiles, BUV) (Table 1).

To date, data collected in relation to the Tonga Island MR have been produced in four monitoring reports (Davidson, 1999, 2001; Davidson and Richards 2007, 2013). A variety of sites were sampled inside and outside the marine reserve (Appendix 1). Results from the 20 year marine reserve monitoring have been summarized in the present report in section 5.6.

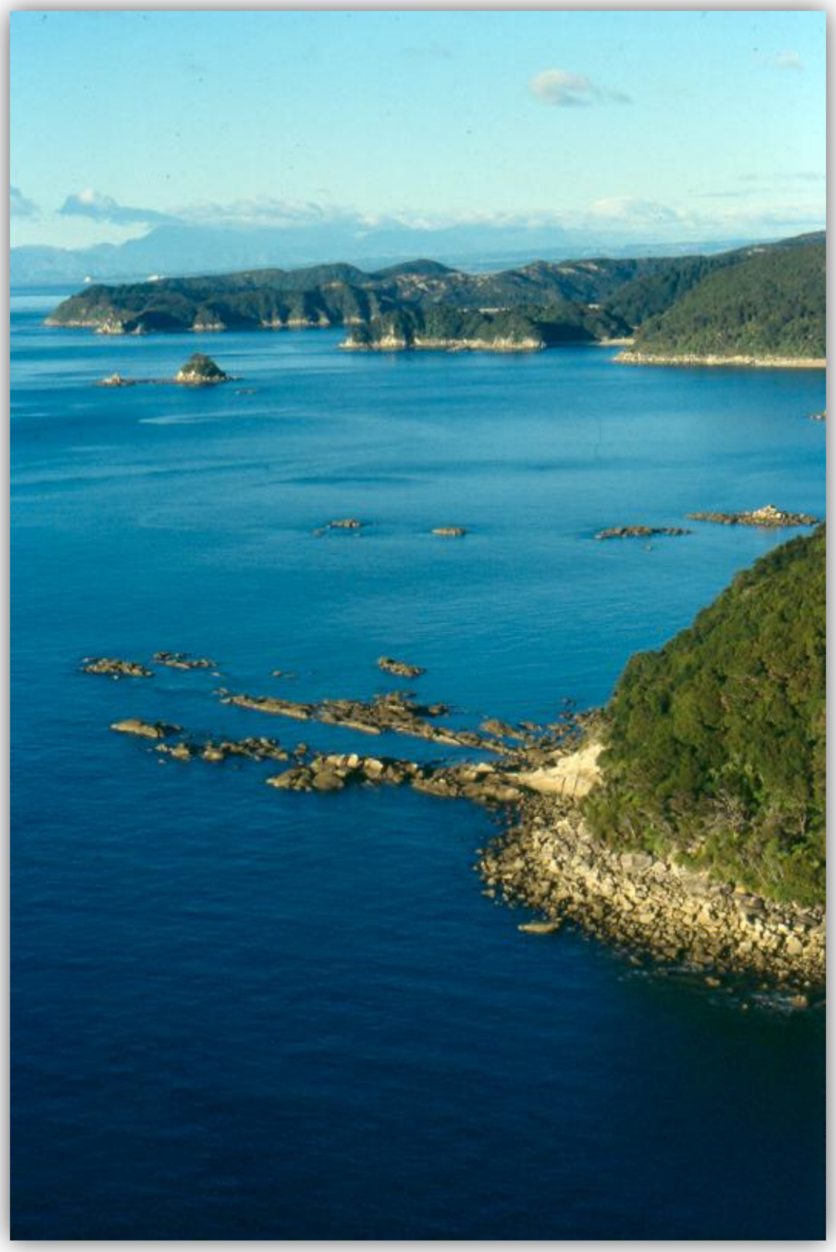


Plate 1. Mosquito Reef (foreground) looking southwards across the marine reserve boundary towards Pinnacle Island, Torrent and Frenchman Bays.

Table 1. Sampling events for Tonga Island Marine Reserve and associated controls (1993 to 2013).

Group	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Reef fish density																					
Reef fish size (selected species)																					
Baited underwater video (BUV)																					
Lobster density																					
Lobster size and sex																					
Benthic quadrat counts																					
Kina density																					
Kina size																					
Cooks turban density																					
Cooks turban size																					
Topshell density																					
Cats eye density																					
Cats eye size																					
Limpet density																					
Scallop size and density																					
Horse mussel density																					
Shore profiles																					
Paua density																					
Paua size																					
Write-up monitoring report																					

4.0 METHODOLOGY IN THE PRESENT STUDY

A variety of scientific methodologies were used to gather data during November 2012. These data included the following aspects.

1. Video sled tows from the Tonga Island MR and areas immediately north, south and offshore of the reserve. Aim: to describe major habitat-sediment types from soft substrata shores and map their distribution.

2. Drop camera images from the Tonga Island MR and areas north, south and offshore of the reserve. Aim: to determine the boundaries of particular habitats, substrata or community types found in sled tows or from historical accounts.

3. Inshore sonar run from Totaranui to Bark Bay. Aim: To detect the interface between soft and hard substrata.

4. Diver contaminant collections. Aim: to collect sediment and biota samples for contaminant analyses.

5. Diver collected photographs of key habitats. Aim: to collect photos of representative or special habitats and communities inside the marine reserve.

6. Diver ground truthing of video and still camera footage. Aim: to check video sled data to ensure accurate identification of habitats-substrata used in maps.

7. Diver collected photographs of subtidal rock surfaces. Develop visual assessment criteria for sediment smothering. Aim: to document and assess fine sediment cover on rocky surfaces at two depths along the coast.

8. Diver collected data on brown macroalgae from reserve and control locations. Aim: describe vertical zonation of large brown macroalgae, species presence/absence and percentage cover.

9. Present relevant historic data collected from the Abel Tasman. Aim: investigate (a) temporal changes to integrity indicators (b) impact of protection on integrity indicators.

4.1 Video sled tows from soft sediment shores

A Tritech Super SeaSpy underwater video camera clamped to a purpose built aluminium sled was towed behind the survey vessel. The camera was connected via a Kevlar cable to a Sony HDV that recorded onto mini DV tapes. The recorder allowed the image to be viewed real time onboard the survey vessel. On occasion, a HDVSeaTek LED light was fitted to the sled frame to illuminate the cameras field of view. Two Z-Bolt green laser pointers were attached to the camera in order to establish a 20 cm wide reference distance in the video footage.

A total of 12 sled tows were collected ranging in length from 760 m to 5 km (Figure 2). Each tow was usually initiated close to shore and most often extended in an offshore direction. A total of around 18 hours of video footage was collected using both the sled and drop camera.

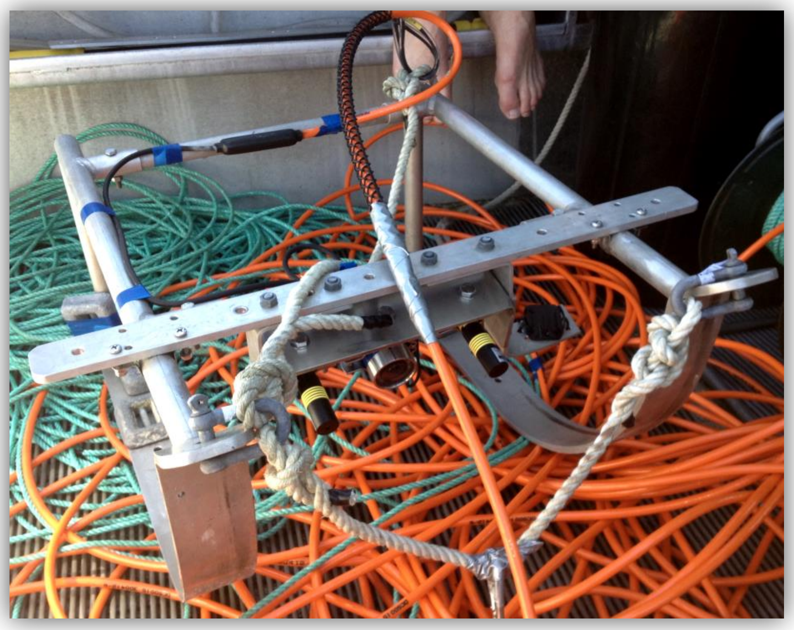


Plate 1. Sled and cable with camera and lasers.

4.2 Drop camera stations

At each drop camera station, a Sea Viewer underwater splash camera fixed to an aluminium frame was lowered to the benthos and an oblique still photograph was collected where the frame landed (Figures 3 and 4). A total of 135 drop camera stations were collected from Abel Head southwards (Figure 3) while a total of 91 images were collected from Abel Head north to Anapai Bay (Figure 4).

The drop camera was linked to a Sony Handycam allowing real time viewing of images on the survey vessel. This enabled the survey team to build up a picture of the habitats, their quality and their geographic spread. The aim of the drop camera data collection was to (1) detect the existence and quality of biological features of particular interest; and (2) determine the geographical boundaries of the biological feature. The location of photograph stations was based on: (a) data collected during sled tows, (b) historical reports or information and (3) the information obtained from viewing drop camera data as it was collected. Additional photographs were taken when any features of particular interest were observed on the remote monitor on-board the survey vessel.

4.3 Sonar

Sonar investigations were conducted using a Lowrance HDS-10 and HDS-8 Gen 2 linked to a Lowrance StructureScan$_{TM}$ Sonar Imaging LSS-1 Module. This unit provides right and left side imaging as well as DownScan Imaging $_{TM}$. The sonar run was conducted along the reef edge from Totaranui south to Falls River. The sonar data was saved onto a SD card and transposed to allow viewing on Google Earth aerial photo images. It should be noted that some distortion of the image occurs when the survey vessel changes course therefore imagery at these locations can appear unclear or distorted. Rocky shore sonar images have not been presented in the present report.

4.4 Diver collected contaminant samples

Sediment was collected from four sites (3 reserve, 1 control) in November 2012 (Figure 5). At each site, three replicate sediment samples were collected from the surface layer. Samples were placed in laboratory supplied containers, stored and sent to Hills Laboratory for testing. Samples were tested for a standard suite of heavy metals (Appendix 2).

Table 2. Dive sites where samples of sediment for contaminant analysis were collected

Site	Treatment	Coordinates	Location
Integrity Dive site 1	Reserve	40 53.70800,173 03.48355	Tonga Quarry
Integrity Dive site 2	Reserve	40 53.07162,173 03.25325	Onatahuti
Integrity Dive site 3	Reserve	40 53.10341,173 03.65537	Reef Point
Integrity Dive site 4	Control	40 55.00140,173 03.32380	Bark Bay

4.5 Diver collected shellfish contaminant samples

Divers collected a variety of shellfish species for contaminant analyses (Table 3). At each site shellfish were collected, labeled and stored for analysis for a suite of contaminants (Appendix 3).

Table 3. Location and code numbers for shellfish contaminant samples.

Species name	Species	Dive site numbers	Sample code (Hills)	Treatment
Horse mussel	*Atrina zelandica*	2a-d	2a, 2b, 2c, 2d	Reserve (Onatahuti Beach)
Horse mussel	*Atrina zelandica*	4a-e	4a, 4b, 4c, 4d	Control (Bark Bay)
Bivalve	Unknown	1	5a, 5b	Reserve (Tonga Quarry)
Bivalve	*Dosinia* sp.	1	8a	Reserve (Tonga Quarry)
Clam	Unknown	3	13a, 13b, 13c, 13b	Reserve (Reef Point)

4.6 Diver collected photographs and diver ground-truthing

At the four dive sites representative photos of inshore soft bottom habitats were collected using an Olympus EP2 camera and housing (Figure 5). On the same dives, a description of the soft bottom habitat present at each site was collected to compare with habitat assessments made from video footage collected from the sled transects and drop camera images (described sections 4.1 and 4.2)

4.7 Sediment on rock

Divers collected photographs of rock surfaces using and Olympus *i*-tough camera in a Seashell housing (Table 4, Figure 6). Photographs of fine sediment on rock surfaces were collected from two depth strata (shallow and depth). Each photograph was taken from flat or gently sloping rock comprised of either bedrock or very large boulders. Photographs were collected in March 2013 during a period with no flood events. A set of assessment criteria were developed to ensure the assessment of fine sediment on rock surfaces could be standardized.

1. **Absent**: no visible sediment on rock surfaces. No water discolouration when disturbed.
2. **Slight:** sediment present but difficult to visually detect. Sediment does no form a distinct layer. Slight water discolouration when disturbed.
3. **Low:** Sediment clearly visible, but does no obscure rock below. If a layer present it is not thick and allows rock surface to be observed. Localised water discolouration when disturbed.
4. **Moderate:** sediment visible to the eye on rock surface. Water discoloured when disturbed. Some areas of rock surface obscured or covered by sediment (< 50%).
5. **High:** sediment layer or coating on rocks clearly visible. Cloud of sediment created when disturbed. Greater than 50% of rock (but not all) covered or obscured by a sediment coating.
6. **Extreme:** 100% of rock surface obscured by sediment coating. Sediment coating forms a blanket over virtually all of rock surface. Only rock, caves and rock under-hangs have lower levels of a sediment coating. Large cloud of sediment produced when disturbed.

Table 4. Diver collected photographs of fine sediment from rock surfaces.

Site name	Treatment	Name	Coordinates
Totaranui (north)	Control	CA1	40.79393768,172.99954482
Ratakura	Control	CA2	40.84046838,173.01550223
Awaroa Beach	Control	CA3	40.85516504,173.04300747
Canoe Bay	Reserve	RA1	40.85230443,173.04641294
Tonga Island	Reserve	RA2	40.88988791,173.06924154
Reef Point	Reserve	RA3	40.88539969,173.05826081
Tonga Arches	Reserve	RA4	40.89888868,173.05499115
Foul Point	Reserve	RA5	40.90392700,173.06221895
Mosquito (north)	Reserve	RA6	40.91158494,173.06563887
Mosquito (south)	Reserve	RA7	40.91269270,173.06288147
Bark Bay Reef	Control	CA4	40.91857527,173.07194945
Frenchman Bay	Control	CA5	40.93474949,173.05983055

4.8 Macroalgae species and vertical distribution

Conspicuous large brown algae species were identified from 5 control sites and 7 reserve sites (Table 5, Figure 7). At each site, divers recorded the vertical spread of brown macroalgae species on rock using their depth gauges. The percentage cover of each species was estimated by the same diver throughout the study. Representative photos at some sites were also collected.

4.9 Marine reserve monitoring data

Selected marine reserve monitoring data was compiled from the Tonga Island MR and associated control sites to investigate temporal changes along this coast since 1993 and to investigate if protection influences integrity indicators. These data were extracted from Davidson and Richards (2013). Sites sampled by Davidson and Richards are summarised in Appendix 1.

Table 5. Location of macroalgae sites from reserve (RA) and control (CA) sites.

Site name	Treatment	Name	Coordinates
Totaranui (north)	Control	CA1	40.79393768,172.99954482
Ratahura	Control	CA2	40.84046838,173.01550223
Awaroa Beach	Control	CA3	40.85516504,173.04300747
Canoe Bay	Reserve	RA1	40.85230443,173.04641294
Tonga Island	Reserve	RA2	40.88988791,173.06924154
Reef Point	Reserve	RA3	40.88539969,173.05826081
Tonga Arches	Reserve	RA4	40.89888868,173.05499115
Foul Point	Reserve	RA5	40.90392700,173.06221895
Mosquito (north)	Reserve	RA6	40.91158494,173.06563887
Mosquito (south)	Reserve	RA7	40.91269270,173.06288147
Bark Bay Reef	Control	CA4	40.91857527,173.07194945
Frenchman Bay	Control	CA5	40.93474949,173.05983055

Plate 2. Finger sponges (*Callyspongia* sp.) and large grey sponge (*Ancorina* sp.) on deep reef (14 m) located at Bark Bay Reef. Note: high level of sediment coating rock surfaces.

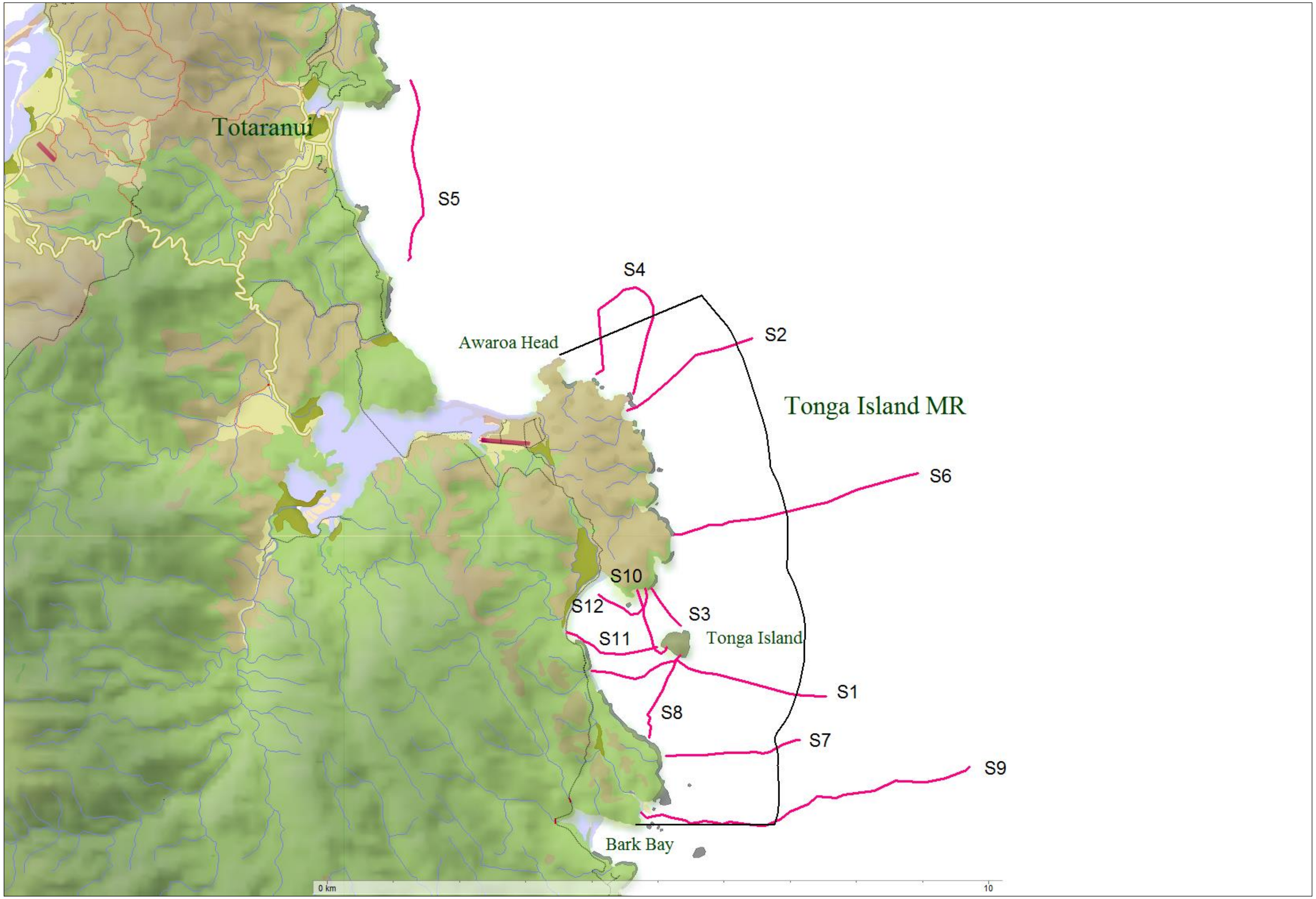


Figure 2. Location of 12 sled tows where video footage was collected in November 2012. Reserve = black line

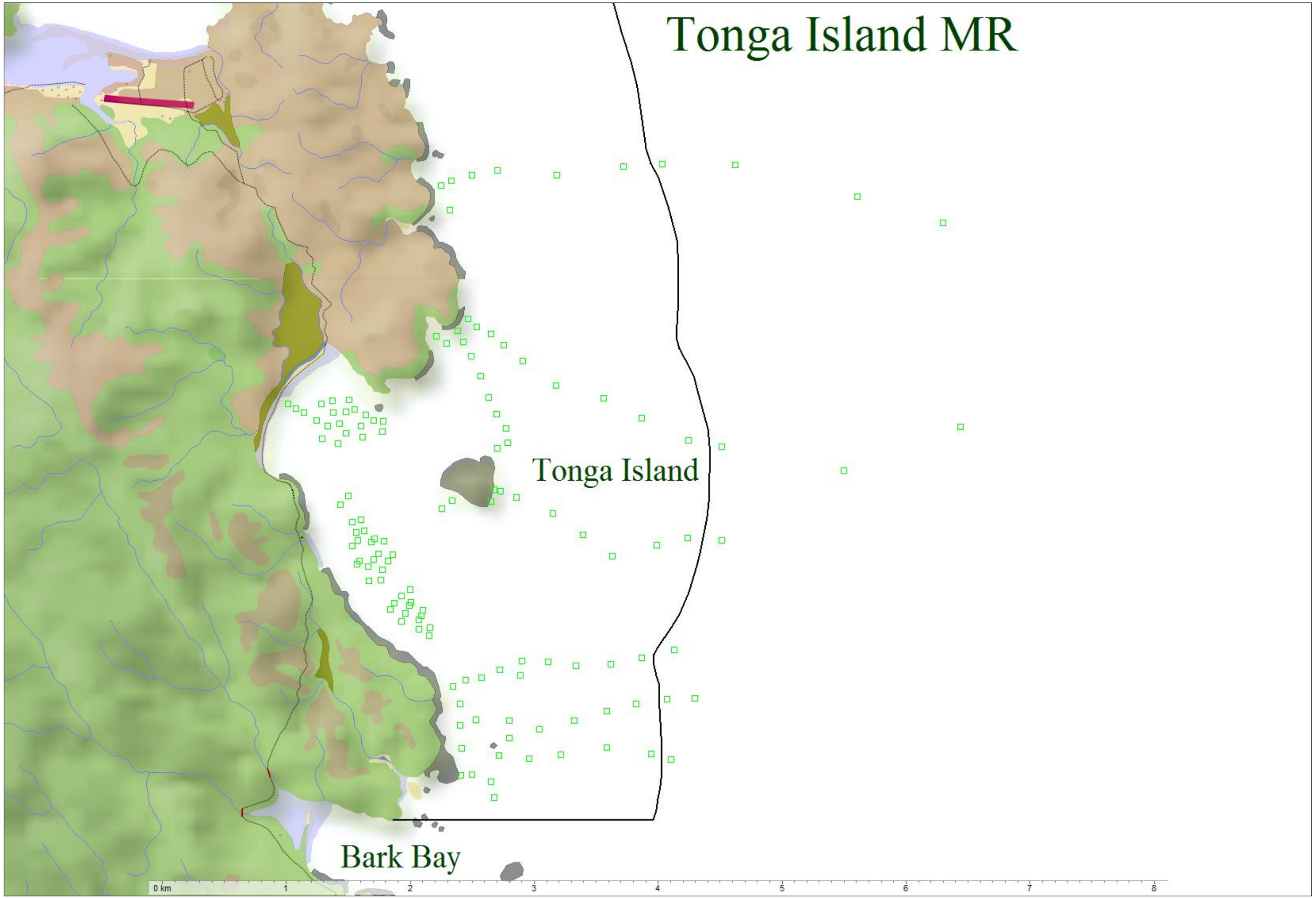


Figure 3. Location of southern drop camera photograph stations (green squares).

