Marine habitats, fish and benthic species within a proposed marine reserve, North Nelson.

NIWA Client Report: NEL2003-005
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and

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1. Introduction

An application for a marine reserve at North Nelson (Glenduan - Ataata Point) has been lodged (Figure 1). NIWA was contracted to characterise the area and provide additional scientific information to aid the Department of Conservation and the Ministry of Fisheries in their decision-making process. Accordingly, the following tasks were completed:

(a) A review of existing information in relation to the ecology of the wider area (i.e. Tasman Bay), potential sewage impacts, and other water quality issues;

(b) A review and update of the existing habitat information relevant to the proposed marine reserve, including existing side-scan information, bathymetric surveys, dredge surveys of sediments offshore from reefs, quadrat surveys of benthic organisms, a ROV survey, and fish counts on reefs.

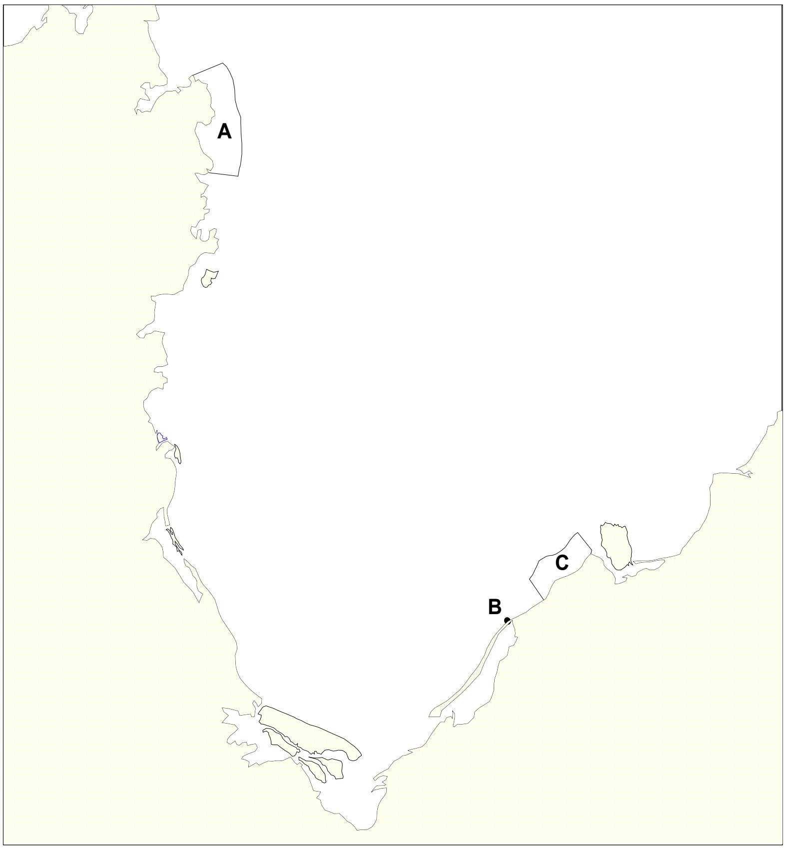

Figure 1. Tasman Bay, showing areas referred to in text. A = Tonga Island Marine Reserve; B = Wakapuaka Treatment Plant outfall; C = proposed North Nelson Marine Reserve.

This report presents a summary of the existing information on the physical and biological environment of Tasman Bay, the methods used to collect additional information, and the results of those surveys. In addition, it discusses results of an additional subtidal reef survey that included samples within the proposed marine reserve area.

2. Existing knowledge

This section provides a review of environmental information relevant to the proposed North Nelson Marine Reserve. Much of the information is derived from the review by Bradford-Grieve et al. (1994), except where stated.

2.1. Physical Environment

2.1.1. Water movement

Circulation in Tasman Bay is predominantly anticlockwise, with stronger flows near D'Urville Island. A weak southerly flow has been observed in the southeastern part of the Bay, towards Nelson. Typical average current velocities are 0.02-0.05 $m.s^{-1}$, but are dominated by tidal flows with typical velocities of 0.15-0.3 $m.s^{-1}$. River flow is potentially important to local oceanography because of its influence on stratification. Heath (1979) considered the higher-order tidal signals of Tasman Bay, noting that the one-sixth diurnal (4.1 hr) tide ran along the axis of the bay, whereas the quarter and eighth diurnal (6.2 and 3 hr) oscillations ran across it.

Along the Boulder Bank, in the vicinity of the Wakapuaka effluent outfall, regular, tidally-driven patterns of water movement occur parallel to the shore (Barter & Forrest, 1998). There is evidence for the occurrence of a southerly current during larger swells.