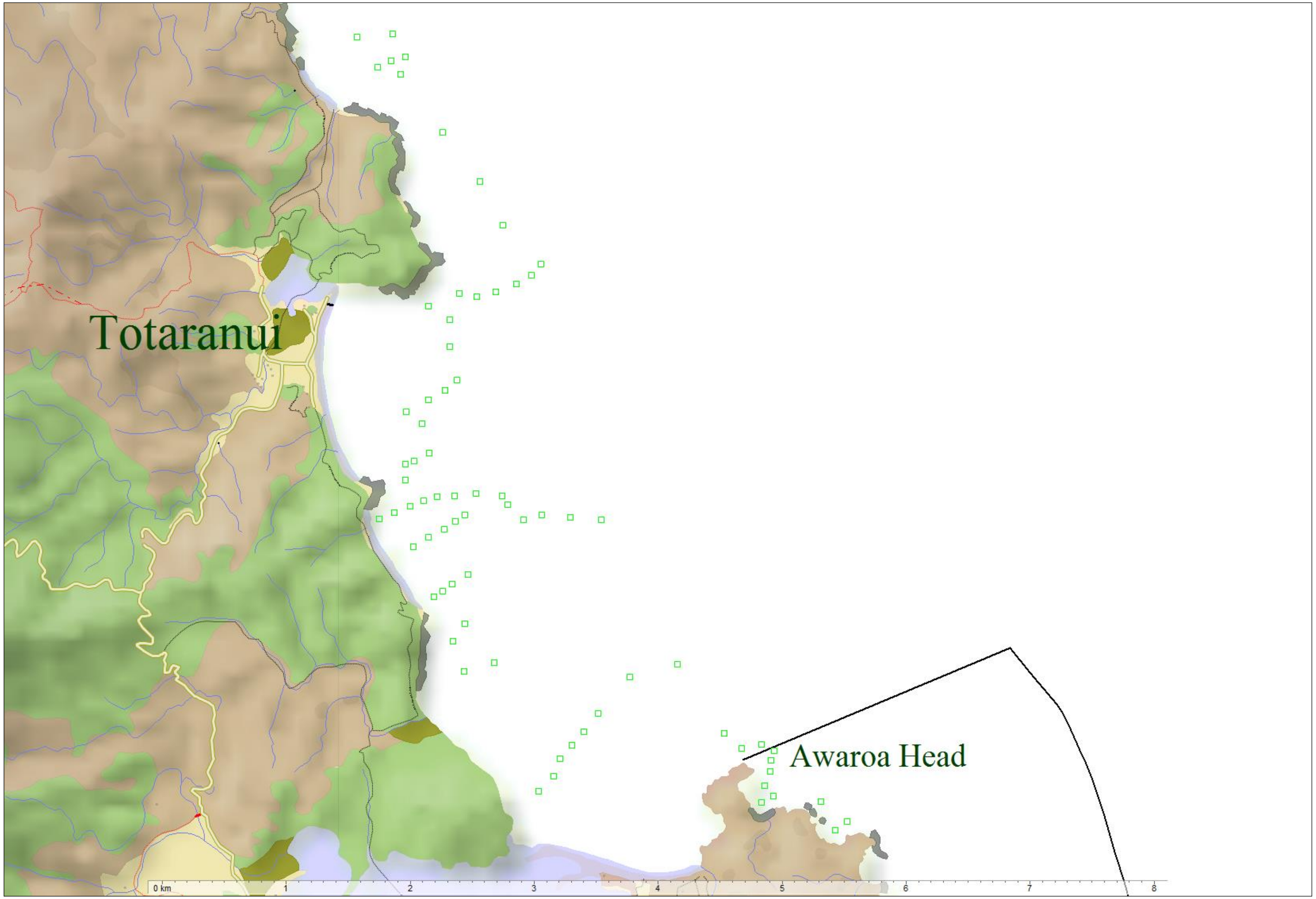


Figure 4. Location of northern drop camera photograph stations (green squares).

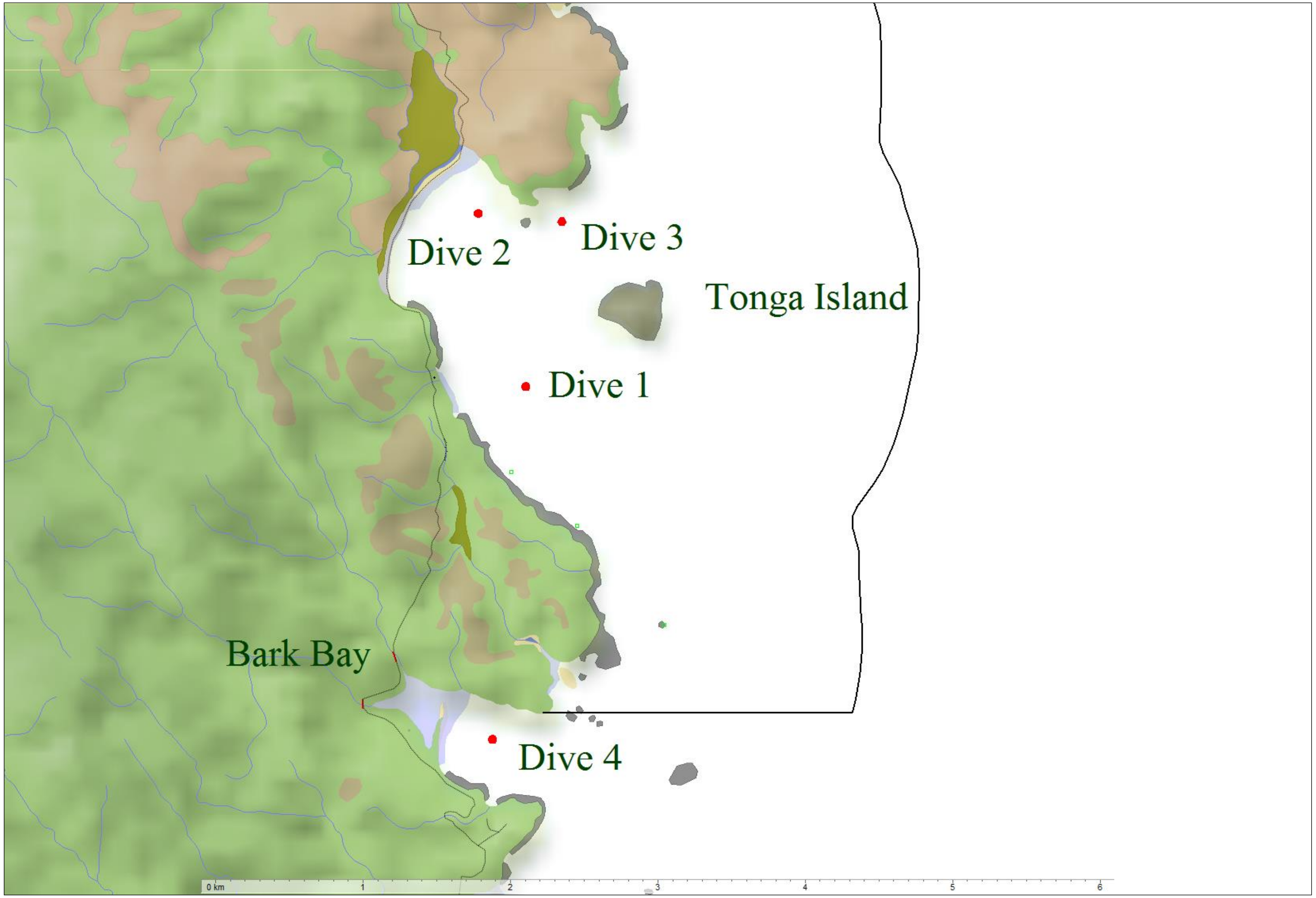


Figure 5. Location of dives where a variety of data were collected (sediment contaminants, biota, photos, ground truthing).

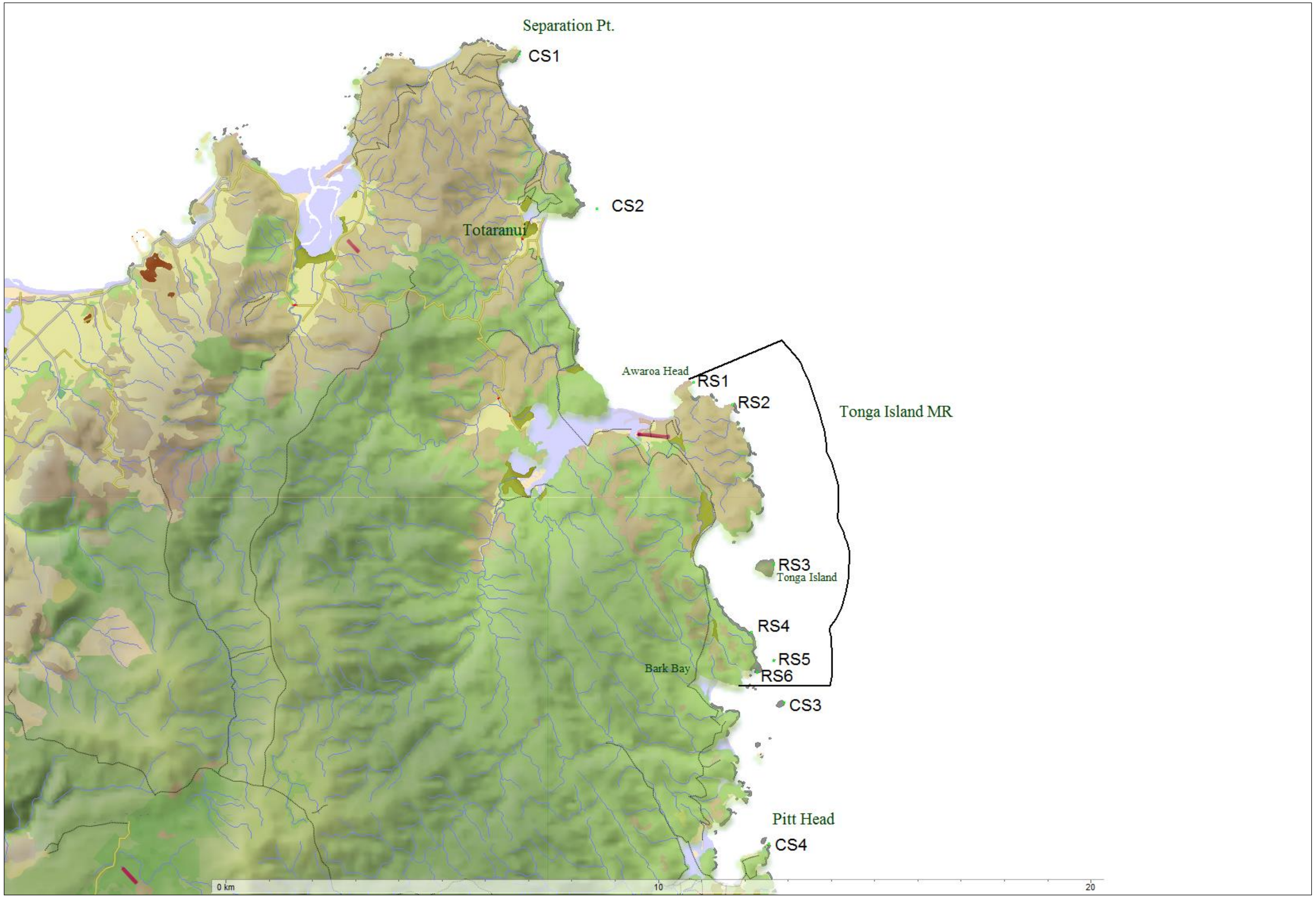


Figure 6. Location of fine sediment photographs on rock at reserve (RS) and control (CS) sites.

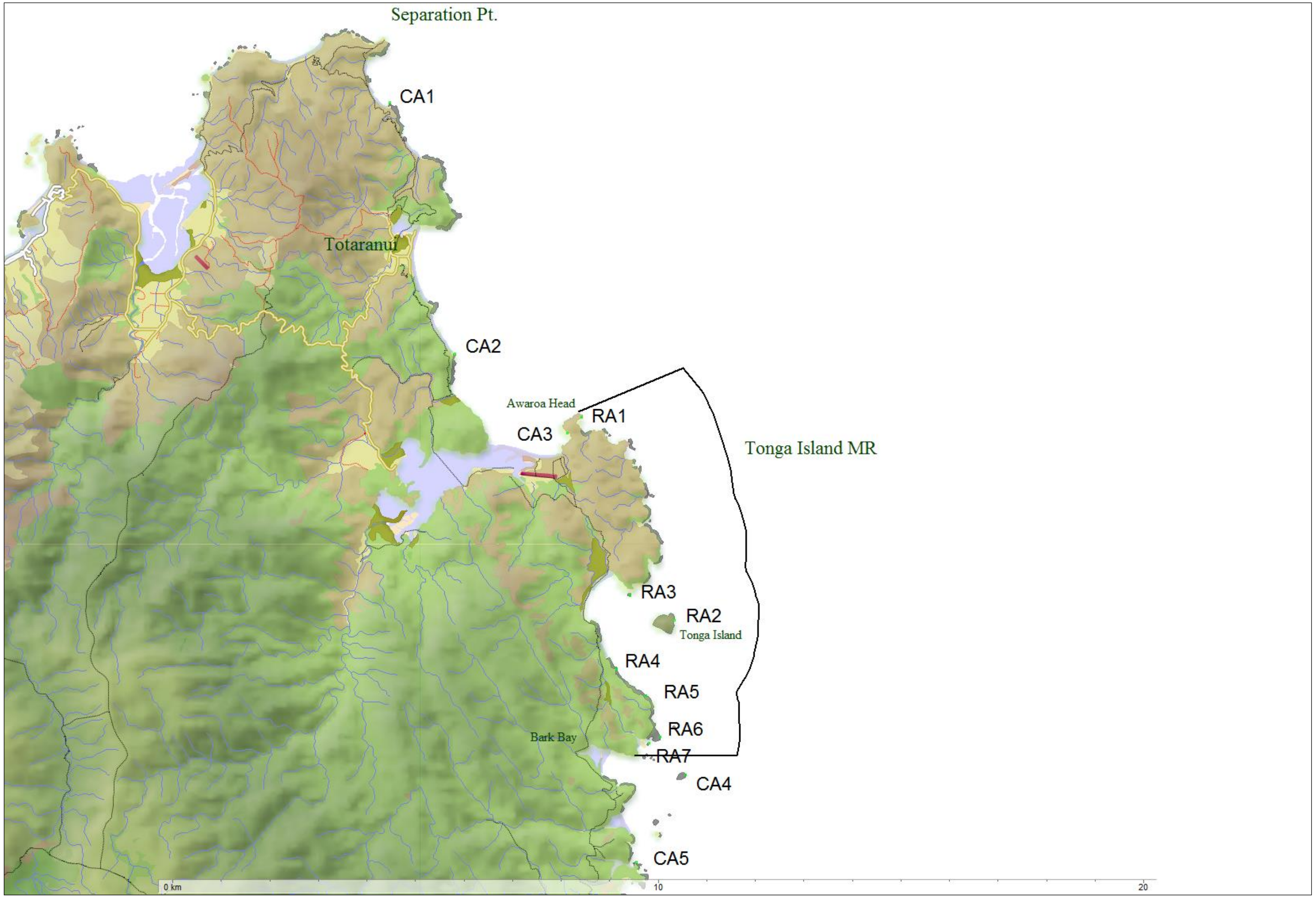


Figure 7. Location of macroalgae sites at reserve (RA) and control (CA) sites.

5.0 RESULTS

5.1 Habitat description and mapping

Mapping of habitats, substratum and biological features were based on sled tows, drop camera photographs, dives and sonar. A summary of sled tows locations and video files are presented Appendix 4. Six major substratum types were recorded for the soft sediment areas of the Abel Tasman coast (Table 5). A description of each substratum follows.

Sand (S)

Sorted sand size particles located in shallow water usually < 2 m depth (Plate 3). Little or no shell was observed with the sorted sand. Sand substratum was always located in areas sheltered from northerly weather, however, some small rippling on the surface was often observed. Relatively few species were observed on the sediment surface. Most common were cushion seastar, hermit crabs and sand dollar.

Plate 3. Sand substratum recorded at Mosquito Bay beach (0.5 m depth).

Rippled sand, shell (Rss)

Rippled sand, shell and granules was located in depths approximately < 15 m in areas exposed to northerly weather. Wave action during storm events has created mega-ripples (Plate 4). This substratum was present around much of the shallow areas of the coast and was most common in areas located along the coast between Foul Point, Whale Rock and Bark Bay. A wide variety of surface dwelling species were observed as well as numerous holes and burrows (Table 5). There were often indications of fish grubbing presumably by blue cod, snapper and rays.

Plate 4. Rippled sand and shell recorded at 8 m depth.

Sand-shell (Ss)

Sand and shell substratum was similar in appearance to rippled sand and shell apart from a lack of mega ripples and a lower granule component (Plate 5). This suggests a lower wave energy environment compared to the rippled sand-shell. Sand-shell substratum extended to depths of up to 10 m but was most common in < 7 m. A comparable surface dwelling fauna was observed to rippled sand and shell with notable differences being drift brown macroalgae, sand dollar and in some places a microalgal mat, present at this more sheltered substratum type.

Plate 5. Sand and shell substratum with blue cod (6 m depth).

Shell hash (Sh)

Shell hash was characterised by a base of silt and clay (mud), but supported a high percentage cover of dead whole and broken shell material (Plate 6). This substratum was recorded at a wide variety of depths from 6 to 19 m. The distribution of this substratum may depend on combinations of wave energy and currents (i.e. it extended to shallow depths in sheltered locations). Shell hash was widespread along most of the Abel Tasman coast and was usually recorded below the areas occupied by sandy substrata (Figure 8). Numerous surface dwelling species were present including very high densities of hermit crabs and spire shells (*Maoricolpus roseus*). A variety of species were also observed growing attached to shell including, hydroids, sponges, red algae and bryozoans. Blue cod and tarakihi were often observed in association with this substratum.

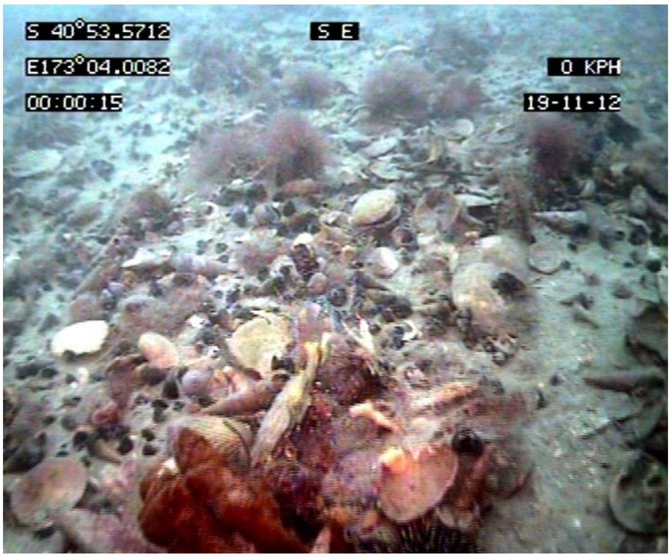


Plate 6. Shell hash substratum recorded near Tonga Island (15 m depth).

Mud-shell (Msh)

Mud and shell was characterised by mud substratum with a strong component of dead whole and broken shell but below the levels of shell typical of shell hash substrata (Plate 7). Shell cover and quantity was highly variable. This substratum was widespread in deeper offshore areas of the coast (Figure 8). Observations suggest that it was patchy in its distribution and the hatched areas on the substratum map are indicative of its distribution. Shell was often coated with silt. A variety of organisms were recorded in association with this substrata including scallop, hydroids, horse mussels, sponges, bryozoan mounds and blue cod.

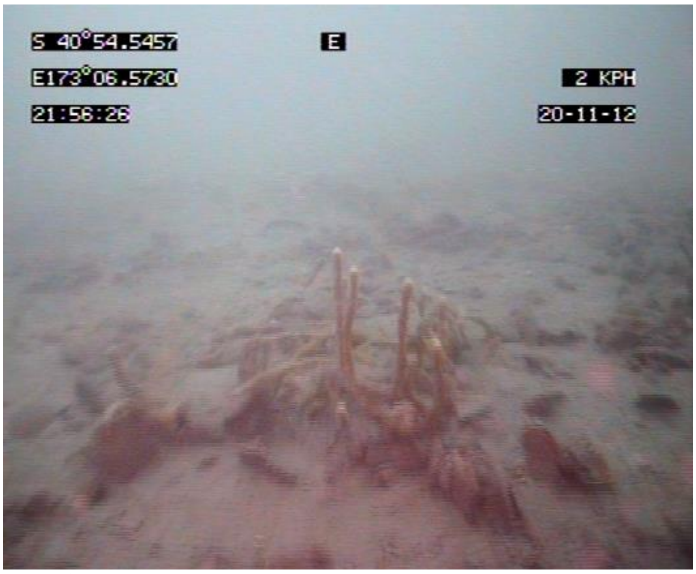


Plate 7. Mud and shell with attached finger sponges recorded from offshore deep areas (28.5 m).

Mud (M)

Mud (silt and clay) was widespread at offshore locations and inshore sheltered sites along the coast (Figure 8). Some shell material was often but not always observed. Shell, when present was always at low levels. Relatively few surface dwelling species were associated with mud. Cushion seastar, parchment worms, flat fish and opal fish were the most often observed species. Holes and animal tracks were regularly recorded from mud substrata (Table 5).

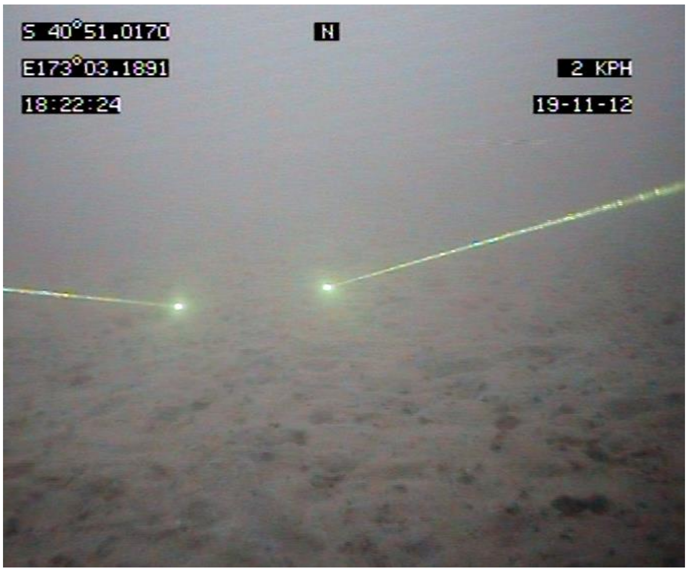


Plate 8. Mud substrata recorded from deep or very sheltered areas (32 m).

Table 5. Summary of major substratum type, their biological and physical variables and major characteristic species.

Name	Sediment	Physical, biological *	Position, aspect	Conspicuous species
Sand (S)	Sorted sand	Small ripples or smooth, burrows, holes	Shallow, wave influenced, sheltered (< 2m)	Cushion seastar, hermit crab, sand dollar
Rippled sand, shell (Rss)	Sand, granules, dead whole and broken shell	Mega rippled, sand, shell	Shallow, exposed, wave influenced (< 15 m)	Cushion sea star, horse mussel, dog cockle, sea cucumber, red algae, hermit crabs, scallop, kina, parchment worms, blue cod
Sand-shell (Ss)	Sand, fine sand, shell (broken, whole)	Burrows, holes, mounds, small ripples or smooth, rhodoliths	Shallow, wave influenced (< 10 m)	Cushion sea star, sand dollar, hermit crab, kina, horse mussel, drift brown algae, microalgae mat, sea cucumber, dog cockle, 11 arm seastar, parchment worms, blue cod, snapper
Shell hash (Sh)	Dead whole & broken shell, mud	Shell abundant on surface, rhodoliths	Moderate depth, below wave influence (6-19 m)	Hermit crab, horse mussel, red algae, ascidians, sea cucumber, kina, dredge oyster, spire shell, scallop, 11 arm seastar, scallop, blue cod, tarakihi, triplefins
Mud-shell (Msh)	Mud, whole/broken shell	Tracks	Deep > 14 m	Scallop, hydroid, horse mussel, sponge, sea cucumber, bryozoans mounds, blue cod, flatfish, opal fish
Mud (M)	Mud, occasional shell	Holes, tracks	Deep >14 m	Cushions seastar, parchment worms, flatfish, opal fish

*** Some or all physical and biological components may be present at each location.**

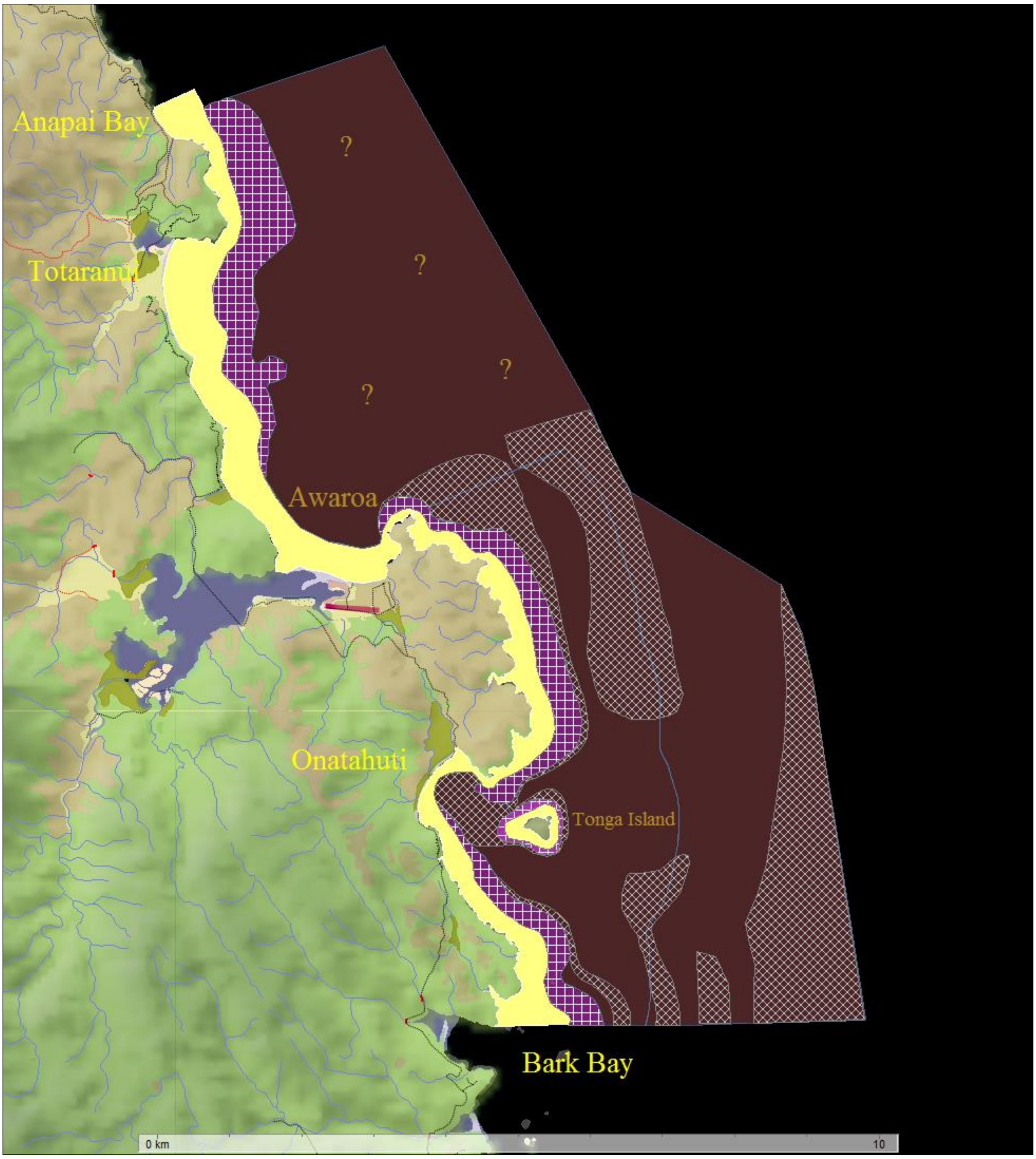


Figure 8. Approximate location of soft sediment substrata along the Abel Tasman coast. The Tonga Island MR is the fine blue line. Yellow = Shallow sand, sand-shell, rippled sand-shell, purple with vertical hatch = shell hash on mud, brown = mud, brown with cross hatch = mud with dead whole and broken shell. Black = unknown, ? = limited survey data available.

5.2 Species, habitats and communities of biological interest

5.2.1 Rhodoliths

During the present study, one new rhodolith bed (20.3 ha) was discovered offshore of Tonga Quarry south-west of Tonga Island (Figure 9). This is the only rhodolith bed known to be located within the boundaries of a marine reserve in New Zealand. The distribution of the bed was mapped using a combination of sled tows, drop camera deployments and dives. Rhodoliths were found between 6.5 m and 14 m depth at this location.

Davidson (1992) noted the existence of a rhodoliths offshore of Totaranui. During the present study this bed was mapped for the first time and the area occupied was found to be approximately 246 ha. Relatively few other identified beds are known from soft sediments in southern New Zealand (Davidson *et al*. 2011, Nelson *et al*. 2012). It is probable that the Totaranui bed is the largest known in the South Island. Part of this bed is protected commercial fishing activities (trawling, dredging and Danish seining) within the Separation Point closed area, however, no restrictions exist for recreational dredging in this area.

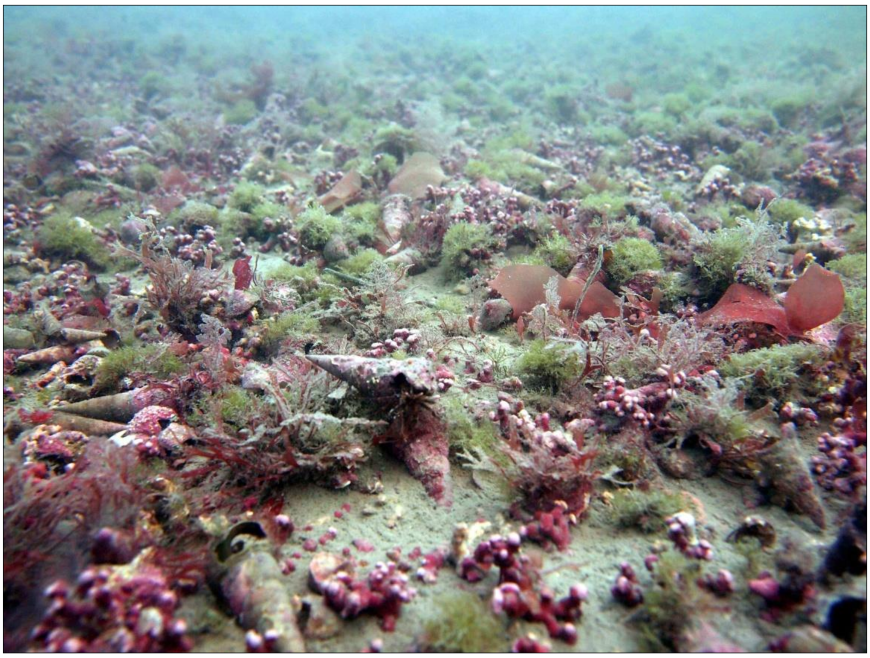


Plate 9. Rhodoliths located at Tonga Quarry site, Tonga Island MR.

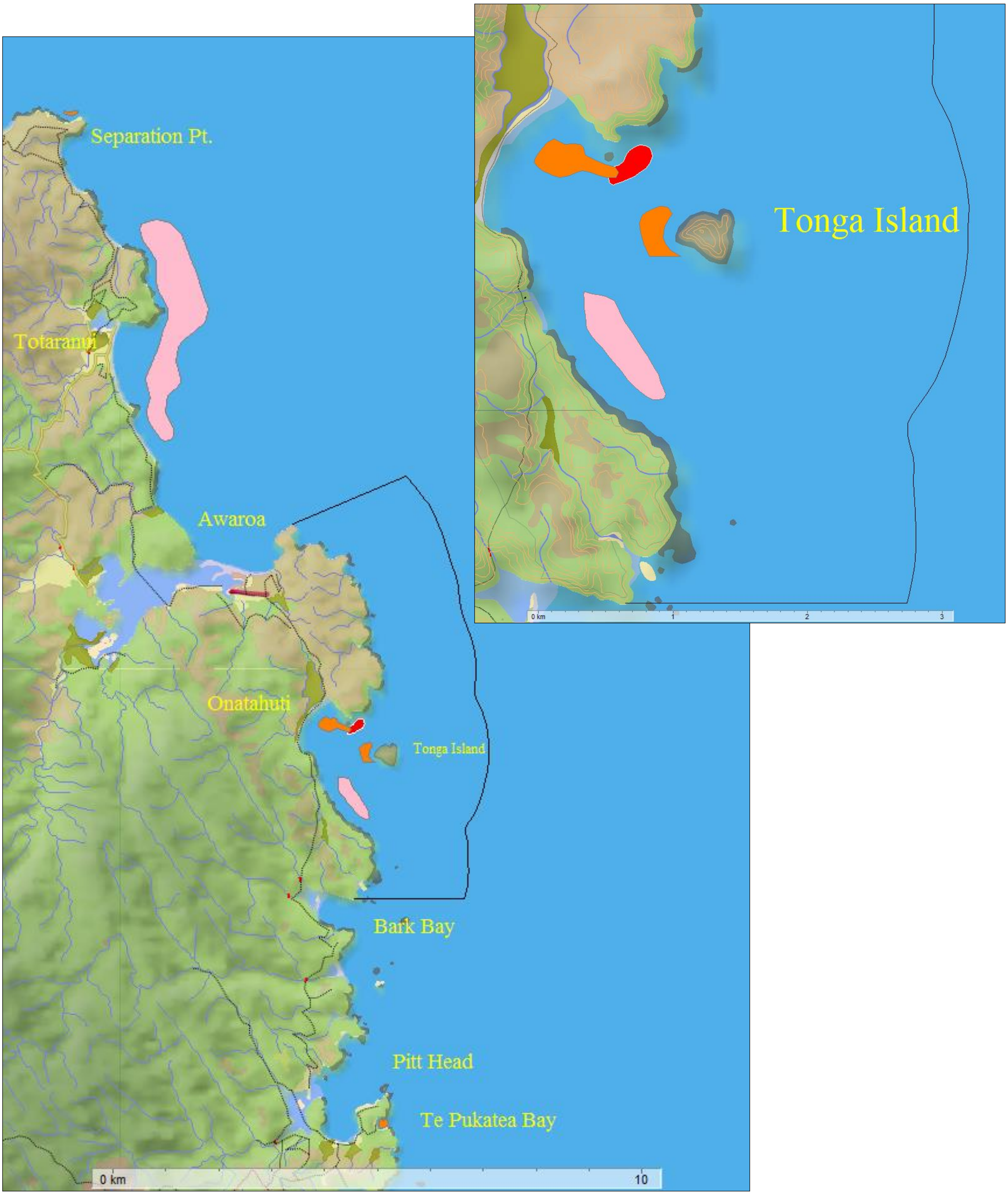


Figure 9. Location of species, habitats or communities of particular biological interest. Light red = rhodolith beds, dark red = red algae beds, orange = horse mussel beds.

5.2.2 Horse mussel beds

Two relatively dense horse mussel beds were identified in the marine reserve west of Tonga Island in the present study (Figure 9). A further two beds have been previously identified in Davidson (1992) from an area north of Separation Point (north) and Te Pukatea Bay (Figure 9). The boundaries of these beds located outside the reserve have not been surveyed, however, Davidson (1992) collected some density data suggesting the bed at Separation Point supported as many as 10 horse mussels per m^2. Davidson and Richards (2013) reported on the live horse mussel density at the Onatahuti Beach was 0.8 individual per m^2, however, the authors stated that as many dead horse mussels were present as live mussels (Plate 10). The authors reported that dead and live horse mussels provided a biogenic habitat for snapper, rays and numerous triplefins. The Onatahuti bed is approximately 10 ha is size and the Tonga Island west site is at least 6.6 ha and may prove larger as areas to the north of Tonga Island of the bed have not been surveyed.

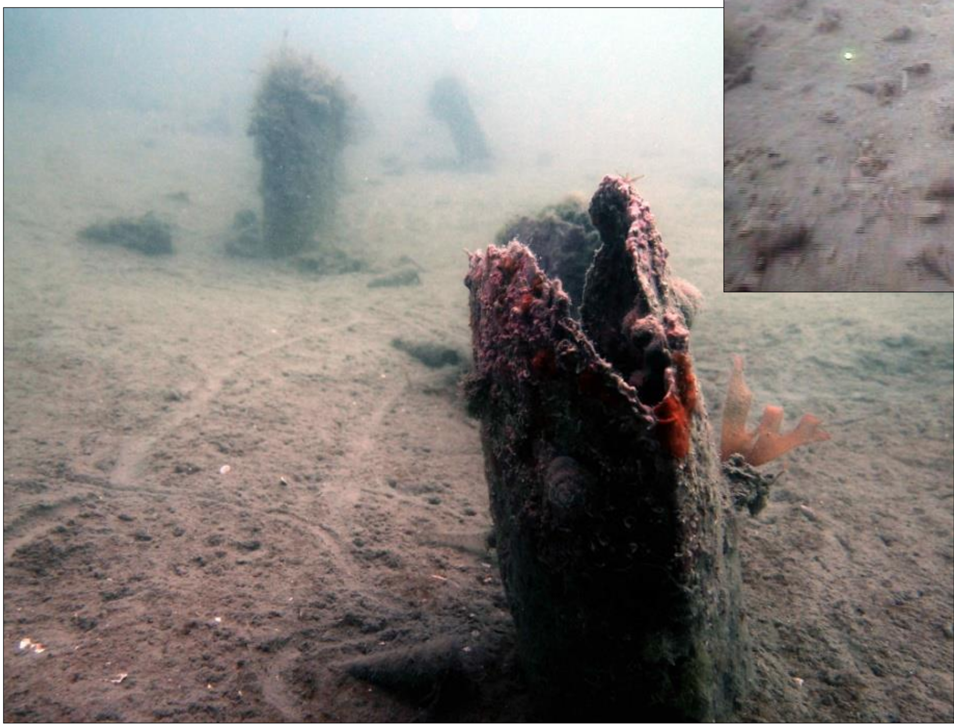


Plate 10. Horse mussel bed located at Onatahuti Beach, Tonga Island MR.

5.2.3 Red algae

One area supporting dense, but low lying red algae was recorded along the Abel Tasman during the present survey (Figure 9). The 5.3 ha area was located north-west of Tonga Island near Reef Point. The red algae were a combination of foliose and filamentous species growing on shell hash substrata (Plate 11). The red algae bed ranged in depth from approximately 10 to 13 m.

Plate 11. Red algae growing on shell hash near Reef Point, Tonga Island MR.

5.2.4 Offshore bryozoans, sponges, hydroid and ascidians

In particular offshore areas surveyed during the present study, clumps of whole dead shell were relatively widespread. These shell debris were recorded inside and offshore of the Tonga Island MR (Figure 8). Intermittently, these shell debris were colonised by bryozoans, hydroids, sponges, ascidians. At no time were these encrusting organisms at densities that would constitute a biogenic habitat, however, they are probably survivors of human activity along this coast. Saxton (1980) provided a historical account documenting the destruction of approximately 160 km^2 of bryozoan “coral” by commercial fishermen towing chains. The extent, composition and location of this bed remains unknown, but it was reportedly located offshore of Torrent Bay and dominated by lace coral.

Bradstock and Gordon (1983) produced a report describing the Separation Point 'corals'. The authors stated these beds were dominated by two species of bryozoan with another 92 species being recorded. This area now recognised within a restricted commercial fishing zone located north and east of Separation Point (Grange *et al*. 2003).

The full extent and location of historical offshore biogenic habitats along the Abel Taman coast is unknown. Further, the degree of damage to these habitats is also unknown as no historic scientific data exists prior to fishing. The present study show extensive areas of offshore dead whole and broken shell. One small piece of lace coral was also observed offshore of the Marine Reserve (Plate 12).

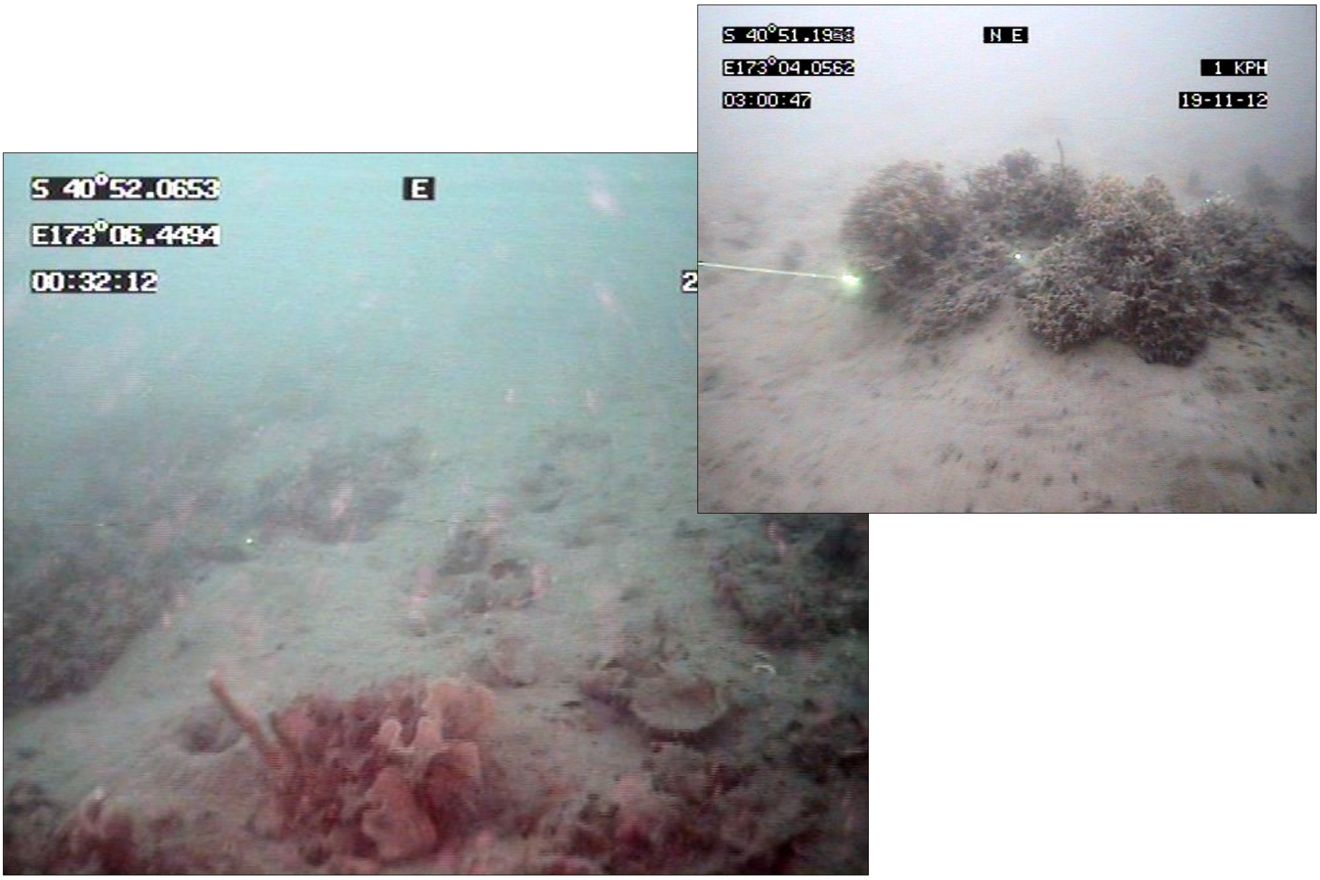


Plate 12. Dead whole shell colonised by encrusting species including a lace coral (foreground bottom left) and bryozoans possibly *Galeopsis porcellanicus* (top right). Photos taken from offshore areas in 28-35 m depth.