The wave climate of Tasman Bay is poorly-known but is generally small, due to shelter from oceanic swells, and being fetch-limited. Northerly and northeasterly winds have the longest fetch and, in combination, blow for between 10 and 30% of the time, predominantly in spring and summer (60% higher incidence than in winter). Given the shallow nature of the Bay, and the fine sediments present, fine-grained material may be resuspended periodically by strong winds, particularly those from the northern quadrant.

2.1.2. Bathymetry

Water depths in Tasman and Golden Bays are generally less than 60 m, and the seabed is gently sloping (typically 1:1000 gradient) so that bathymetric contours tend to follow the outline of the coast. There are no major changes in seafloor morphology in either bay, and the localised areas of rocky reef that occur lie shallower than the 10-m depth contour and between 1 and 4 km of the shore.

Along the southern part of the Boulder Bank, the seabed slopes to 10 m over a relatively short distance and then more gradually to 20 m. Along the northern part, both the 10 m and 20 m contours lie relatively close to shore, beyond which the seabed slopes gradually to 30 m.

2.1.3. Sedimentology

Most of the seabed of Tasman and Golden Bays consists of silt, with patches of shelly gravel. Sandy sediments occur around Farewell Spit, D'Urville Island and many of the bays around the edges of Tasman and Golden Bays. Biogenic reefs, dominated by bryozoan colonies, occur around Separation Point (Grange, in press). The predominantly muddy nature of the sediments reflects the input from rivers (mainly the Aorere, Takaka, Motueka and Waimea) and the relatively low average intensity of waves and currents in the area.

Off the Boulder Bank, around the Wakapuaka sewage effluent outfall, boulder habitat extends for 10s to 100s of metres offshore, sometimes patchily distributed within areas that are predominantly composed of soft, medium-grained sand (Barter & Forrest, 1998).

2.1.4. Geomorphology of the Boulder Bank

The Boulder Bank stretches for 13 km from Mackay Bluff, at the northern end, to Haulashore Island in the south, and ends just north of Arrow (Fifeshire) Rock. It consists of 2 units of granodiorite gravel - a ridge of mobile, well-sorted pebbles and cobbles, and a gravel platform of poorly-sorted gravels and boulders (Dickinson & Woolfe, 1997). The ridge lies above mean sea level and slopes steeply seaward. The platform is exposed only at low tide, and slopes gently seaward.

Alternative explanations for the origin of the Boulder Bank are:

i) longshore drift carrying material southwest from its source on Mackay Bluff (the Bank is composed almost entirely of Cable Granodiorite, which only outcrops at the headlands of Mackay Bluff and Cable Bay);

ii) landward transgression of gravels from an offshore ridge of Cable Granodiorite, driven by Holocene sealevel rise (Dickinson & Woolfe, 1997). Dickinson & Woolfe (1997) argue for the latter on the grounds that the structure of the bank, and the fact that although the gravel ridge of the bank is actively migrating, the boulders are immobile and could not have migrated 13 km over the last 6500 years through longshore drift. Johnston (2001) argued against the interpretations of Dickinson & Woolfe (1997), provided additional material regarding morphology of the bank, and reiterated the view that the boulder bank was derived from material eroded from Mackay Bluff. However, Johnston (2001) did acknowledge that a submerged bank might contribute to the northern boulder bank.

Gravel-dominated barriers are important features of mid-high latitude coasts, but their stability and relationship to gravel deposits of inner shores are poorly understood (Hartstein & Dickinson, 2001). There is growing evidence to suggest that Holocene migration rates were episodic, but there is a lack of direct evidence (Hartstein & Dickinson, 2001, cite only one described example of such 'overstepping'). Such information on the behaviour of gravel shores during the Holocene transgression is important for predicting responses to the current phase of sealevel rise. Hartstein & Dickinson (2001) present another example of gravel barrier migration using field measurements and direct observations of the Cable Bay gravel barrier to model migration and overstepping. Between 8000-6000 years BP, the barrier migrated landward over back-barrier muds by the processes of overwash and rollover. After 6000 years BP, a large storm, or series of storms, caused rapid landward migration during which part of the barrier volume was left on the shoreface (forming the present-day offshore gravel lag) while the rest was entrained inland.

2.1.5. Water quality

Possible threats to water quality in Tasman Bay include use of agricultural chemicals, sewage treatment, and runoff from land containing sediment, nutrients and toxic contaminants. A review of the use of agricultural chemicals in the Nelson area during the period 1986-1988 concluded that only the horticultural chemical azinophos-CH3 had the potential to adversely affect aquatic environments, and that, because of its short half-life in soil (c. 3 weeks), the risk of impact was small.