5.2.5 Macroalgae forest

Granite with a high percentage cover of large brown seaweed is relatively uncommon along the Abel Tasman coast (Davidson 1992). The largest macroalgae bed is located at Foul Point in the Tonga Island MR (Plate 16) and the other in Anapai Bay north of Totaranui. The Foul Point forest was present prior to reservation (Davidson 1992). In recent years divers have noticed and increase in macroalgae at some sites that have been monitored for 20 years. No data has been collected on this phenomenon, however, this may be correlated to a decline in kina densities in the reserve. In 2013, divers in the reserve recorded the first *Ecklonia radiata* plant on a shore with a shallow subtidal component. Previously all *Ecklonia* plants were restricted to deeper offshore rocks separated from shallow rocky shores (Plate 13).

5.2.6 Anemone bed

Davidson (1992) noted the presence of a dense bed of anemones (*Actinothoe albocincta*) at Snapper Rocks. The author stated this was the highest density of this species in Tasman and Golden Bays.

5.2.7 Limestone community

Davidson (1992) and Davidson and Chadderton (1994) recorded a very different subtidal community on limestone substrata at the northern end of the coast compare to granite shores. Limestone supported considerably more macroalgae and a different assemblage of invertebrates.

5.3 Contaminants and pollution

5.3.1 Sediment contaminants

A variety of metals were analysed from sediment collected at four sites (3 reserve and 1 control) in November 2013 (Table 6, Appendix 2). Apart from nickel, all levels were well below the ANZECC low trigger levels (Table 6). Nickel levels were above the low trigger level standard at all but two of the samples. Naturally high concentrations of heavy metals (Ni, Cr and Cu) enter the sea via the Motueka River. These metals come from the weathering of ultramafic rock in the Red Hills and settle onto the seafloor in the river plume area of Tasman Bay (Robertson *et al*. 2002, Forrest *et al*., 2007; Gillespie *et al*., 2011; Robertson and Stevens 2012). It is probable that the elevated levels of these metals including nickel at most of the samples in the present study is due to this natural phenomenon as the plume originating from the Motueka River extends many tens of kilometers northwards (Forrest *et al*. 2007). Sediment metal levels were comparable to those collected by Forrest *et al*. (2007) from offshore of Tonga Island.

Table 6. Sediment contaminant levels recorded from the Abel Tasman Coast compared to ANZECC/ARMCANZ 2000 guideline standards. Values are all in mg/kg dry weight.

Contaminant	Trigger level low	Trigger level high	Range of values from ATNP	Highest value site
Arsenic	20	70	4 - 7	Bark Bay
Cadmium	1.5	10	<0.1 - 0.12	Reef Point
Chromium	80	370	19 – 48	Tonga Quarry
Copper	65	270	9 - 13	Tonga Quarry
Lead	50	220	10.1 – 13.8	Tonga Quarry
Mercury	0.15	1	< 0.10	NA
Nickel	**21**	52	18 – **46**	Tonga Quarry
Zinc	200	410	51 - 74	Reef Point

5.3.2 Shellfish contaminants

Contaminants in shellfish were analysed from five sites and four species (Table 7, Appendix 3). FSANZ standards have been displayed, however, there are no published guidelines for acceptable concentrations of chromium, copper, nickel or zinc in shellfish tissue. At first glance it appeared that arsenic exceeded NZ Food Safety Guidelines, however once a 10% adjustment was made to convert total arsenic into organic arsenic, values were well below the standard. At two sites cadmium levels in horse mussel flesh and one unidentified bivalve were exceeded. This was unexpected and difficult to explain as cadmium levels in sediments were below ANZECC standards (Table 6). Zinc samples were mostly around 10-30 mg/kg, however, the unidentified bivalve from Tonga Quarry had a value of 50 mg/kg. A similar result was recorded from the same shellfish for nickel with all other values remaining at relatively low levels.

Table 7. Shellfish contaminant levels recorded from Abel Tasman coast compared to New Zealand Food Safety Authority (FSANZ) standards. Values are all in mg/kg dry weight.

Contaminant	**FSANZ max level for**	**Range of values ATNP**	**Highest value site**	**Sites exceeded**	**Species exceeded**
Arsenic	1*1	**1.55-4.6*1**	Onatahuti Beach		
Cadmium	2	0.82 – **7.7**	Tonga Quarry	Tonga Quarry Onatahuti Beach	Unidentified bivalve, horse mussel
Chromium		< 0.10 – 3.3	Bark Bay		
Copper		0.21 – 1.54	Tonga Quarry		
Lead	2	0.015 – 1.13	Bark Bay		
Mercury	0.5	< 0.005 – 0.022	Tonga Quarry		
Nickel		< 0.10 – 5.9	Tonga Quarry		
Zinc		1.43 - 50	Tonga Quarry		

*1 FSANZ level is for total organic arsenic,
*2 Total arsenic
*3 USFDA estimation for organic arsenic = 10% of total arsenic (86 mg/kg level for total arsenic)

5.4 Sedimentation

Photographs taken of rock surfaces at two depths collected at 10 sites located along the length of the Abel Tasman coast show highest levels of sediment build-up at deep sample stations. At these deep sites, high to extreme levels of fine sediment on substratum and the flora and fauna were recorded (Table 8, Appendix 5). Levels of sediment although present were lower at the shallow strata compared to deeper sites. At shallow locations, sediment was present but seldom formed a layer obscuring the rock surface (Appendix 5).

The lower levels of sediment at shallow sites is probably due to wave action and currents relocating fine particles thereby reducing the build-up recorded at depths below approximately 5 m. Sediment was regularly observed coating plants and encrusting animals (Plates 13 and 14).

Plate 13. *Ecklonia radiata* plants located at 5 m depth at Tonga Island. Note fine sediment smothering blade surfaces.

Plate 14. Deep rock surfaces smothered in fine sediment located in 12 m depth at Bark Bay.

Table 8. Sedimentation rankings from 10 rocky sites located along the Abel Tasman coast.

Site name	Treatment	Code	Sedimentation rank Shallow (2-4m)	Sedimentation rank Deep (5-6m)
Separation Point	Control	CS1	3	6
Totaranui Reef	Control	CS2	5	5
Canoe Bay	Reserve	RS1	2	6
Able Head	Reserve	RS2	3	5
Tonga Island	Reserve	RS3	3	5
Foul Point	Reserve	RS4	2	5
Whale Rock	Reserve	RS5	3	6
Mosquito Reef	Reserve	RS6	4	6
Bark Bay Reef	Control	CS3	2	5
Pitt Head	Control	CS4	3	6

The source of fine sediment on rock surfaces is likely to originate to be the Motueka River plume. The sediment on rock surfaces is very fine suggesting it has originated from outside the Park. Most sediment in the Abel Tasman estuaries are characterised by coarse sand and little mud, suggesting fine sediment is not transported into the marine area from the granite dominated bush clad catchments. Gillespie *et al*. (2011) reported that the plume and its associated effects was primarily offshore and northwards of the Motueka River mouth. Based on present data collected from rocky surfaces along the Abel Tasman coast it is likely that the impact zone calculated by these authors can be extended to Separation Point.

5.5 Macroalgae species and vertical distribution

The Abel Tasman supports a relatively low diversity of large macroalgae (Nelson *et al*. 1992). Where present, it often exhibits a relatively small vertical distribution on rock surfaces and varies in percentage cover from 0 to 100 % (Table 9). Dominant species were narrow flapjack (*C. maschalocarpum)* and wide flapjack *(C flexuosum).* Narrow flapjack, when present, was located immediately at and below low water (Plate 15). Wide flapjack was often absent or observed as an occasional plant. At some locations it reached relatively high percentage cover (Plate 16, Table 9). Wide flapjack was present at more sites in the reserve compared to sites outside. Where present, it was at a higher percentage cover in the reserve (Table 9).

Plate 15. *C. maschalocarpum* growing on rock, but restricted to the low water zone, Foul Point.

Plate 16. *C. flexuosum* recorded at depths of 2.5-10 m at 20-90 % cover, Foul Point, Tonga Island MR.

Plate 17. Sole *C flexuosum* adult plant growing on rock wall.

Table 9 Macroalgae sites and depth range with estimated percentage cover for the Abel Tasman.

Site name	Treatment	Code	Species	Depth range (m)	Percentage cover
Totaranui (north)	Control	CA1	*C. maschalocarpum*	0 - 1 m	0 - 25 %
			Cystophora sp.	0 - 1 m	0 - 3 %
Ratakura	Control	CA2	*C. maschalocarpum*	0 - 1.5 m	20 - 100 %
			Cystophora sp.	0 - 1.5 m	0 - 5 %
Awaroa Beach	Control	CA3	*Cystophora* sp.	0 - 0.2 m	0 - 1 %
			Codium adhaerens	0 - 0.2 m	0 - 5 %
Canoe Bay	Reserve	RA1	*C. maschalocarpum*	0 - 0.3 m	90 - 100 %
Tonga Island	Reserve	RA2	*C. maschalocarpum*	0 - 0.5 m	0 - 15 %
			C. flexuosum	3 - 9 m	0 - 40 %
Reef Point	Reserve	RA3	*C. maschalocarpum*	0 - 0.5 m	0 - 5 %
Tonga Arches	Reserve	RA4	*C. maschalocarpum*	0 - 1.8 m	70 - 80 %
			C. flexuosum	0 - 1.8 m	1%
			Cystophora sp.	0 - 1.8 m	2 - 3 %
Foul Point	Reserve	RA5	*C. maschalocarpum*	0 - 1.8 m	60 - 80%
			C. flexuosum	2.5 - 10 m	20 - 90 %
Mosquito (north)	Reserve	RA6	*C. maschalocarpum*	0 - 0.3 m	90 - 100 %
Mosquito (south)	Reserve	RA7	None		
Bark Bay Reef	Control	CA4	*C. maschalocarpum*	0 - 0.5 m	50 - 100%
			C. flexuosum	3 - 9 m	0 - 5 %
Frenchman Bay	Control	CA5	*C. maschalocarpum*	0 - 0.3 m	0 - 30 %

5.6 Marine reserve monitoring

The following section provides a summary of data collected from 1992 to 2013 as part of the marine reserve monitoring programme (Davidson and Richards 2013).

5.6.1 Reef fish

Spotty was always the most abundant reef fish and their abundance increased from 1992 to 2013 at both treatments. Tarakihi abundance varied dramatically between years, but was most often the next most abundant species after spotty. Goatfish, blue cod, butterfly perch, scarlet wrasse were relatively common, but were usually below densities recorded for spotty and tarakihi. Banded wrasse, blue moki, marblefish, leatherjacket, marblefish, sweep, red moki, were often observed, but were seldom common at sites. Butterfish, sea perch and magpie moki were sporadically seen as individuals at some sites (Figure 10).

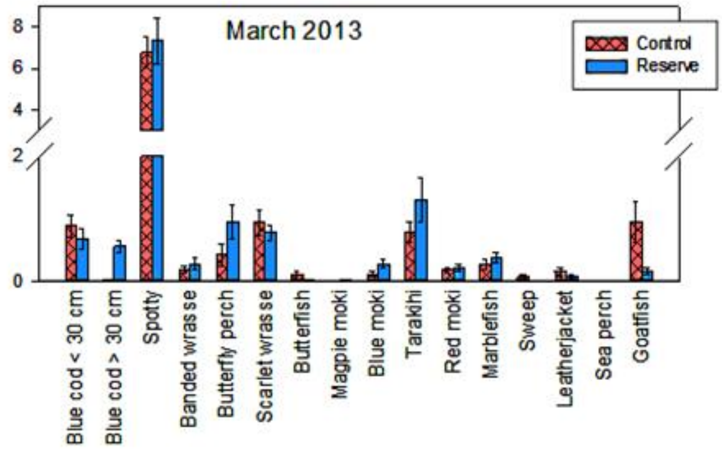


Figure 10. Mean densities of all reef fish sampled in selected years from pooled reserve (blue) and control sites (red). Error bars are +/- 1 s.e.

Blue cod (*Parapercis colias*) were recorded from reserve and control groups on all sample occasions from 1992 to 2013. A significant difference in the mean density of reserve versus control sublegal blue cod (< 300 mm total length) occurred only in February 2007 (Figure 11). The mean density of sublegal blue cod for the pooled control treatment generally mirrored the density in the reserve over the 20 year sample period with major peaks in February 2005, March 2011 and March 2013. The density of small blue cod from the pooled reserve treatment peaked in the same years as small control cod. Despite relatively large year to year variations, the overall reserve and control small cod abundance generally increased over the duration of the study.

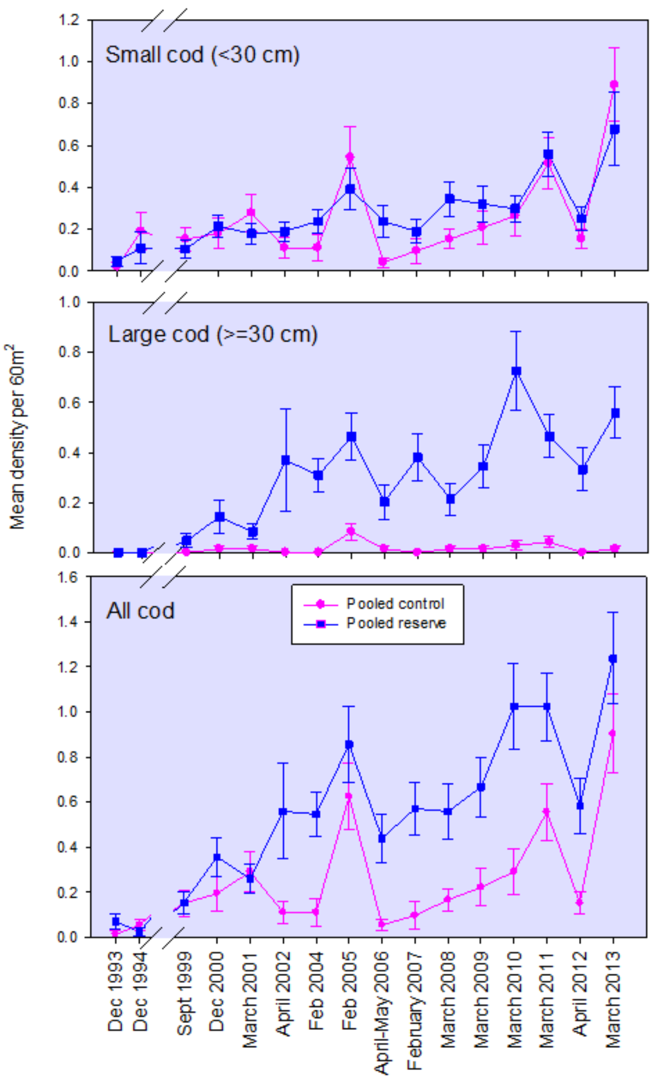
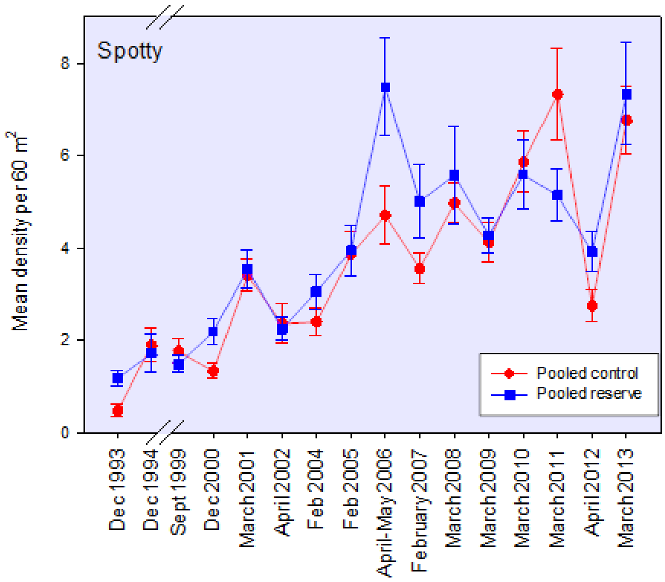


Figure 11. Pooled mean density of small, large and all blue cod from each reserve and control treatment sampled from 1993 to 2013. Error bars are +/- 1s.e.

Large blue cod were often absent from the control treatment. No large blue cod were recorded from the reserve treatment in the first two sample years, however after 2002 they were significantly more abundant at reserve sites compared to the control sites. At the end of the study large blue cod were 40 times more abundant in the reserve compared to the control treatment.

Spotty were recorded from both treatments in all years, however, little difference between the pooled reserve and control treatments was recorded in each sample year. Spotty density varied between years over with at least four abundance peaks. At the end of the study, spotty in both reserve and control treatments were 14 times more abundant than at the start of the study. No obvious pattern of abundance in relation to reservation was apparent.

Tarakihi (*Nemadactylus macropterus*) were recorded from both treatments in all years and their abundance varied considerably between years. In some years tarakihi were rare to absent from some individual reserve and control sites. Tarakihi abundance at both pooled reserve and control treatments followed similar trends over the duration of the study. No obvious pattern of abundance in relation to reservation was apparent.



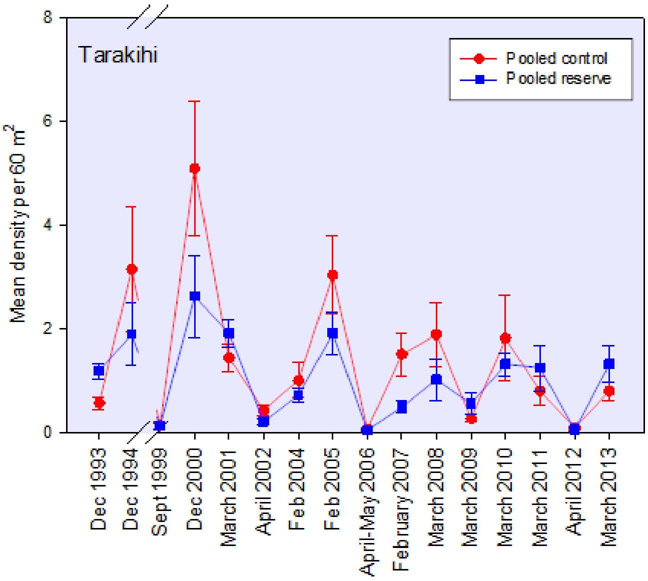


Figure 12. Pooled mean density of spotty and tarakihi from all control and reserve sites sampled from 1993 to 2007. Error bars are +/- 1s.e.

In all but one sample occasion (December 1994), the abundance of blue moki (*Latridopsis ciliaris*) was higher for the pooled reserve treatment, compared to the control treatment (Figure 13). In some, but not all years, blue moki abundance was significantly higher for the pooled reserve treatment compared to the control treatment. Blue moki density from both treatments showed fluctuations but neither treatment showed a consistent pattern of increase or decrease over the duration of the study (Figure 13).

Red moki (*Cheilodactylus spectabilis*) abundance also fluctuated over the duration of the study (Figure 13). For most years, reserve and control treatments supported comparable densities of red moki. An exception occurred in March 2008 to 2010 when control red moki abundance declined to low levels at the control treatment, while reserve red moki remained a higher levels (Figure 13). At the end of the study red moki abundance at both treatments was at an all time high.

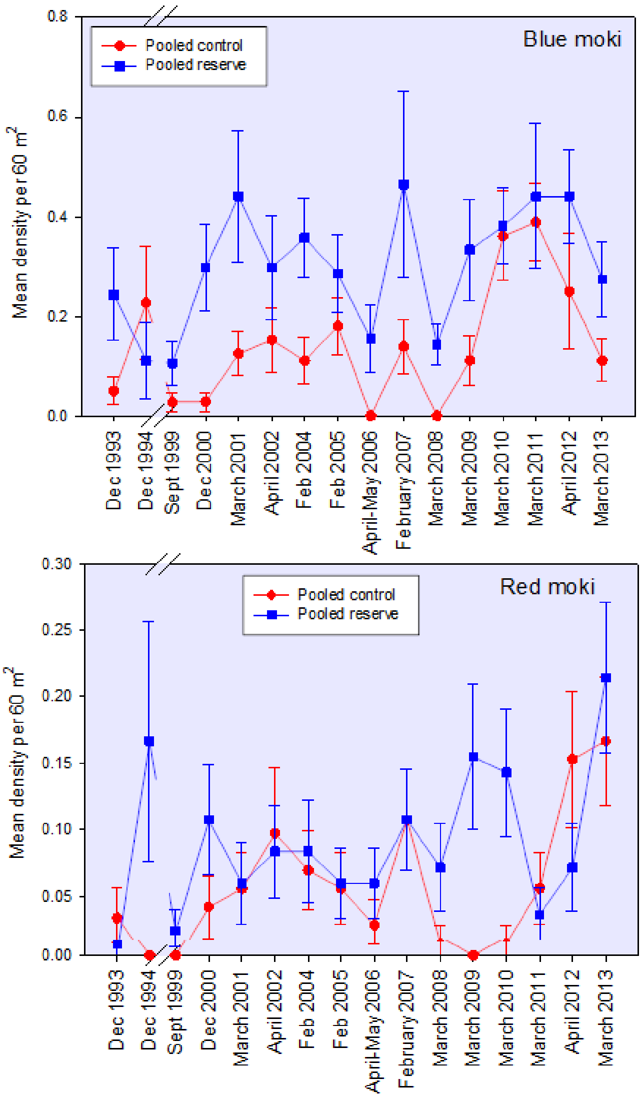


Figure 13. Pooled mean density of blue moki and red moki from all control and reserve sites sampled from 1993 to 2013. Error bars are +/- 1s.e.

Blue cod size was estimated by divers during underwater visual fish counts annually from 2000 TO 2013 (Figure 14). Blue cod mean size at pooled reserve sites remained relatively constant over the 13 year period with an average size ranging from an average of 26.9 cm to 31.4 cm. The mean size of blue cod from the pooled control treatment remained lower than at the reserve (Figure 14).

Reserve blue cod size exhibited a greater size range than at control sites (Figure 15). Large individuals > 34 cm were seldom seen at control sites, with only occasional individuals over 40 cm being recorded. In contrast, much of the cod population at reserve sites was legal size and above. At the end of the study, only 5% of control cod were 30 cm length and over, compared to 48% at the reserve treatment.

The average size of blue moki for reserve and control treatments fluctuated over sample period (Figure 14). The average size of control blue moki was always lower. Increases and decreases in the mean size of blue moki over the duration of the study appeared to follow similar trends at each treatment with highs and lows occurring in the same years suggesting reservation has a limited effect.

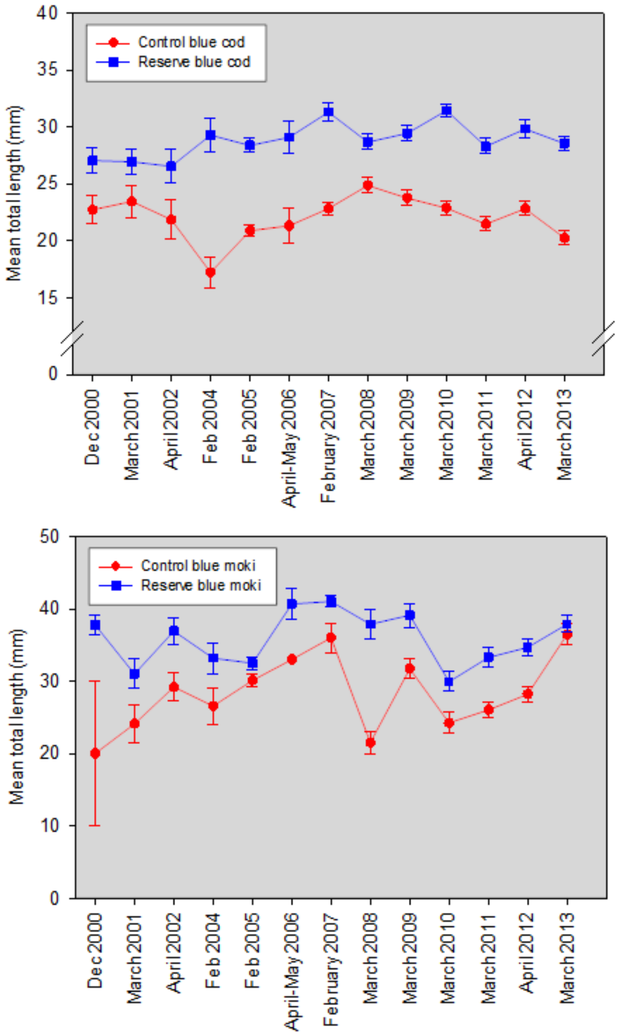


Figure 14. Pooled mean size of blue cod and blue moki from control and reserve sites sampled from 2000 to 2013. Error bars are +/- 1s.e.

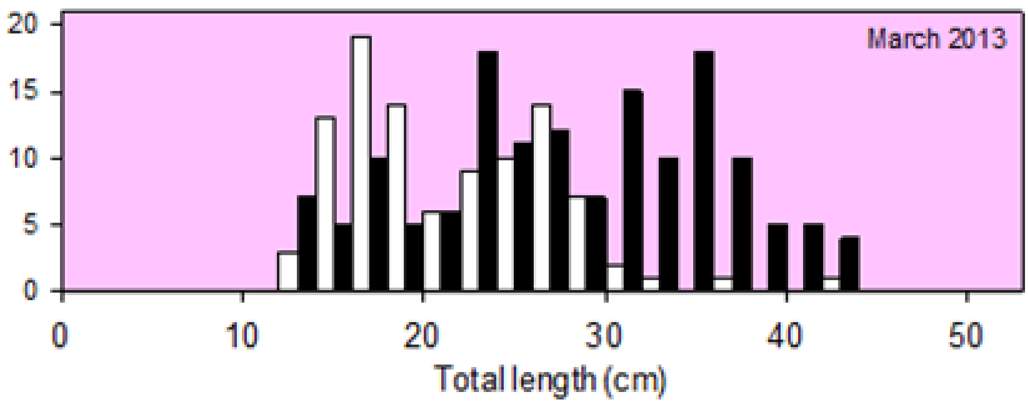


Figure 15. Pooled size frequency of blue cod from pooled control and reserve sites in 2013.

5.6.2 Spiny lobster density, sex and size

Reserve lobster density increased over the 20 year study at both shallow and deep strata (Figure 16). Control lobster abundance in the shallow strata initially increased, peaking in February 2008 and then declining in subsequent years. Control lobsters in the deep strata also initially increased in abundance that was followed by a decline. The peak for deep strata was larger and five years earlier than shallow strata (December 2002).

Deep and shallow reserve lobsters fluctuated in abundance over the study. In the latter half of the study they were dramatically more abundant in the reserve compared to control sites as well as reserve densities recorded at the start of the study (Figure 16). At the end of the study, shallow lobsters were 8 times more abundant in the reserve compared to the control treatment, and 6.8 times more abundant at the deep strata compared to the associated control sites.

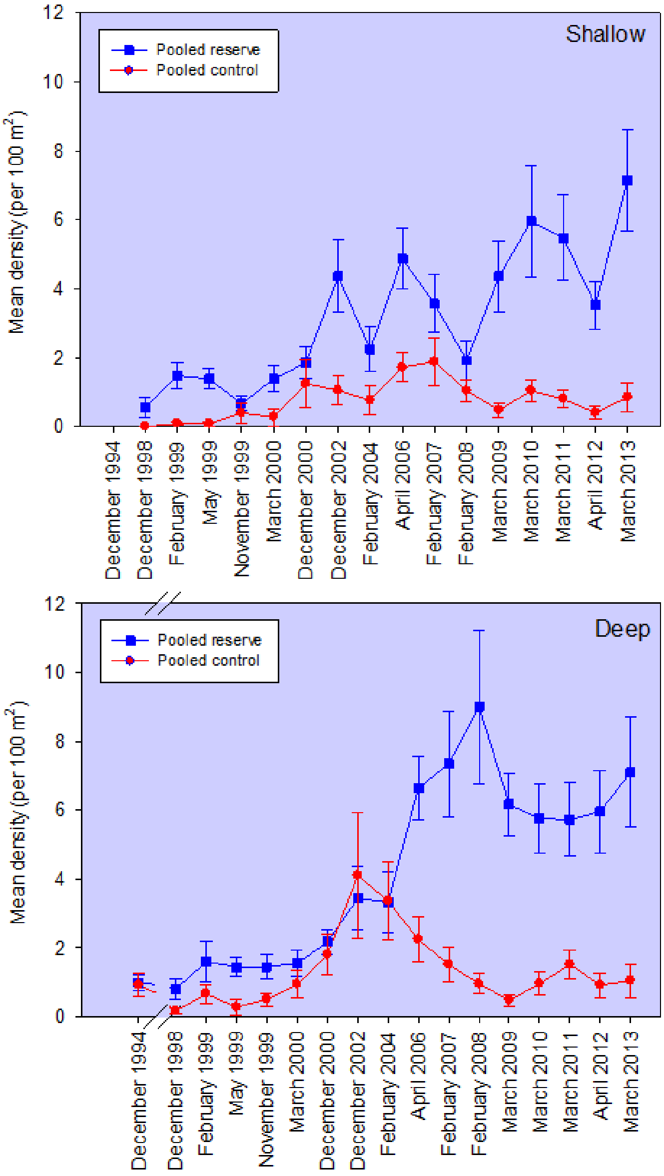


Figure 16. Pooled mean density of lobsters from pooled control and reserve treatments sampled from 1994 to 2013 from deep and shallow strata. Error bars are +/- 1s.e.

Numbers of juvenile lobsters followed comparable patterns at both treatments (Figure 17) (approximately 500 m^2 searched area per treatment). Peaks occurred suggesting irregular recruitment in December 2000 and 2002 and to a lesser extent February 2007. Juvenile lobsters from the 2000-2002 peak grew through to the larger size classes observed as mature females from 2006 onwards.

The juvenile peak in numbers also lead to a dramatic increase in the number of non-reproductive males recorded in April 2006. These males grew through into the reproductive size class in the reserve from February 2007 onwards. A small increase in the number of non-reproductive males and reproductive females outside the reserve was also recorded following this juvenile peak, but this small increase at control sites was short lived and few males grew through to reproductive size.

Post April 2006, the numbers of mature females and reproductive males increased dramatically in the reserve compared to early years in the reserve and the control treatment. At the end of the study these large animals were strong component in the reserve but not at control sites (Figure 18).

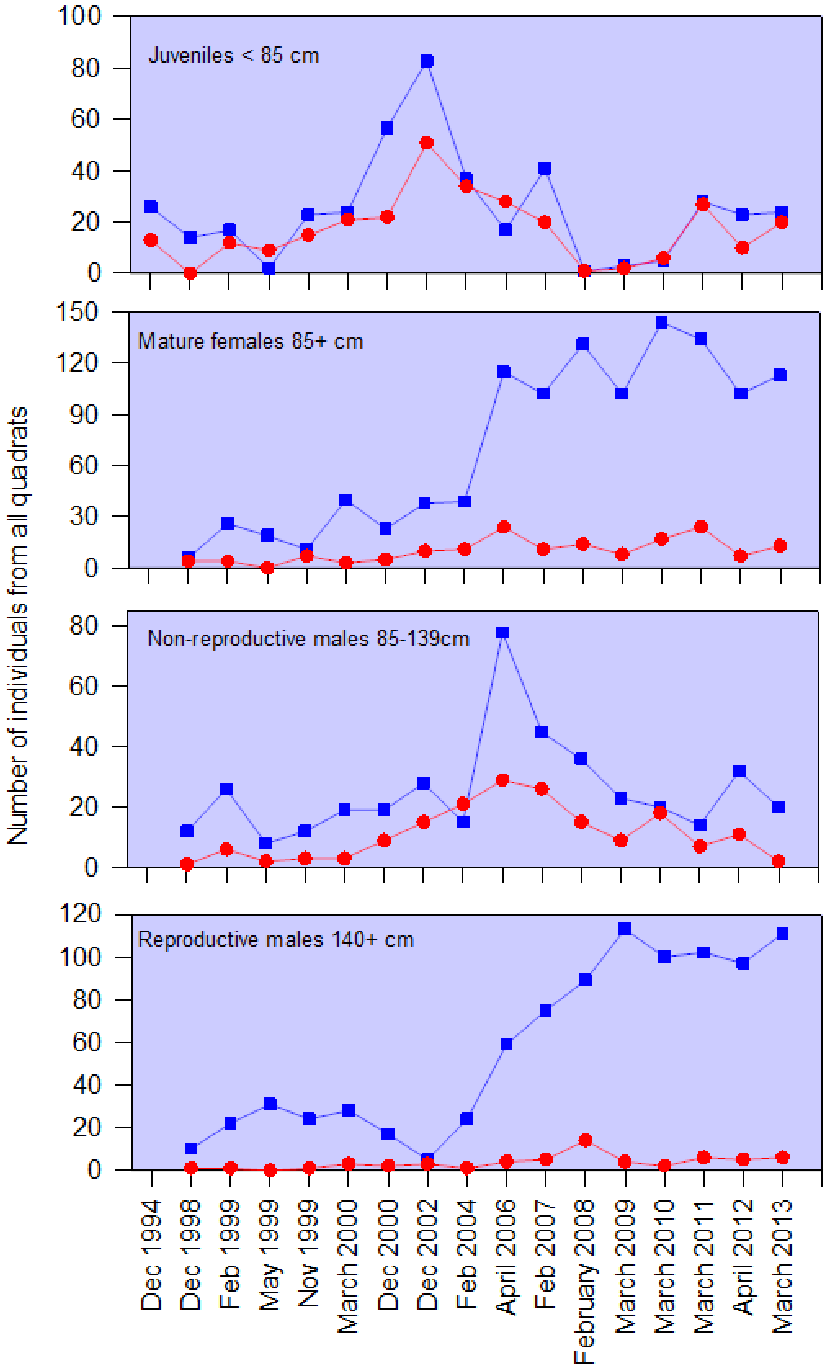


Figure 17. Number of spiny lobster individuals that could be sexed from all control (red) and reserve (blue) quadrats sampled from 1994 to 2013. Lobsters have been divided into reproductive classes according to MacDiarmid (1989). Sizes are estimated carapace length (mm). Counts of extra lobsters from outside quadrats have been excluded.

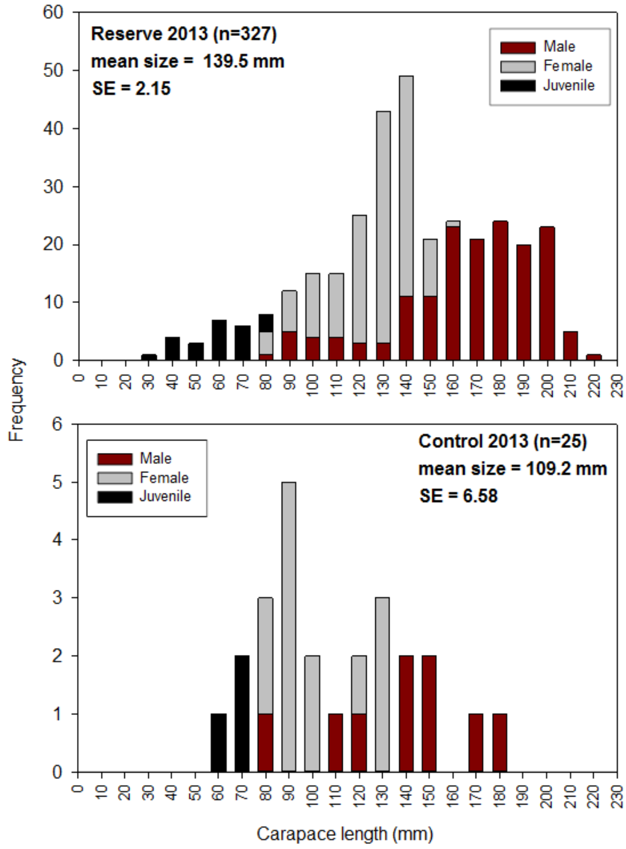


Figure 18. Size-frequency distributions of spiny lobster pooled across reserve and control treatments from March 2013. Sizes are estimated carapace length (mm).

5.6.3 Kina density

Kina density declined at the pooled reserve treatment over the three sample occasions (Figure 19). In contrast, kina density for the control treatment increased from 1993 levels up to levels recorded for the reserve in 1993 (Figure 19). The decline in kina density at the reserve site was not large (i.e. 1.57 to 1.18 individuals per m^2), but this was in direct contrast to the increase recorded at the control treatment (0.75 to 1.4 individuals per m^2). This is likely to be due to increased predation from lobsters and fish.

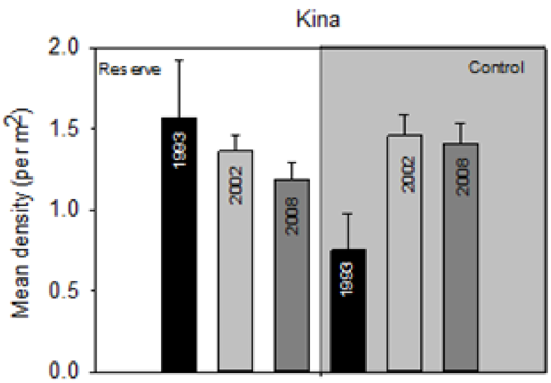


Figure 19. Mean density of kina from pooled reserve and control sites sampled on three occasions between 1993 and 2013. Error bars are +/- 1 s.e.

5.6.4 Scallop density

Mean density of scallops in both reserve and control sites were comparable in the first two sample occasions (1994, 1999) (Figure 20). By 2003 and again in 2006, scallop density in the reserve increased dramatically relative to control treatment where it slowly increased over the same period. In 2008, the density of scallops declined down to control levels. In 2010 reserve scallop density dropped further. By 2013 reserve scallop declined to near zero. In contrast, scallop density at the two control sites remained relatively stable over the same period.

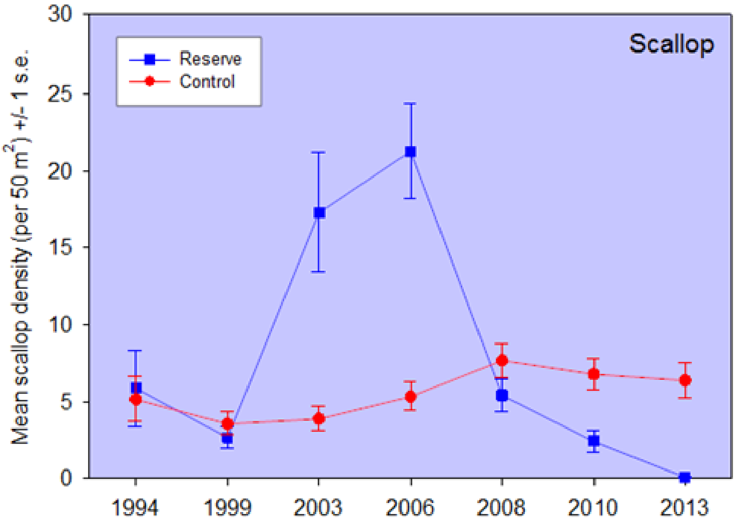


Figure 20. Mean scallop density from pooled reserve and control sites 1994 to 2013. Error bars are +/- 1s.e.

5.6.5 Black foot paua

Black foot paua were sampled from reserve and control sites for the first time in 2013. Only two of the four control sites and two of the five reserve sites supported paua. Of the four sites with paua, the control site located at Ratakura Point north of the marine reserve supported the highest densities (Figure 21). The other control and the two reserve sites supported lower but comparable densities of paua.

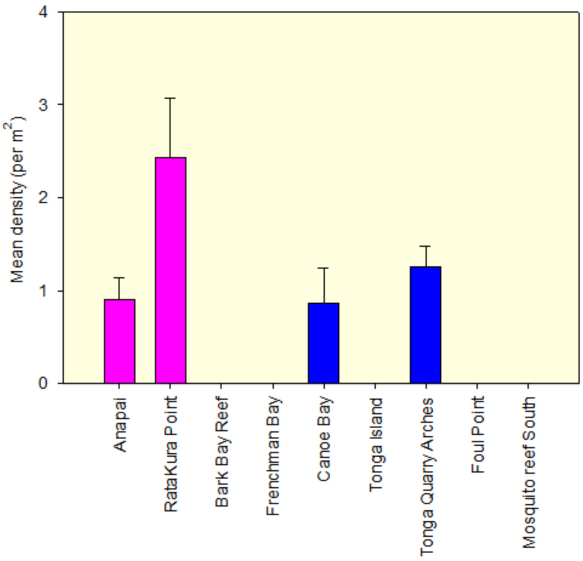


Figure 21. Mean density of black foot paua from reserve (blue) and control (pink) sites collected in 2013.

Largest paua and the largest mean size of paua were recorded from the pooled reserve treatment (Figure 22). At Tonga Quarry arches one legal size paua was recorded (i.e. 125 mm length). This is the largest paua recorded in the study and considerably larger than any paua along the Abel Tasman coast and at Horoirangi Marine Reserve, North Nelson (Davidson *et al*., 2013). At this site 19 paua were larger than the largest paua recorded at the other sites sampled in the present study (i.e. > 112 mm length).

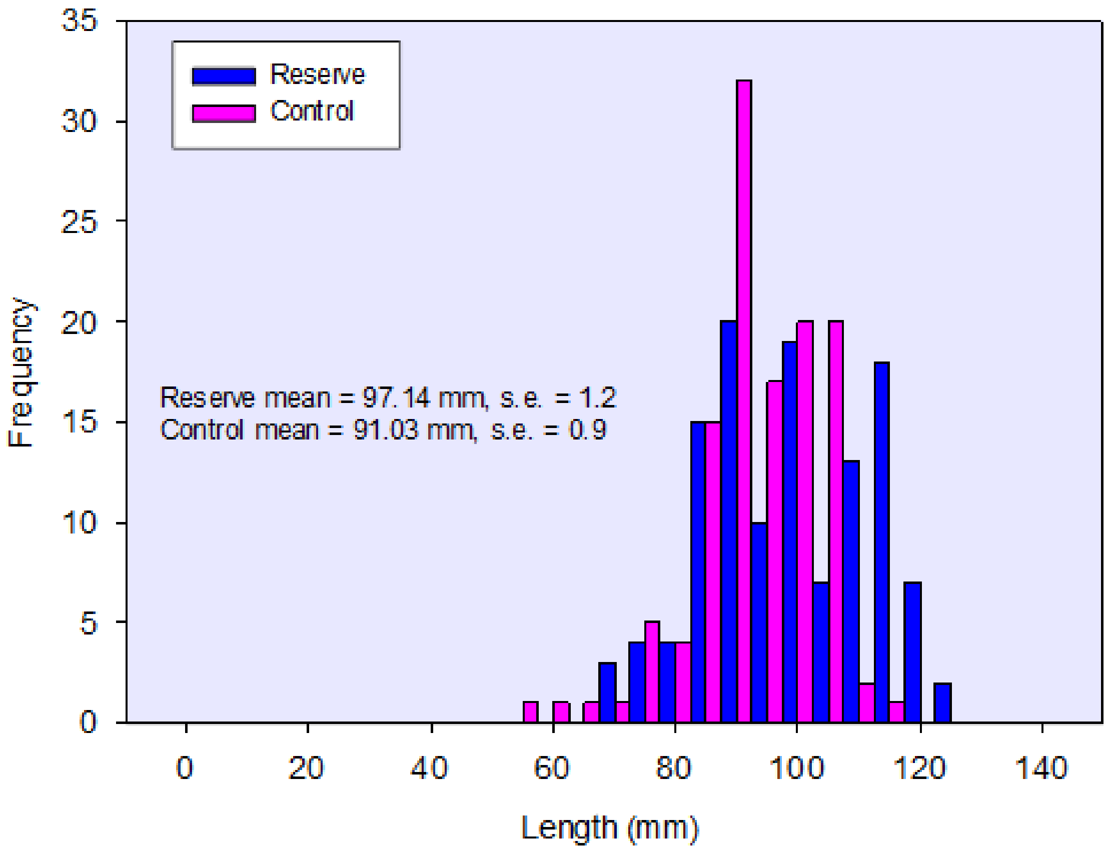


Figure 22. Size-frequency of black foot paua from pooled reserve (blue) and control (pink) sites in 2013.

6.0 ECOLOGICAL INTEGRITY INDICATORS

This report presents data collected during field work in November 2012 and March 2013 from the Tonga Island Marine Reserve and adjacent Abel Tasman coast. The present report also summarises existing biological publications for this coast. The aim of the study was to bring these data together in order to provide data for assessing ecological integrity using key indicators as outlined in Table 3 (In: Thrush *et al*., 2011). Not all potential indicators listed by these authors were within the scope of the present report or available from other studies. Based on existing publications including data collected during the present study, a list of indicators was generated. Indicators generally fell into two major fields and have been separated accordingly. Groups either had biological or resource attributes (Table 10) or human assigned attributes or impacts (Table 11).

Indicators generally fell into these two groups, but overlap between groups existed (Tables 10 and 11). For example, the biological attribute of a forest catchment percentage is often a direct reflection of present or past human activity in the catchment.

(1) biological attributes or features such as lobster and fish abundance and size, macroalgae species, number of substratum types, important species or habitats.

(2) Human activity related impacts such as fishing, benthic disturbance, structures, sedimentation, land clearance, contaminants including heavy metals in sediment and shellfish (may be natural or human related), farming, industrial and residential development.

Primary sources of information for each indicator has also been listed (Tables 10 and 11).

Indicator variables have been split into (A) Abel Tasman coast (excluding the MR) and (B) Tonga Island MR. This separation provides an indication of whether the establishment of a marine reserve potentially alters ecological integrity.