Total freshwater and effluent loadings of nitrogen to Tasman Bay represent about 7% of the total nitrogen pool in the Bay, suggesting that oceanic water is the major source of 'new' nutrients (source of information: letter dated 5 October 2001 from Paul Barter (Cawthron) to Peter Ollivier (Duffill Watts & Tse) updating the Wakapuaka Oxidation Pond Environmental Impact Assessment): The average load of nutrients from the Wakapuaka treatment ponds represents, in turn, about 5.7% of total freshwater/effluent loading to Tasman Bay. Nutrients from the ponds may slightly exacerbate natural phytoplankton blooms, but they are considered unlikely to cause them.

Under present operating conditions, the Wakapuaka sewage effluent does not cause detectable adverse effects on water quality or the seabed (Barter & Forrest, 1998). This was attributed to effective treatment, large dilution via subtidal diffuser discharge and to effective mixing as the effluent plume rises to the surface after discharge. Effluent is well-dispersed after discharge because the receiving environment is semi-exposed, relatively dynamic with moderate water currents and experiences periods of large swells. Unusually high biological oxygen demand of the pond influent, combined with calm conditions, caused the ponds to 'crash' in April/June 1999 and April/June 2000, resulting in reduced effluent quality (high concentrations of suspended solids and coliform bacteria) (source of information: letter from Paul Barter to Peter Ollivier dated 5 October 2001, cited above). Sampling after the crashes (October 2001) showed no obvious deterioration in sediment quality around the outfall, or to assemblages on hard substrata.

Reported concentrations of cadmium in scallops from Tasman Bay were relatively high but it was not clear whether this was due to sources on land or in the sea. Possible sources include runoff of superphosphate fertiliser, which contains relatively high concentrations of cadmium, or natural marine sources via introduction of deep offshore water to the Bay.

Chang (1983) identified a prymnesiophyte phytoplankter as being responsible for the "Tasman Bay slime" outbreaks of spring 1981, whose mucilage disrupted fisheries. Mackenzie & Gillespie (1986) considered hydrography, nutrient chemistry and plankton from an inshore site in Tasman Bay. They considered that nitrogen supply limited phytoplankton growth, and that rainfall events preceded phytoplankton blooms. Gibbs (2001) compared sedimentation, suspension and resuspension in Tasman Bay with that in Beatrix Bay, Marlborough Sounds. He noted that resuspension of sediments was an important contributor to suspended solids. Gillespie et al. (2000) studied microphytobenthos of sediments primarily in Tory Channel, but included some information from Tasman Bay. They noted that microphytobenthic populations were less dense and taxonomically distinct in the bay, and concluded that they could make important contributions to macroinvertebrate foodwebs.

2.2. Biological Environment

2.2.1. Habitats and biota

Around 350 invertebrate species have been identified from soft-sediments in Tasman Bay. Data derive mainly from qualitative surveys and quantitative data on these benthic assemblages are limited.

The faunas of sandy-mud or muddy sediments in Tasman Bay have been described as an "*Amphiura rosea – Dosinia lambata* community", occurring particularly in western parts of the Bay. Characterising species in this community are the bivalves *Dosinia lambata*, *Neilo australis* and *Nucula nitidula* or *N. hartvigiana*, the turret shell *Maoricolpus roseus*, the brittle-star *Amphiura rosea* and the heart-urchin *Echinocardium cordatum* (amongst many other, co-occurring species). Most of these species are deposit feeders. Sandier sediments, such as occur in central, eastern and northern parts of the Bay, contain assemblages characterised by the bivalves *Gari lineolata*, *Dosinia lambata*, *Nucula hartvigiana*, *Neilo australis, Pratulum pulchellum* and *Scalpomactra scalpellum*, *Amphiura rosea* and *Echinocardium cordatum*. Again, most of these are deposit feeders, and the number of species common to both of these so-called 'communities' suggests that faunal differences among places within the Bay are not particularly distinct.

Habitat structure and species composition of areas off the Boulder Bank adjacent to the Wakapuaka effluent outfall were similar to those described for other parts of the Boulder Bank (Barter & Forrest, 1998). Widespread surface-living species in sandy areas included the cushion star, *Patiriella regularis*, the 11-armed starfish, *Coscinasterias muricata*, hermit crabs, sea cucumbers (*Stichopus mollis*) and whelks (*Cominella virgata* and *C. adspersa*). The lancelet, *Epigonichthys hectori*, was also present at most sampling sites, at densities of 100-753 m^{-2} (among the highest recorded in New Zealand for this scientifically-interesting species). The infaunal community was dominated by syllid, sabellid, lumbrinerid and cirratulid polychaetes, amphipods and cumaceans (relative dominance varied among sites), with averages of 10-17 taxa, and 45-200 individuals per 10 cm deep x 13 cm diameter core. Overall, diversity and abundances of macrofauna in this part of the Bay were quite low, perhaps reflecting the low organic content of the sand and its instability in response to disturbance during storms and large swells.