6.1 Biological indicators

This section summarises indicators related to biological attributes or features.

6.1.1 Intertidal and subtidal substrates, habitats

A lower number of intertidal substrate types were located in the Tonga Island MR compared to the remainder of the Abel Tasman coast (Table 10). The reserve supports three small estuarine areas totaling 9.7 ha, all dominated by coarse sand substrata. The rest of the coast supports 627.5 ha of estuarine substrates, recorded from 11 estuaries. In contrast, the same number of subtidal soft substrata was recorded within and outside the marine reserve (Table 10). Intertidal and subtidal limestone rock was restricted to Taupo Point in Golden Bay, a 1.1 ha area located distant to the Tonga Island MR.

For intertidal and subtidal habitats the reserve usually supported a slightly lower number of habitats compared to the remainder of the Abel Tasman coast (Table 10). Habitats absent from the Tonga Island marine reserve were estuarine silt, estuarine shellfish beds and limestone walls. All substrata types in the Tonga Island MR were also found from the wider Abel Tasman coast (Table 10).

6.1.2 Special species and communities

A number of intertidal and subtidal species and communities were recorded in the present study and from previous studies (Table 10). Davidson (1992) and Davidson and Chadderton (1994) reported the presence of *Ecklonia radiata* plants for particular locations in the Tonga Island MR and adjacent coast. These are the only known locations for this macroalgal species from a line between Cape Soucis and the tip of Farewell Spit in Tasman and Golden Bays. During the present study two *Ecklonia* plants were found at a new location on the eastern side of Tonga Island.

Davidson and Chadderton (1994) reported a unique assemblage of species from the approximately 1ha of limestone formations located at Taupo Point near the northern end of the Abel Tasman coast. This assemblage supported a very different community compared to granite shores and the authors suggested this was due to the environmental attributes associated with limestone substrata. Limestone is not found in the Tonga Island MR.

Davidson (1992) reported the presence of a high density anemone bed (*Actinothoe albocincta*) at Snapper Rocks located south of Te Pukatea Bay. The authors stated this was the highest density of this species known from the top of the South Island. No comparable bed was located within the Tonga Island MR.

6.1.3 Macroalgae

Macroalgae is relatively uncommon along the Abel Tasman coast (Davidson and Chadderton 1994, Nelson *et al*., 1992). Where present, macroalgae species are usually restricted to the sublittoral fringe on bedrock (Table 10). The exceptions are at particular locations on granite and all limestone substrata. Granite macroalgae beds are more common and occupy larger areas within the Tonga Island MR compared to the Abel Tasman coast. Dense and large beds exist at Foul Point in the reserve and Anapai Bay outside the reserve. These macroalgae beds are characterised by a low diversity of species dominated by *C. flexuosum* and may extend to 8-10 m depth. There have been some areas within the reserve where macroalgae cover at depth appears to have increased (e.g. Cottage Loaf Rock). This may be due to an increase in large predators resulting in a decline in kina densities recorded in the reserve by Davidson and Richards (2013). These preliminary results are the first recorded community changes in the Tonga Island MR that can be attributed to reserve implementation.

The reasons for the lack of macroalgae from much of the rocky subtidal of the reserve and Abel Tasman coast are complex (Davidson and Chadderton 1994). These authors suggested the lack of macroalgae from granite but not limestone was related to the granite providing an ideal grazing surface for kina and molluscs, particularly cats-eye snails. This combined with a lack of large oceanic swells restricted macroalgae to the low tide mark where the small waves prevalent along this coast were sufficient to remove grazers. In the present study, very sheltered sites supported little or no macroalgae. It is also probably that high turbidity and the smothering of rock surfaces by fine sediment also play a part in this relationship.

6.1.4 Estuarine plants

Estuarine areas are located at three locations in the reserve totaling 9.66 ha compared to 623.7 ha in the 11 estuarine areas located along the remainder of the coast. Not surprisingly, the Tonga Island MR supported only 1.8 % of the salt marsh and herb field vegetation for this coast (2.75 ha in the reserve versus 147 ha outside the reserve). In contrast the reserve supports eelgrass (seagrass) at two locations compared to only two locations outside the reserve. The reserve accounts for 0.27 ha or 63 % of the eelgrass for this coast. In comparison, the total area of eelgrass located in Golden Bay is 46.5 ha (Robertson and Stevens 2012).

Very little salt marsh and herbfield habitat has been destroyed by infilling along the Abel Tasman coast. Largest areas of infilling are located at each end of the coast at Marahau in the south and Wainui in the north. It is likely that saltmarsh and herbfield communities in the Tonga Island MR, although small, are little impacted by historic human activities along the coast.

One naturally uncommon estuarine plant is known from this coast. The sea musk *Mimulus repens* is located at Marahau Estuary. The introduced cord grass *Spartina* has been eradicated from this coast.

6.1.5 Invertebrates

No difference in the number of marine invertebrates was recorded between the reserve and the adjacent coast (Davidson 1992). Little difference in the abundance of rocky invertebrates has been recorded between reserve and non reserve areas until recently. Davidson and Richards (2013) reported a decline in the abundance of kina in the reserve. The authors stated this required further monitoring, however, they suggested this result may be due to an increase in predation on small kina by lobsters and large fish. Over the same period kina densities at control locations increased. A decline in kina numbers may have other community-wide impacts and could be regarded as a change to a more natural state in the reserve.

6.1.6 Reef fish

The same species of fish were recorded inside and outside the reserve (Davidson and Richards 2013), but the abundance and size of particular species was greater within the reserve. At the end of their study, for example, large legal sized blue cod were 40 times more abundant in the reserve compared to the control treatment. This is most likely due to the cessation of fishing in the reserve and is therefore representative of a more natural state. The authors also stated that snapper may be considerably more abundant in the reserve but diver sampling techniques failed to document this as this species has a tendency toward diver-negative behaviour.

6.1.7 Lobsters

Lobsters were larger, more abundant and dominated by large reproductive males and females in the reserve compared to areas outside (Davidson and Richards (2013). The authors reported that shallow lobsters were 8 times more abundant in the reserve compared to the control treatment, and 6.8 times more abundant at the deep strata compared to the associated control sites. This situation is likely representative of a more natural state than at areas where fishing is permitted.

6.1.8 Sea Birds

Approximately 36 sea bird species visit or reside along the Abel Tasman coast (Davidson 1992). Notable marine bird species and bird areas included banded rail records at 10 sites, reef heron feeding and breeding sites, blue penguin feeding and breeding areas, fluttering shearwater and gannet feeding areas. Important bird sites are spread along the coast, both inside and outside the Tonga Island MR.

6.2 Human related indicators

This section summarises indicators related to human values or impacts that influence biological values or features.

6.2.1 Species, communities under threat or ranked as threatened

No intertidal or subtidal threatened status species are known for the Tonga Island MR or Abel Tasman coast (Table 11). The coastal peppercress (*Lepidium banksii*) is, however known from a number of terrestrial locations along the coastal fringe. The Department of Conservation is actively managing coastal peppercress through fertilising and spraying for aphids and white cabbage butterfly infestations. The Department is also transplanting coastal peppercress to supplement existing populations, as well as establishing new ones.

Two reserve and three non reserve species/communities of importance are threatened to a degree. Rhodolith and bryozoans are fully protected within the Tonga Island MR, however, outside this protected area they have variable protection. The bryozoans and rhodoliths located within the Separation Point closed area are protected from commercial power fishing methods but not from recreational dredges. The remainder of the Totaranui rhodolith bed is located south of Totaranui and has no protection from the use of bottom towed devices.

Ecklonia radiata plants are known from a limited number of locations along this coast. It is likely their continued presence at these sites is threatened by high numbers of grazers due to a lack of large predators and sedimentation from river inputs.

6.2.2 Marine protection

Tonga Island MR was established in November 1993. It is 1835 ha and extends one nautical mile, or 1.852 km, offshore from mean high water. The marine reserve boundaries extend from the headland immediately north of Bark Bay to Awaroa Head, and include the shoreline of all islands and stacks within its boundaries. This is a total no-take zone and includes a prohibition on all activities that result in the take or disturbance of marine life or natural features.

Separation Point is closed to dredging, trawling and Danish seining under the Fisheries Act (14,600 ha). The water inshore of a line between Foul Point and Fisherman Island is closed to commercial oyster and scallop dredging under the Fisheries Act.

6.2.3 Marine contaminants

Sediment and shellfish contamination levels were relatively low. Nickel levels in sediment exceeded recommended levels at all replicates in the reserve and sites 1 of 3 outside the reserve. This is most likely due to natural levels due to elevated levels in the catchment of the Motueka River (Gillespie *et al*. 2011). This also explains the higher than would be expected levels of chromium and copper.

In shellfish only cadmium levels exceeded recommended levels. This occurred at 3 of the 16 replicate samples. The reason for this phenomenon is unknown. Overall contaminant levels in sediment and shellfish were low and close to what could be considered relatively natural.

6.2.4 Marine sedimentation

Sediment on subtidal rock surfaces ranged from slight in shallow areas to extreme in deeper areas (Table 11). Highest levels were recorded in the south of the coast. The most likely source of sedimentation on rock surfaces is the Motueka River flood plume rather than the bush clad catchments of the Abel Tasman that flood on occasion, but only in severe storm events. Sediment originating from the Motueka River during flood events appears to flow offshore and north extending a plume through the Abel Tasman coast (Gillespie *et al*., 2011). This plume of dirty water is most noticeable south of Bark Bay. The Motueka River drains a catchment of 2180 km^2 (Forest *et al*. 2007) and sends an extensive plume of sediment into Tasman Bay during a flood (Gillespie *et al*., 2011). River sediment that settles onto the soft bottom benthos is likely to be resuspended by fishing activities that use bottom towed devices. Fine material of rocks is also resuspended by onshore winds and waves.

Impacts of sedimentation in marine environments include direct effects on the species themselves, such as clogging of the gills of filter feeders and decreases in filtering efficiencies with increasing suspended sediment loads (e.g. cockles, pipi, scallops), reductions in settlement success and survival of larval and juvenile phases (e.g. paua, kina), and changes in the foraging abilities of finfish (e.g. juvenile snapper) (see Morrison *et al*. 2009 for review). The authors also suggested that indirect effects may include the modification or loss of important nursery habitats, especially those composed of habitat–forming (biogenic) species (e.g. green-lipped and horse mussel beds, seagrass meadows, bryozoan and tubeworm mounds, sponge gardens, kelps/seaweeds, and a range of other 'structurally complex' species).

MacDiarmid *et al*. (2012) undertook an assessment of the relative impact of sixty-five potentially hazardous human activities that may affect sixty-two identifiable marine habitats in New Zealand's territorial seas and 200 nautical mile exclusive economic zone (EEZ). The authors stated that threats deriving from human activities in catchments that discharge into the coastal marine environment were among some of the highest scoring threats to New Zealand's marine habitats. Foremost was increased sedimentation resulting from changes in land-use. The authors considered it was third equal highest ranked threat over all habitats and was the highest ranked threat for five coastal habitats including harbour intertidal mud and sand, subtidal mud, seagrass meadows and kelp forest. Other threats derived from human activities in catchments ranking 19= or higher and included sewage discharge, increased nitrogen and phosphorus loading and heavy metal pollution. Three other highly ranked (threats, algal blooms, increased turbidity, and oil pollution) stem in part from human activities in catchments.

The Tonga Island MR is subjected to the same sediment laden water that flows past the rest of the coastline from the Motueka River. Sedimentation has likely had a major impact on the habitats and communities living in the Marine Reserve and adjacent coast. It is therefore likely this catchment effect will be a major component of the integrity score for this coast.

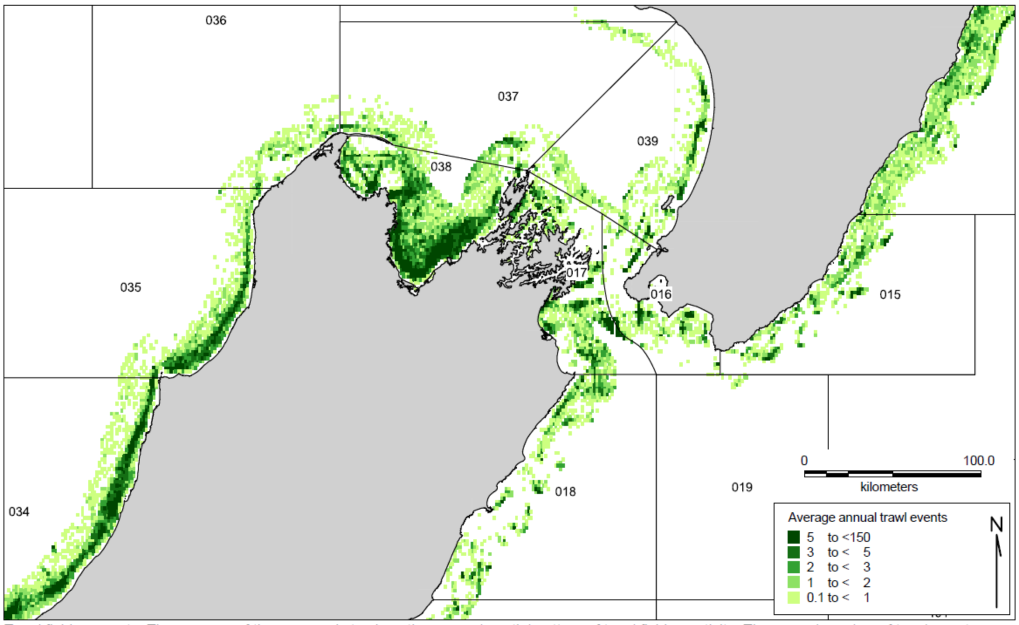
6.2.5 The impacts of bottom towed devises

In an assessment of the relative impact of sixty-five potentially hazardous human activities MacDiarmid *et al*. (2012) ranked bottom towed devices as an overall third equal highest ranking threat in the study.

The Abel Tasman has been historically dredged and trawled by commercial fishers. Some commercial activity still exists, however, little data is available on the location and intensity of activities (Figure 22). MPI data presented in Figure 23 suggests the area occupied by rhodoliths is intermittently fished, but this may be a result of the low resolution of the data. Recreational scallop dredging is a regular pass time and generally focused in the Bark Bay, Totaranui, Mutton Cove, Awaroa areas.

Two of the communities recognised in the present report as threatened are potentially impacted by bottom towed devices. Rhodolith and bryozoan mounds located on soft substrata in the Awaroa to Separation Point area are likely impacted by commercial and recreational dredging. Although the Totaranui to Separation Point area is closed to commercial dredging and trawling, there are no restrictions on recreational dredging.

Figure 23. MPI data published on trawl effort and locations.



Trawl fishing events: The purpose of these maps is to show the general spatial pattern of trawl fishing activity. The annual number of trawl events is shown for the position where each trawl event started, averaged for all events starting in each 1 nautical mile grid cell and for three fishing years 2007-10. Black lines show general statistical areas. Fishing activity shown in these maps includes only those fishing events that report coordinates of fishing position which in the case of trawling is almost 100% of events. All fishing returns are subject to occasional errors in recording method codes, and position coordinates. Where possible these errors have been corrected.

http://www.fish.govt.nz/NR/rdonlyres/FB056B66-B90B-4A51-96CC-A20B4A45AF88/0/TrawlMap3_effort.pdf

6.2.6 Anchoring

At present there are no restrictions on anchoring in Tonga Island MR or the wider Abel Tasman coast. Fortunately the rhodolith bed located in the reserve is not located in an area frequently used for anchoring (Plate 18). In contrast the horse mussel bed located at the northern end of Onatahuti Beach is an area that is regularly used as an anchorage.

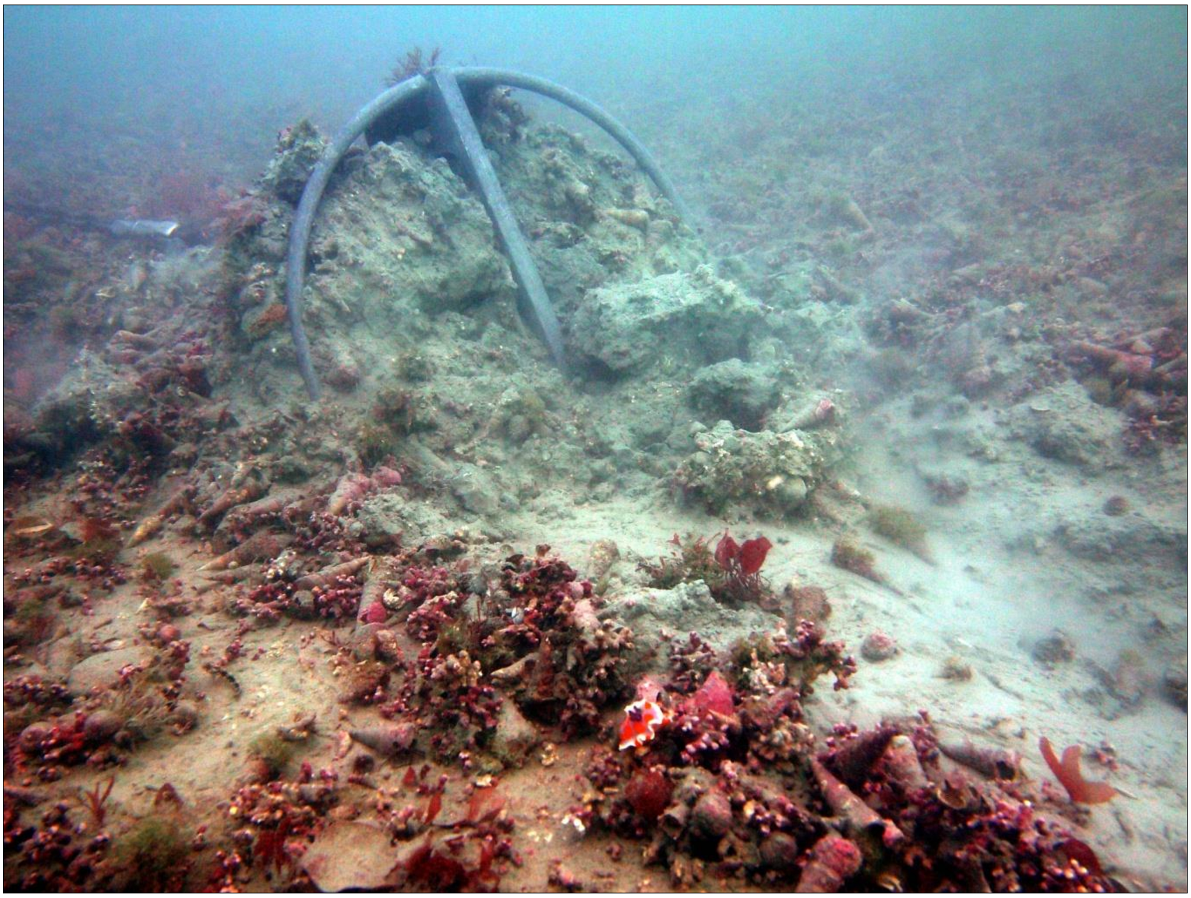


Plate 18. Anchor impact on a rhodolith bed located in Tonga Island MR.

6.2.7 Rubbish

Apart from floating rubbish that drifts or is blown ashore, terrestrial rubbish is largely absent from the Abel Tasman coast. Drift rubbish is regularly removed by Department of Conservation staff and tourist operators and is only visible in areas seldom visited. Subtidal rubbish is present but relatively rare and often very old. At particular locations subtidal rubbish exists in the reserve and along the wider coast. Old appliances presumably dumped by bach owners or their contractors, lost or discarded fishing devices such as dredges, pots, nets and lines as well as items such as tyres are located at various locations along the coast (Plate 19).

Plate 19. Variety of subtidal rubbish recorded by sled tows in present study - old dredge (left) and tyre with accompanying beer bottle (right).

6.2.8 Catchments

All of the catchments along the Abel Tasman coast are clad in various stages of regenerating native vegetation. A number of problem plant species exist at particular locations including pines, hakea (*Hakea sericea*) old man's beard, banana passion vine, African club moss, wandering willy (*Tradescantia*), pampas, Japanese honeysuckle, Himalayan honeysuckle, Spanish heath, wattle, and gorse. Pest animals such as deer, goats and wasps are also present. The Department of Conservation and other agencies undertake active management of these problem species.

The regenerating and relatively natural catchments of the Abel Tasman coast ensure that sediment, nutrient and contaminant runoff is maintained at a minimum. It is important to note that the Motueka catchment is highly modified and should also be regarded as a catchment of the Abel Tasman coast as much of the material that enters the sea from this catchment flows northwards along the Abel Tasman coast.

6.2.9 Terrestrial edge intactness

The terrestrial edges of the Abel Tasman coast have been modified by historic farming and associated land clearance. Many of the hill slopes are slowly regenerating. Unlike many areas of New Zealand, however, the terrestrial environment next to the coast has not been permanently modified by urbanization, industrialization and farming. The regeneration process of this terrestrial edge is therefore extensive and improving. A variety of introduced species are present along this terrestrial edge including ice-plant and marram.

6.2.10 Marine structures

Structures along the terrestrial fringes are present, but are at relatively low levels compared to most marine areas of New Zealand (Table 11). Terrestrial huts and track facilities are present along the coast, however, only campsites (no huts) exist adjacent to the Tonga Island MR. Private land exists along the Abel Tasman coast with the largest settlements located at Torrent Bay, Awaroa, and Astrolabe Roadstead. No private land is located adjacent to the Tonga Island MR.

Marine structures are also relatively uncommon along this coast. Buoys for navigation and to mark the reserve boundaries are located in the marine reserve. Cleaning of the marine reserve marker buoys has an impact on the benthos, however this is localised and represents a relatively minor impact (Plate 20).

Plate 20. Live mussel shell on the benthos under a marine reserve marker float at the southern boundary.

6.2.11 Human development

Two launching ramps are located in the intertidal zone (i.e. estuarine, beach); both are located at the camp ground at Totaranui and are DOC built and administered.

Three areas of intertidal habitat have been historically infilled. A causeway has been built linking the Marahau information centre with the coastal track (565 m length). A reclamation has also been undertaken for a car park and the Marahau information centre (Plate 21). Lastly, infilling Wainui Bay at the northern end of the coast has occurred.

Plate 21. Infilled estuary used for the track causeway, Marahau information centre and café and car park.

Table 10. Biological environmental indicators assessed based on data collected during the present study and other studies.

Variable	Type	ATNP coast	Tonga Island MR	Sources	Details								
Substrata (soft)	**Intertidal**	4	1	2	Coarse sand	Sand	Fine sand	Mud					
	Subtidal	6	6	1	Sorted sand	Sand, granules, dead whole and broken shell	Sand, fine sand, shell (broken, whole)	Dead whole & broken shell, mud	Mud, whole/broken shell	Mud, occasional shell			
Substrata (hard)	**Intertidal**	3	2	2, 7	Bedrock granite	Bedrock limestone	Boulder, cobble granite						
	Subtidal	3	2	2, 7	Bedrock granite	Bedrock limestone	Boulder granite						
Habitats (soft)	**Intertidal**	5	3	1, 2	Sand beach	Vegetated	Estuarine sands	Estuarine silts	Shellfish beds				
	Subtidal	9	9	1,2,4	Sorted sand	Megarippled sand	Shell hash on silt	Mud, whole/broken	Mud, occasional	Rhodoliths	Horse	Red algae	Bryozoan
Habitats (hard)	**Intertidal**	5	4	1, 2, 7	Perwinkle zone	Barnacle zone	Polychaete zone	Algal zone	Limestone walls				
	Subtidal	5	4	2	Deep granite reef	Shallow granite reef	Limestone walls	Granite algae forest	Granite barrens				
Special species/communities	**Intertidal soft**	2	2	2	Estuarine vegetation	Shellfish beds							
	Subtidal soft	2	3	1, 5	Rhodolith bed	Horse mussel bed	Red algae bed	Bryozoan mounds					
	Intertidal hard	1	0	2, 7	Limestone assemblage								
	Subtidal hard	3	1	2, 7	Limestone assemblage	Anemone bed	*Eckonia radiata*						
Common brown macroalgae	**No. species**	5	5	2	*C. maschalocarpum*	*C. flexuosum*	*Glossophora kunthii*	*Cystophora* spp.	*Ecklonia radiata*				
	All algae species	60	60	6									
	Vertical spread	0-9 m	0-10 m	1									
	% cover	Absent to low	Absent to high	1									
Estuarine plants	**Salt marsh, herb field**	144.27 ha	2.75 ha	2									
	Eelgrass	0.43 ha	0.27 ha	2									
Invertebrates (soft substrata)	**Subtidal species**	71	71	2									
	Intertidal species	34	34	2									
Invertebrates (hard substrata)	**Subtidal species**	73	73	2									
	Intertidal species	53	53	2									
Reef fish	**Species**	64	64	2									
	Abundance	Low	Moderate	3	Low = uncommon	Moderate = common	High = abundant						
	Size	Low	High	3	Low = sublegal dominant	High = legal dominant							
Lobster	**Abundance**	Low	High	3	Low = uncommon	Moderate = common	High = abundant						
	Size	Low	High	3	Low = sublegal dominant	High = legal dominant							
Marine birds	**Species**	36	36	2									

Code	Sources
1	Present study
2	Davidson 1992
3	Davidson & Richards (2013)
4	Thrush *et al*. 2003
5	Bradstock & Gordon 1983
6	Nelson et al 1992
7	Davidson & Chadderton 1994

Table 11. Human related environmental indicator assessed based on data collected during the present study and other studies.

Variable	Type	ATNP coast	Tonga Island MR	Sources	Details				
Species, communities under threat	**Iintertidal and subtidal**	3	2		Rhodolith bed	Bryozoan mounds	Ecklonia radiata		
Threatened marine species	**Terrestrial edge**	1	0		*Lepidium banksii*				
	Intertidal or subtidal	0	0						
Marine protection	**Marine reserve**	0%	100% (1835 ha)		Tonga Island MR (1993)				
	MPI	1			Commecial oyster and scallop zone landward of line between Foul Pt & Fisherman Is.				
	MPI	14600 ha	0%		Separation Point (MPI restriction) (1980)				
Marine contaminants exceeded	**Sediment**	1 of 3	9 of 9	1	Nickel	Tonga quarry	Onatahuti	Reef Point	Bark Bay
	Bivalves	0	3 of 16	1	Cadmium	Tonga Quarry	Onatuhuti		
Sedimentation on rocks	**Shallow**	Slight to high	Slight to high	1					
	Deep	High to extreme	High to extreme	1					
Marine problem species species	**Invasive**	0	0	1,2					
	Introduced intertidal	2	2	2	Ice plant	Marram			
Dredging-trawling area %		c. 90 %	0%						
Anchoring		No restrictions	No restrictions						
Rubbish	**Terrestrial edges**	Low-moderate	Low-moderate	1	Floating debris washed ashore				
	Subtidal, intertidal	Rare	Rare	1	Bottles, kitchen appliances, tyres, fishing pots & dredges, fishing nylon, nets and hooks				
Catchments	**Farm, forestry**	0%	0%	2					
Terrestrial edge intactness	**Native/stable vegetation**	c. 95%	100%	2					
Structures	**Buoys**	Many	6		TDC, DOC				
	Navigational markers	4	1		MNZ				
	Housing	Numerous	0		Private land (Torrent Bay, Awaroa, Astrolabe Roadstead, Boundary Bay, Frenchmans Bay, Bark Bay Spit)				
	Huts	7	0		DOC (Tinline, Anchorage, Torrent Bay, Bark Bay, Awaroa, Totaranui lodge, Whararangi)				
	Campsites	15	2		DOC				
Human development	**Causeway**	1 (565 m)	0	2	DOC (Marahau)				
	Launching ramp	2	0	2	DOC (Totaranui beach and estuary)				
	Land infilling	2	0	2	DOC (Marahau visitor centre and carpark), Private (Wainui)				

Code	Sources
1	Present study
2	Davidson 1992
3	Davidson & Richards (2013)
4	Thrush *et al*. 2003
5	Bradstock & Gordon 1983
6	Nelson et al 1992
7	Davidson & Chadderton 1992

7.0 Mechanisms for improving ecological integrity

A variety of important marine habitats or communities are located within the Tonga Island MR and adjacent coast. There are two major and one minor issue in relation to these habitats. Improvements to these issues would ultimately raise ecological integrity scores over the long term.

1. Sedimentation from catchments

   Sediment has a variety of adverse impacts in the subtidal marine environment. Management measures in the Motueka catchment that lower sediment loading would potentially improve the current issue. It is critical that coastal managers are made aware of the link between extreme sediment smothering on rock surfaces and offshore soft bottom communities along the coast and management of the Motueka River catchment.
2. Physical damage

   A number of sensitive habitats and communities exist in the Tonga Island MR and adjacent coast. At present **anchoring** is an activity that can be legitimately undertaken in the MR including on sensitive habitats. The sensitivity of these habitats to disturbance should be considered if any anchoring restrictions are implemented in the future. Physical damage of important habitats occurs at a number of locations at the northern end of the Park. Some areas are protected from commercial **dredging** while others are not. No restrictions on recreational dredging exist in areas outside the MR. The establishment of restrictions on the use of **bottom towed devices** would contribute to enhancing ecological integrity at these sites. Most boats that dredge the northern end of the Park launch at either Totaranui or Tarakohe. Signage showing the location of sensitive areas and a request to avoid these areas when dredging for scallops may be a mechanism to explore.
3. Problem species

   The introduced **ice plant** is common around the fringes of many estuaries along the Park including the MR. This species hybridizes with the native ice plant. Removal of this plant is also suggested in the Park Management Plan. Removal of this species would improve intertidal and adjacent terrestrial integrity scores.

ACKNOWLEDGEMENTS

People involved in the project were:

- Louise Chilvers (DoC Marine Species and Threats Team, Wellington)
- Greig Funnell (DOC Marine Ecosystems Team, Invercargill)
- Don Neale (DoC Marine Ecosystems Team, Hokitika)
- Dirk de Vries (DoC Motueka Area Office)
- Rob Davidson (Contractor - Davidson Environmental Ltd)
- Kris Ramm (DOC Marine Species and Threats Team, Wellington)

We would like to thank a number of people who assisted with diving (Simon Bayly, Dirk deVries, Laura Richards and Alix LaFerriere). We would like to thank DoC's boat skipper Stu Fowler, particularly during some uncomfortable watches while divers were in the water. Thanks are also due to Martin Rodd and his team (Bill Franklin, Stu Houston) at the Motueka Department of Conservation Field Centre for their enthusiasm and logistical assistance.

Funding for this project was provided by the Department of Conservation, Wellington. Thanks are also due to Andrew Baxter for constructive comments on the manuscript.

REFERENCES

ANZECC 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 Volume 1. National Water Quality Management Strategy Paper No. 4. Canberra, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

Bradstock, M.; Gordon, D.P. 1983. Coral-like bryozoan growths in Tasman Bay, and their protection to conserve fish stocks. New Zealand Journal of Marine and Freshwater Research 17: pp 159-163.

Cornelisen, C.; Gillespie, P.; Kirs, M.; Barter, P.; Goodwin, E.; Forrest, R.; Knight, B.; Quarterman, A. 2011. Motueka River plume facilitates transport of ruminant faecal contaminants into shellfish growing waters, Tasman Bay New Zealand. New Zealand Journal of Marine and Freshwater Research 45: 477-495.

Davidson, R.J. 1992. A report on the intertidal and shallow subtidal ecology of the Abel Tasman National Park, Nelson. Department of Conservation, Nelson/Marlborough Conservancy Occasional Publication. No. 4, 161 p.

Davidson, R.J.; Richards, L.A.; Bayly, S.; Devries, D.; Bodin, G.; LaFerriere, A.; Fowler, S. 2013. Horoirangi Marine Reserve, North Nelson, report on rocky shore biological monitoring: 2006-2013. Prepared by Davidson Environmental Ltd. for Department of Conservation. Survey and monitoring report no. 694.

Davidson, R.J.; Abel, W.; Richards, L.A. 2009: Biological monitoring update 1992-2009: Long Island-Kokomohua Marine Reserve, Queen Charlotte Sound. Prepared by Davidson Environmental Limited for Department of Conservation, Nelson. Survey and Monitoring Report No. 573.

Davidson, R.J.; Richards, L.R. 2007. Tonga Island Marine Reserve, Abel Tasman National Park update of biological monitoring, 1993 – 2007. Prepared by Davidson Environmental Limited for Department of Conservation, Nelson. Survey and Monitoring Report No. 484.

Davidson, R. J.; Richards L. A. 2005: Comparison of fish at reserve and control sites from Long Island-Kokomohua and Tonga Island Marine Reserves using baited underwater video (BUV), catch, measure, release (CMR) and underwater visual counts (UVC). Prepared by Davidson Environmental Limited for Department of Conservation, Nelson. Survey and Monitoring Report No. 466.

Davidson, R. J.; Richards L. A. 2004: Comparison of fish at reserve and control sites from two South Island marine reserves (Long Island-Kokomohua and Tonga Island) using baited underwater video. Prepared by Davidson Environmental Limited for Department of Conservation, Nelson. Survey and Monitoring Report No. 466.

Davidson, R.J, Villouta, E., Cole, R.G., and Barrier, R.G.F. 2002. Effects of marine reserve protection on spiny lobster abundance and size at Tonga Island Marine Reserve, New Zealand. *Aquatic Conservation: Marine and Freshwater Ecosystems*. 12: 213-227.

Davidson, R.J.; Chadderton, W.L. 1994. Marine reserve selection along the Abel Tasman National Park coast, New Zealand: consideration of subtidal rocky communities.Aquatic Conservation: Freshwater and marine ecosystems Vol. 4, 153-167.

Dennis, A. 1985. A park for all seasons, the story of Abel Tasman National Park. Published by Department of Conservation. 160 pp.

Dix, B. 1993 Population changes and diet preferences of the New Zealand fur seal Arctocephalus forsteri in the eastern Cook Strait. Unpublished M.Sc. thesis, School of Biological Sciences, Victoria University of Wellington.

Dix, T.G. 1972. Biology of *Evechinus chloroticus* (Echinoidea: Echinometridae) from different localities. 4. Age, growth and size. N.Z. Journ. Mar. Freshw. Res. Vol. 6 (1,2). pp 48 68.
Dix, T.G. 1970. Biology of *Evechinus chloroticus*. (Echinoidea: Echinometridae) from different localities. 1. General. N.Z. Journ. Mar. Freshw. Res. Vol. 4(2). pp 91 116.
Dix, T.G. 1970. Biology of *Evechinus chloroticus* (Echinoidea: Echinometridae) from different localities. 2. Movement. N.Z. Journ. Mar. Freshw. Res. Vol 4. pp. 267 277.
Dix, T. G. 1969. Aggregating in the Echinoid *Evechinus chloroticus*. Pacific Science 23: 123-124.
D'Archino, R. 2012. Marine algal survey of Port Pegasus (Stewart Island), Expediation November 2011. Report prepared for Department of Conservation by NIWA.
Elliott, G. 1989. The distribution of banded rails and marsh crakes in coastal Nelson and the Marlborough Sounds. Notornis 36: 117-123.
Elliott, G. 1990. Banded rail distribution in Tasman Bay and Marlborough Sounds. Prepared for Department of Conservation. Winter 1990.
Forest, B.M.; Gillespie, P.A.; Cornelisen, C.D.; Rogers, K.M. 2007. Multiple indicators reveal river plume influence on sediments and benthos in a New Zealand coastal embayment. New Zealand Journal of Marine and Freshwater Research,Vol. 41: 13–24.
Freeman, D. 2005. Reef fish monitoring: Te Tapuwae o Rongokako Marine Reserve. Report prepared by Department of Conservation, Technical Report No. 25.
Freeman D.J., MacDiarmid A.B., Taylor R.B., Davidson R.J., Grace R.V., Haggitt T.R., Kelly S., Shears N.T. 2012. Trajectories of spiny lobster *Jasus edwardsii* recovery in New Zealand marine protected areas – is settlement a driver? Environmental Conservation 39: 295-304.
Freeman D.J., Breen P.A., MacDiarmid A.B. 2012a. Use of a marine reserve to determine the direct and indirect effects of fishing on growth in a New Zealand fishery for the spiny lobster *Jasus edwardsii*. Canadian Journal of Fisheries and Aquatic Sciences 69: 894-905.
Freeman, D.J. and MacDiarmid, A.B. 2009. Healthier lobsters in a marine reserve: effects of fishing on disease incidence in the spiny lobster, *Jasus edwardsii*. Marine and Freshwater Research 60(2): 140–145.
Gillespie, P.A.; Forrest, R.W.; Peake, B.M.; Basher, L.R.; Clement, D.M.; Dunmore, R.M.; Hicks, D.M. 2011. Spatial delineation of the depositional footprint of the Motueka River outwelling plume in Tasman Bay, New Zealand New Zealand Journal of Marine and Freshwater Research Vol. 45, Iss. 3.
Grange, K.R.; Tovey, A.; Hill, A.F. 2003. The spatial extent and nature of the bryozoan communities at Separation Point, Tasman Bay. New Zealand Ministry of Fisheries. Marine Biodiversity Biosecurity Report No. 4. 22 p.
Guisado D.D.; Cole R.G.; Davidson R.J.; Freeman D.J.; Kelly S.; Macdiarmid A.; Pande A.; Stewart R.; Struthers C.; Bell J.J.; Gardner G.P.A.; 2012. Comparison of methodologies to quantify the effects of age and area of marine reserves on the density and size of targeted species. Aquatic Biology. Vol. 14, 185-200.
McKnight, D.G. and Grange, K.R. 1991. Macrobenthos sediment-depth relationships in Marlborough Sounds. Report prepared for Department of Conservation by Oceanographic Institute, DSIR. No. P692. 19 p.
MacDiarmid, A.; McKenzie, A.; Sturman, J.; Beaumont, J.; Mikaloff-Fletcher, S.; Dunne, J. 2012. Assessment of anthropogenic threats to New Zealand marine habitats. New Zealand Aquatic Environment and Biodiversity Report No. 93. 255 p.
Morrison, M.A., Lowe, M., Parsons, D., Usmar, N, and McLeod, I. 2009. A review of land-based effects on coastal fisheries and supporting biodiversity in New Zealand. New Zealand Aquatic Environment and Biodiversity Report. No. 37.

Neill, K.; D'Archino, R.; Farr, T.; Nelson, W. 2012. Macroalgal diversity associated with soft sediment habitats in New Zealand. New Zealand Aquatic Environment and Biodiversity Report 87. 127 p.

Nelson, W.A. 2009. Calcified macroalgae - critical to coastal ecosystems and vulnerable to change: A review. Marine and Freshwater Research 60:787–801.

Nelson, W.A.; Neill, K.; Farr, T.; Barr, N.; D'Archino, R.; Miller, S.; Stewart, R. 2012. Rhodolith beds in northern New Zealand: Characterisation of associated biodiversity and vulnerability to environmental stressors. New Zealand Aquatic Environment and Biodiversity Report No. 99. 102 p.

Nelson, W.A., Adams, N.M, and Fox, J.M. 1992. Marine algae of the northern South Island. National Museum of New Zealand Miscellaneous Series, 26, 79p.

Pande, A., MacDiarmid, A.B., Smith, P.J., Davidson, R.J., Cole, R.G., Freeman, D., Kelly, S., and Gardner, P.A. 2008. Marine reserves increase the abundance and size of blue cod and rock lobster. Marine Ecology Progress Series 366: 147-158.

Reid, C.M., James, N.P. and Bone, Y. 2011. Carbonate sediments in a cool-water macroalgal environment, Kaikoura, New Zealand. Sedimentology 58(7): 1935-1952. http://dx.doi.org/10.1111/j.1365-3091.2011.01246.x.

Robertson, B.M.; Stevens L. 2012. State of the environment report. Tasman Coast: Waimea Inlet to Kahurangi Point Habitat Mapping, Ecological Risk Assessment, and Monitoring Recommendations. Produced for Tasman District Council by Wriggle Coastal Management Ltd.

Robertson, B.M., Gillespie, P.A., Asher, R.A., Frisk, S., Keeley, N.B., Hopkins, G.A., Thompson, S.J., Tuckey, B.J. 2002. Estuarine environmental assessment and monitoring: A National protocol. Part A. Development, Part B. Appendices, and Part C. Application. Prepared for supporting Councils and the Ministry for the Environment, Sustainable Management Fund Contract No. 5096. Part A. 93p. Part B. 159p. Part C. 40p plus field sheets.

Rushton, G.E. 1987. Proposed marine protected area: Coastline of the Abel Tasman National Park, Central South Region. Central Fisheries Region Internal Report No. 1. 40 pp.

Saxton, F.L. 1980. Coral loss could deplete fish stocks. Catch. Vol 7. pp 12 13.

Shears, N.T., Grace, R. V., Usmar, N. R., Kerr, V., and Babcock, R. 2006. Long-term trends in lobster populations in a partially protected vs. no-take Marine Park.. *Biological Conservation* 132: 222-231.

Steller, D.L.; Cáceres-Martínez, C. 2009. Coralline algal rhodoliths enhance larval settlement and early growth of the Pacific calico scallop Argopecten ventricosus. Marine Ecology Progress Series 396: 49–60.

Taylor, R.H; Barton, K.J.; Wilson, P.R.; Tomas, B.W.; Karl, B.J. 1995. Population status and breeding of New Zealand fur seals (*Arctocephalus forsteri*) in the Nelson-northern Marlborough region. New Zealand Journal of Marine and Freshwater Research, Vol. 29, 223-234.

Thrush S.F., Hewitt J.E., Lundquist C.J., Townsend M., Lohrer A.M. 2011. A strategy to assess trends in the ecological integrity of New Zealand's marine ecosystems. Hamilton, New Zealand, National Institute of Water and Atmospheric Research Ltd.

Thrush, S.F.; Hewitt, J.E.; Funnell, G.A.; Nicholls, P.; Budd, R.; Drury, J. 2003. Development of mapping and monitoring strategies for soft-sediment habitats in marine reserves. NIWA report prepared for Department of Conservation. HAM2003-118.

Tuckey, B.J.; Gibbs, M.T.; Knight, B.R.; Gillespie, P.A. 2006. Tidal circulation in Tasman and Golden Bays: implications for river plume behaviour. New Zealand Journal of Marine and Freshwater Research. 40: 305-324.

Willis, T.J.; Triossi, F.; Meynier, L. 2008. Diet of fur seals *Arctocephalus forsteri* at Tonga Island, Abel Tasman National Park. NIWA Client Report: NEL2008-011, NIWA Project: DOC07401.

Appendix 1 Sites sampled during Tonga Island MR monitoring.

Table 1. Reef fish sites sampled annually since 2007.

Type	Coordinates	Location	Code	Treatment	Substratum
Reef fish	40 47.05806,172 59.90864	Separation Point	CF1	Control	Boulder, cobble
Reef fish	40 48.170,173 00.530	Totaranui north	CF2	Control	Bedrock
Reef fish	40 48.858,173 01.115	Totaranui Reef	CF3	Control	Bedrock
Reef fish	40 51.12408,173 02.62163	Awaroa	CF4	Control	Bedrock, boulder
Reef fish	40 51.15995,173 02.77066	Canoe Bay	RF1	Reserve	Boulder, cobble
Reef fish	40 51.39304,173 03.44764	Abel Head	RF2	Reserve	Boulder, cobble, bedrock
Reef fish	40 51.72980,173 03.67184	Cottage Loaf	RF3	Reserve	Boulder, cobble, bedrock
Reef fish	40 53.10127,173 03.51041	Reef Pt.	RF4	Reserve	Bedrock, boulder
Reef fish	40 53.45573,173 04.13343	Tonga Is.	RF5	Reserve	Bedrock, boulder
Reef fish	40 54.23512,173 03.74018	Foul Pt.	RF6	Reserve	Bedrock, boulder
Reef fish	40 54.58073,173 04.14347	Whale Rock	RF7	Reserve	Bedrock, boulder
Reef fish	40 55.10164,173 04.30913	Bark Bay Reef	CL5	Control	Boulder, cobble, bedrock
Reef fish	40 56.35684,173 03.70098	Totara Rocks	CL6	Control	Bedrock, boulder

Table 2. Lobster sample sites sampled annually since 2007.

Type	Coordinates	Location	Code	Treatment	Substratum
Lobster	40 47.05806,172 59.90864	Separation Point, 1	CL1	Control	Boulder, cobble
Lobster	40 51.12408,173 02.62163	Awaroa, 2	CL2	Control	Bedrock, boulder
Lobster	40 51.70603,173 03.66512	Cottage Loaf, 3	RL1	Reserve	Boulder, cobble, bedrock
Lobster	40 53.43768,173 04.13356	Tonga Is. 4	RL2	Reserve	Bedrock, boulder
Lobster	40 54.23333,173 03.75072	Foul Pt. 5	RL3	Reserve	Bedrock, boulder
Lobster	40 54.58073,173 04.14347	Whale Rock, 6	RL4	Reserve	Bedrock, boulder
Lobster	40 54.69568,173 03.85761	Mosquito Reef, 7	RL5	Reserve	Bedrock, boulder
Lobster	40 55.10164,173 04.30913	Bark Bay Reef, 8	CL3	Control	Boulder, cobble, bedrock
Lobster	40 56.28063,173 03.74358	Totara Rocks, 9	CL4	Control	Bedrock, boulder
Lobster	40 56.90667,173 04.06431	Pitt Head, 10	CL5	Reserve	Bedrock, boulder

Table 3. Scallop and horse mussel density sample sites sampled in 2008, 2010, and 2013.