Barter & Forrest (1998) noted the absence of large seaweeds on the subtidal boulders, but encrusting corallines were conspicuously present. Common species around the outfall and at distant control sites were *Patiriella regularis*, *Coscinasterias muricata*, *Evechinus chloroticus*, *Cookia sulcata*, *Modiolarca impacta*, *Monia zelandica*, ascidians (*Cnemidocarpa bicornuata*, *Botryllus schlosseri*, *Didemnum candidum*), finger sponges such as *Callyspongia ramosa* and *Raspailia topsenti,* the massive sponge *Ancorina alata*, and the globose sponges *Aaptos aaptos* and *Tethya* spp. The outfall pipe had high densities of the anemone *Actinothoe albocincta*, whereas densities on nearby rocky areas were lower (a similar pattern reported by a study of the fisheries outfall 5.5 km to the south). A seaweed bed was reported north of the outfall pipe, at the lower edge of the boulder habitat. Barter & Forrest (1998) state that there are "very few harvestable shellfish along the Boulder Bank".

The faunal assemblages in the sediments of Tasman Bay provide food for several species of fish, including those of commercial or recreational importance, such as snapper and tarakihi. Snapper population size in Tasman Bay is known to have fluctuated greatly over time, and there is recent evidence that this has had genetic effects (Hauser et al. 2002). There is a general relationship between snapper year class strength and water temperature, and it appears to apply to the Tasman Bay fishery. Highest catches of juvenile snapper come from the west side of Tasman Bay (Blackwell & Stevenson 1997). Godfriaux (1974) identified polychaetes and crustaceans as comprising most of the diet of tarakihi less than 15 cm fork length.

The subtidal reef assemblages of Nelson Boulder Bank have been sampled by Nick Shears, Clinton Duffy et al., and those authors have indicated that they will supply a separate report. It suffices to say here that inshore (< 6 m depth) there were mixed seaweed beds comprising *Carpophyllum maschalocarpum*, *C. flexuosum*, and *Sargassum sinclairii*. (*Cystophora retroflexa* is also present - R. Cole, pers. obs., this study, see below). Further offshore there occurred a barrens habitat with variable densities of sea urchins, and on some transects, there was also a deeper monospecific stand of *Carpophyllum flexuosum*. Some information regarding the chemical composition of that seaweed is available, specifically regarding grazer deterrence. Cole & Haggitt (unpubl.) have recorded polyphenolic composition of *C. flexuosum* on Nelson Boulder Bank, finding it to be variable at short distances (adjacent plants, adjacent axes within plants), but still in keeping with the high levels described further north (Cole & Haggitt 2001). From the early work of McLean & Grange (1995) and Grange & Cole (1996) it is known that there are sponge gardens toward the lower edge of the reef in some parts of the boulder bank, but Shears et al. limited their sampling to depths shallower than 12 m.

Barter & Forrest (1998) reported small numbers of fish from their survey of subtidal habitats around the Wakapuaka outfall, the most common being variable triplefins (*Fosterygion varium*), spotties (*Notolabrus celidotus*) and blue cod (*Parapercis colias*). In contrast to an earlier study of the fisheries outfall off the Boulder Bank near Nelson, abundances did not appear to be any higher around the outfall than elsewhere.

Cole (2001) included 5 sites on the Nelson Boulder Bank in his survey of herbivorous fishes. He failed to record any herbivorous fishes in those counts, but butterfish (*Odax pullus*) and marblefish (*Aplodactylus arctidens*) have been observed there (RGC pers. obs., present study).

Taylor et al. (1995) included the Tasman Bay area in their study of fur seals (*Arctocephalus forsteri*). Although Tasman Bay proper was not occupied by seals, populations in all four Nelson - Marlborough areas considered were expanding, which they explained as owing to recolonisation of traditional breeding grounds following human exploitation.

2.3. Summary of general ecology of Tasman Bay.

Tasman Bay is a large (>4000 km2) wide, shallow (generally > 30 m), and relatively sheltered bay, characterised by weak tidal currents that cause a general anticlockwise circulation pattern but a southerly flow in the south-western part near Nelson, that is strongly influenced by local wind conditions. The tidal range is large (almost 4 m during spring tides) and river input is important is supplying nutrients.