Type	Coordinates	Location	Code	Treatment	Substratum
Scallop, horse mussel	40 53.059,173 03.212	Tonga north inshore	RSH1	Reserve	Sand, shell
Scallop, horse mussel	40 53.08315,173 03.35917	Tonga north (offshore)	RSH2	Reserve	Sand, shell
Scallop, horse mussel	40 53.44986,173 03.11798	Tonga south	RSH3	Reserve	Sand, shell
Scallop, horse mussel	40 54.96729,173 03.52886	Bark Bay (north), 4	CSH1 (north)	Control	Sand, shell
Scallop, horse mussel	40 55.08517,173 03.44385	Bark Bay (centre), 5	CSH2 (middle)	Control	Silt, shell

Table 4. Black foot paua density and size sample sites sampled in 2013.

Type	Coordinates	Location	Code	Treatment	Substratum
Black foot paua	40 48.22345,173 00.55782	Anapai	CB1	Control	Bedrock
Black foot paua	40 50.38838,173 00.89888	RataKura Point	CB2	Control	Bedrock
Black foot paua	40 51.32175,173 02.83716	Canoe Bay	RB1	Reserve	Bedrock
Black foot paua	40 53.49448,173 04.11720	Tonga Island	RB2	Reserve	Bedrock, large boulders
Black foot paua	40 53.94527,173 03.29827	Tonga Quarry Arches	RB3	Reserve	Bedrock
Black foot paua	40 54.25572,173 03.74434	Foul Point	RB4	Reserve	Bedrock
Black foot paua	40 54.75786,173 03.71389	Mosquito reef South	RB5	Reserve	Bedrock, large boulders
Black foot paua	40 55.11512,173 04.30229	Bark Bay Reef	CB3	Control	Bedrock, large boulders
Black foot paua	40 56.08962,173 03.59312	Frenchman Bay	CB4	Control	Bedrock

Table 5. Key invertebrate density sample sites sampled in 2008.

Type	Coordinates	Location	Code	Treatment	Substratum
Key species	40 47.04179,172 59.90323	Separation Pt. 1	CI1	Control	Bedrock, boulder
Key species	40 51.09813,173 02.66039	Awaroa Head, 2	CI2	Control	Bedrock, boulder
Key species	40 51.14185,173 02.80856	Canoe Bay, 3	RI1	Reserve	Bedrock, boulder
Key species	40 54.02087,173 03.41261	Arch Pt. 4	RI2	Reserve	Bedrock, boulder
Key species	40 54.21737,173 03.73238	Foul Pt. 5	RI3	Reserve	Bedrock, boulder
Key species	40 54.57986,173 04.15273	Whale Rock, 6	RI4	Reserve	Bedrock, boulder
Key species	40 56.34183,173 03.66733	Totara Rock, 7	CI3	Control	Bedrock, boulder

Appendix 2. Hill Laboratories sediment results.

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
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Hamilton 3240, New Zealand

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ANALYSIS REPORT

Page 1 of 2

Client:	Dr Debbie Freeman	**Lab No:**	1093084 SPv1
Contact:	Dr Debbie Freeman	**Date Registered:**	25-Jan-2013
	C/- Department of Conservation	**Date Reported:**	05-Feb-2013
	PO Box 10420	**Quote No:**	49404
	WELLINGTON 6140	**Order No:**	
		Client Reference:	Sediment/Shellfish ex Tui
		Submitted By:	Dr Debbie Freeman

Sample Type: Sediment

Sample Name:		Site 1 A	Site 1 B	Site 1 C	Site 2 A	Site 2 B
Lab Number:		1093084.1	1093084.2	1093084.3	1093084.4	1093084.5
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	5	4	4	5	5
Total Recoverable Cadmium	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Recoverable Chromium	mg/kg dry wt	48	45	37	32	34
Total Recoverable Copper	mg/kg dry wt	13	13	10	9	10
Total Recoverable Lead	mg/kg dry wt	13.8	13.2	11.3	11.8	12.3
Total Recoverable Mercury	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Recoverable Nickel	mg/kg dry wt	46	46	36	29	32
Total Recoverable Zinc	mg/kg dry wt	70	68	56	61	65

Sample Name:		Site 2 C	Site 3 A	Site 3 B	Site 3 C	Site 4 A
Lab Number:		1093084.6	1093084.7	1093084.8	1093084.9	1093084.10
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	6	4	4	4	7
Total Recoverable Cadmium	mg/kg dry wt	< 0.10	0.12	< 0.10	< 0.10	< 0.10
Total Recoverable Chromium	mg/kg dry wt	34	41	39	43	23
Total Recoverable Copper	mg/kg dry wt	10	11	11	12	8
Total Recoverable Lead	mg/kg dry wt	12.4	12.0	11.8	13.0	10.9
Total Recoverable Mercury	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Recoverable Nickel	mg/kg dry wt	32	40	38	43	23
Total Recoverable Zinc	mg/kg dry wt	67	66	64	74	54

Sample Name:		Site 4 B	Site 4 C			
Lab Number:		1093084.11	1093084.12			
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	7	6	-	-	-
Total Recoverable Cadmium	mg/kg dry wt	< 0.10	< 0.10	-	-	-
Total Recoverable Chromium	mg/kg dry wt	20	19	-	-	-
Total Recoverable Copper	mg/kg dry wt	8	7	-	-	-
Total Recoverable Lead	mg/kg dry wt	10.2	10.1	-	-	-
Total Recoverable Mercury	mg/kg dry wt	< 0.10	< 0.10	-	-	-
Total Recoverable Nickel	mg/kg dry wt	19	18	-	-	-
Total Recoverable Zinc	mg/kg dry wt	52	51	-	-	-

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Samples

823 365 laboratory

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Samples**
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-12
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, screen level.	-	1-12
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-12

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Martin Cowell - BSc (Chem)
Client Services Manager - Environmental Division

Appendix 3. Shellfish contaminant results

Hill Laboratories
BETTER TESTING BETTER RESULTS

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Page 1 of 2

SPv1

Client:	Dr Debbie Freeman	**Lab No:**	1093100
Contact:	Dr Debbie Freeman	**Date Registered:**	25-Jan-2013
	C/- Department of Conservation	**Date Reported:**	04-Feb-2013
	PO Box 10420	**Quote No:**	49404
	WELLINGTON 6140	**Order No:**	
		Client Reference:	Sediment/Shellfish ex Tui
		Submitted By:	Dr Debbie Freeman

Sample Type: Shellfish

	Sample Name:	2 A	2 B	2 C	2 D	4 A
	Lab Number:	1093100.1	1093100.2	1093100.3	1093100.4	1093100.5
Arsenic	mg/kg as rcvd	4.3	4.2	4.6	3.4	1.73
Cadmium	mg/kg as rcvd	0.68	1.65	0.82	3.0	0.089
Chromium	mg/kg as rcvd	< 0.10	< 0.10	< 0.10	0.17	0.30
Copper	mg/kg as rcvd	0.32	0.25	0.21	0.22	0.28
Lead	mg/kg as rcvd	0.029	0.031	0.015	0.030	0.051
Mercury	mg/kg as rcvd	< 0.010	< 0.010	< 0.010	0.010	< 0.005
Nickel	mg/kg as rcvd	< 0.10	< 0.10	< 0.10	< 0.10	0.13
Zinc	mg/kg as rcvd	21	31	34	30	19.2

	Sample Name:	4 B	4 C	4 D	4 E	5 A
	Lab Number:	1093100.6	1093100.7	1093100.8	1093100.9	1093100.10
Arsenic	mg/kg as rcvd	1.54	1.79	1.55	1.8	1.91
Cadmium	mg/kg as rcvd	0.22	0.082	0.80	0.091	7.7
Chromium	mg/kg as rcvd	0.32	0.30	0.21	3.3	0.33
Copper	mg/kg as rcvd	0.36	0.25	0.27	1.19	0.97
Lead	mg/kg as rcvd	0.100	0.046	0.054	1.13	0.111
Mercury	mg/kg as rcvd	< 0.006	0.004	< 0.005	< 0.03	0.022
Nickel	mg/kg as rcvd	0.28	0.11	0.10	2.1	4.8
Zinc	mg/kg as rcvd	19.5	15.3	16.0	21	27

	Sample Name:	5 B	8 A	13 A	13 B	13 C
	Lab Number:	1093100.11	1093100.12	1093100.13	1093100.14	1093100.15
Arsenic	mg/kg as rcvd	1.81	1.73	3.7	3.7	3.6
Cadmium	mg/kg as rcvd	5.1	0.20	0.46	0.53	0.41
Chromium	mg/kg as rcvd	0.24	0.32	0.34	0.47	0.44
Copper	mg/kg as rcvd	1.00	1.54	1.03	1.13	1.31
Lead	mg/kg as rcvd	0.125	0.085	0.079	0.24	0.20
Mercury	mg/kg as rcvd	0.012	< 0.010	0.013	< 0.010	0.011
Nickel	mg/kg as rcvd	5.9	1.57	2.5	2.5	2.3
Zinc	mg/kg as rcvd	50	11.8	10.9	11.5	9.9

	Sample Name:	13 D				
	Lab Number:	1093100.16				
Arsenic	mg/kg as rcvd	3.0	-	-	-	-
Cadmium	mg/kg as rcvd	0.43	-	-	-	-
Chromium	mg/kg as rcvd	0.23	-	-	-	-
Copper	mg/kg as rcvd	1.47	-	-	-	-
Lead	mg/kg as rcvd	0.186	-	-	-	-
Mercury	mg/kg as rcvd	0.008	-	-	-	-
Nickel	mg/kg as rcvd	1.43	-	-	-	-

Sample Type: Shellfish						
	Sample Name:	13 D				
	Lab Number:	1093100.16				
Zinc	mg/kg as rcvd	11.4	-	-	-	-

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Shellfish

Test	Method Description	Default Detection Limit	Samples
Homogenise*	Mincing, chopping, or blending of sample to form homogenous sample fraction. Analysis performed at Hill Laboratories - Food & Bioanalytical Division, Waikato Innovation Park, Ruakura Lane, Hamilton.	-	1-16
Biological Materials Digestion	Nitric and hydrochloric acid micro digestion, 85°C for 1 hour. Analysis performed at Hill Laboratories - Food & Bioanalytical Division, Waikato Innovation Park, Ruakura Lane, Hamilton.	-	1-16
Arsenic	Biological materials digestion, ICP-MS.	0.02 mg/kg as rcvd	1-16
Cadmium	Biological materials digestion, ICP-MS.	0.0004 mg/kg as rcvd	1-16
Chromium	Biological materials digestion, ICP-MS.	0.02 mg/kg as rcvd	1-16
Copper	Biological materials digestion, ICP-MS.	0.010 mg/kg as rcvd	1-16
Lead	Biological materials digestion, ICP-MS.	0.002 mg/kg as rcvd	1-16
Mercury	Biological materials digestion, ICP-MS.	0.002 mg/kg as rcvd	1-16
Nickel	Biological materials digestion, ICP-MS.	0.02 mg/kg as rcvd	1-16
Zinc	Biological materials digestion, ICP-MS.	0.2 mg/kg as rcvd	1-16

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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J. M. Sritharan

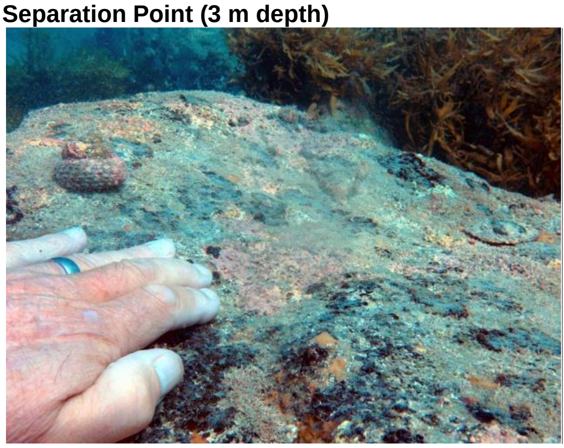
Malar Sritharan BSc
Laboratory Technician - Food and Bioanalytical Division

Appendix4 Sled footage locations

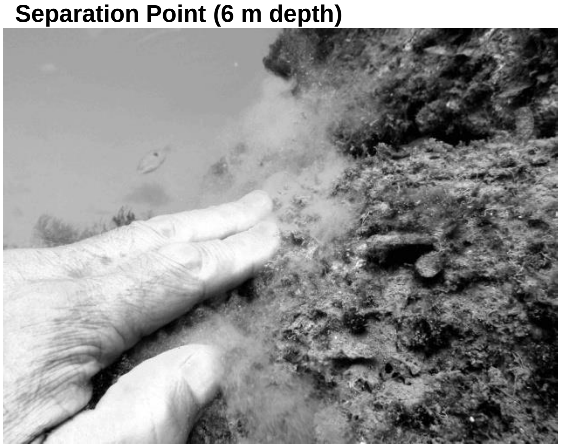
Sled tow	Tape number	Time on tape
S1 Tonga Quarry to offshore	Tape 1	All
S1 Tonga Quarry to offshore	Tape 2	All
S1 Tonga Quarry to offshore	Tape 3	All
S2 Abel Head to offshore	Tape 4	All
S2 Abel Head to offshore	Tape 5	All
S3 North coast to Tonga Is	Tape 6	All (GPS not responding)
S4 Awaroa offshore return Abel Head	Tape 7	All
S4 Awaroa offshore return Abel Head	Tape 8	All
S5 Awaroa Beach to Totaranui	Tape 9	All
S5 Awaroa Beach to Totaranui	Tape 10	0 - 37 min
S6 Wharf Rock offshore	Tape 10	37 min to end
S6 Wharf Rock offshore	Tape 11	All
S6 Wharf Rock offshore	Tape 12	0 - 4.30 min
S7 Offshore in to Foul Point (east)	Tape 12	4.30 min to end
S8 Foul Point to Tonga Is.	Tape 13	All
S9 Mosquito Bay to offshore	Tape 14	All
S9 Mosquito Bay to offshore	Tape 15	All
S9 Mosquito Bay to offshore	Tape 16	0 – 40.19 min
S10 Reef Point to Tonga Is.	Tape 16	40.19 min to end
S10 Reef Point to Tonga Island	Tape 17	0 – 12.07 min
S11 Tonga Is. To Onetahuti	Tape 17	12.08 to end
S12 Onetahuti to Reef Point	Tape 18	All

Appendix 5 Sediment photos collected form rocks along the Abel Tasman

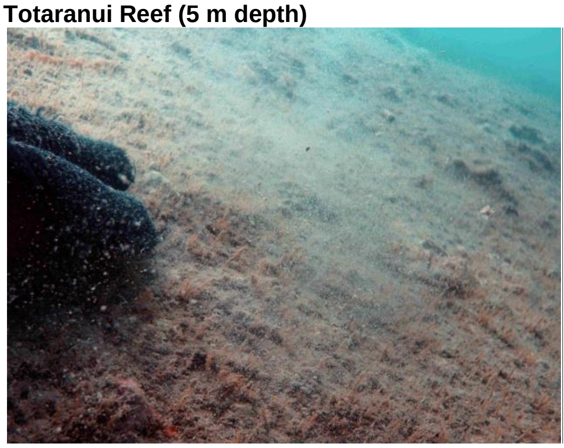
Separation Point (3 m depth)



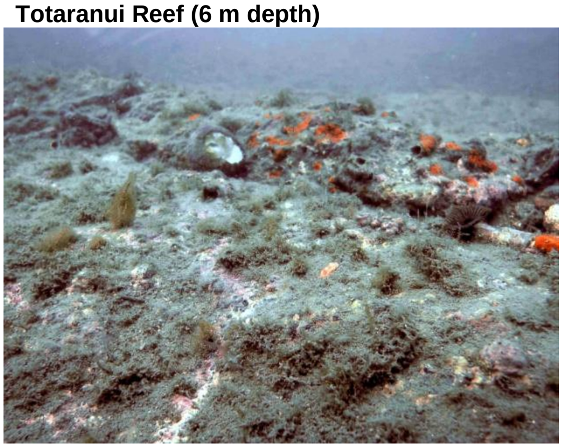
Separation Point (6 m depth)



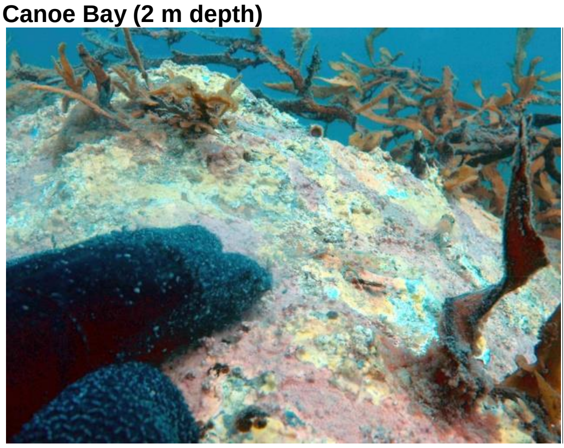
Totaranui Reef (5 m depth)



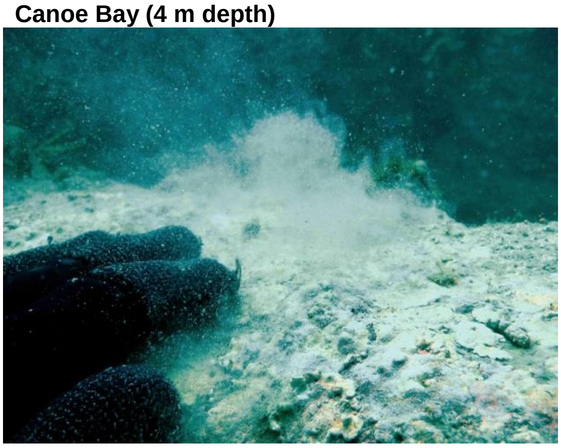
Totaranui Reef (6 m depth)



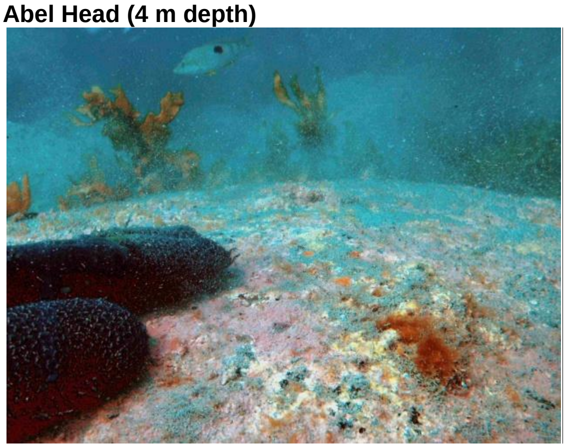
Canoe Bay (2 m depth)



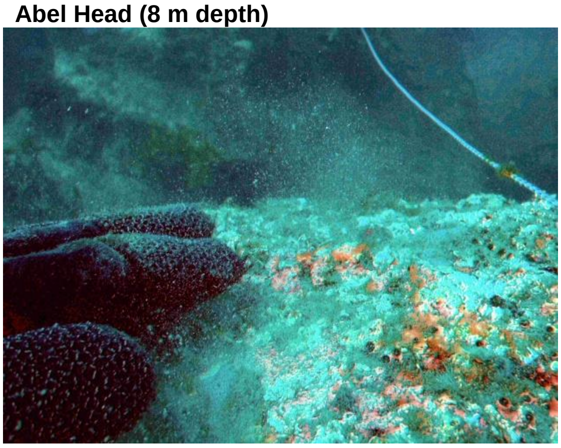
Canoe Bay (4 m depth)



Abel Head (4 m depth)



Abel Head (8 m depth)

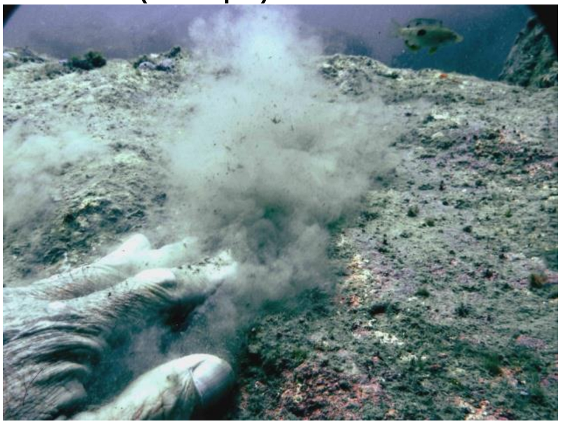


Tonga Island (4 m depth)

Tonga Island (6 m depth)

Foul Point (2 m depth)

Foul Point (6 m depth)

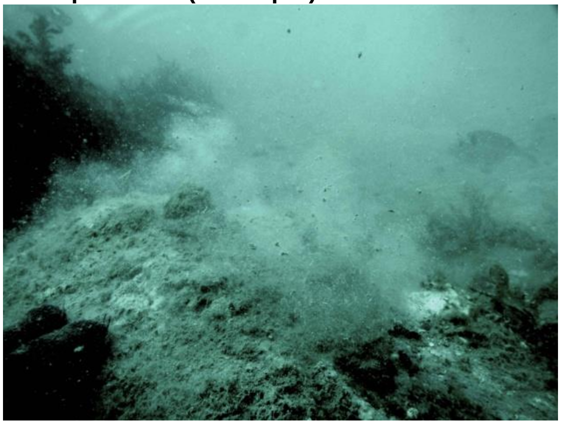


Whale Rock (3 m depth)

Whale Rock (6 m depth)

Mosquito Reef (3 m depth)

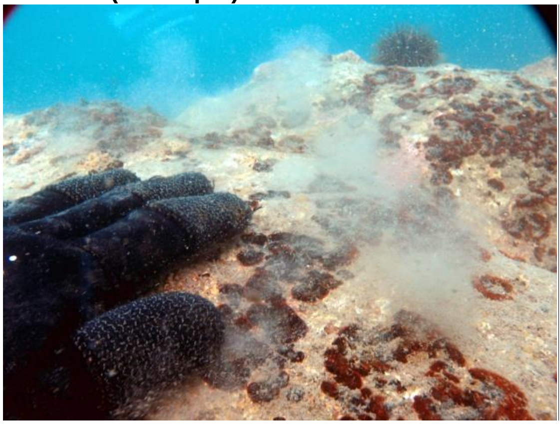
Mosquito Reef (6 m depth)



Bark Bay (2 m depth)

Bark Bay (5 m depth)

Pitt Head (3 m depth)



Pitt Head (6 m depth)