Water quality is generally good, being influenced by land runoff from urban and agriculture activities, with about 5.7% of the total freshwater/effluent loading coming from a single source, the Wakapuaka treatment ponds. No detectable adverse effects on water quality or the seabed have been recorded from this effluent and the southerly flow near the outfall will tend to carry any effluent away from the proposed North Nelson Marine Reserve.

The intertidal areas are of 3 distinct types: sandy beaches, extensive estuaries, and rocky reefs that can be further sub-divided into bedrock reefs (mainly along the Abel Tasman and north-eastern coasts) and boulder beaches along the Boulder Bank. Beyond 400 m from the shore, much of the seabed of the Bay consists of mud and silt, with patches of shell gravel. Biogenic reefs (dominated by bryozoan colonies) occur off Separation Point.

The mud and silt subtidal habitats support a variety of benthic species, but the most dominant are deposit-feeding bivalves, brittle stars and heart urchins. This community occurs throughout the Bay, with little change in dominant species patterns except for the addition of suspension-feeding bivalves in the sandier patches. A large proportion of the seabed is used for scallop enhancement, which involves seeding of scallop spat followed by dredging the adults 2-4 years later, rotated by area and based on an annual stock assessment.

The subtidal area of the Boulder Bank consists of a narrow band of macroalgae, dominated by *Carpophyllum* spp. Urchin barrens dominate in depths between around 6 and 8 m, below which a richer fauna of ascidians and sponges have been reported before the mud seabed is reached at around 12-15 m depth.

3. Methods

The proposed marine reserve area was sampled using a variety of methods, including depth soundings, dredge sampling, video sampling using a ROV, quadrat sampling of rocky reefs, and fish transects on rocky reefs. Methods for each of these are described in turn below.

3.1. Depth sounding

Bathymetric surveys were undertaken for the western part of the proposed reserve area using a portable Triducer 200 KHz depth transducer interfaced with a Garmin GPS, recording position and depth data approximately every 2 seconds. The data were then plotted using ArcView GIS.

3.2. Sidescan sonar

Existing side-scan data were generously provided by Dr W. Dickinson (Victoria University) and N. Hartstein (NIWA). These data had been previously collected as part of a study on the possible origin of the Boulder Bank (see introduction above) and included images of the study area. This survey used NIWA’s 100 KHz C-MAX side-scan, positioned with DGPS and post-processed into a mosaic using CODA software. These side-scan images were used to delineate reef areas, identify different sedimentary types offshore from reefs, and to stratify dredge and ROV sampling.

3.3. Remote-operated Vehicle

A VideoRay ROV, fitted with a high-resolution video camera, was deployed at 22 stations within the proposed marine reserve area. Stations were planned to cover the range of sediment types and habitats and the approximate position for each was determined from the bathymetric data and side-scan sonar results. At each station, the vessel was anchored and the ROV flown from the surface in random directions for approximately 5 minutes. The video signal was recorded on to Digital-8 tape in the field. Post-processing included viewing the video footage and recording the dominant habitat type and species present, along with depth. Samples of video were captured digitally from each ROV station and used to produce MPEG files suitable for viewing on PC.

3.4. Dredge Sampling

Eight dredge samples were taken in sediments offshore of the reef habitats. The position of each was determined from side-scan sonar and ROV results. The naturalist's dredge used has an opening measuring 600 mm x 260 mm and is covered with 2 mm mesh. It has been widely used for characterising the fauna of areas in Marlborough Sounds. We consider that it samples species that are both surface-dwelling and buried up to 5-10 cm in the sediments adequately. Each dredge position was recorded using GPS and all material collected by the dredge returned to the laboratory for sorting, enumeration, and identification.

3.5. Benthic Habitats of Rocky Reefs.

Nine sites were sampled between 0 and 12 m depth by Department of Conservation and University of Auckland researchers in a separate programme in 1999. Those results have been made available to us (Shears and Duffy report, presented as Appendix 3 attached).

Given such intensive sampling of shallow areas, we focussed quadrat sampling at depths between 12 m and the reef edge during December 2002. On six transects spread through the proposed reserve area, five 1-m^2 quadrats were sampled roughly equally spaced through the depth interval, so that the entire depth range of reef was sampled.

In each quadrat, depth, substratum type, substratum cover (estimated in 5% categories), number of mobile benthic invertebrates (echinoderms and larger molluscs), and numbers of benthic invertebrates such as sponges were recorded.

Additional organisms and habitat associations were noted when they occurred outside quadrats.

Two types of variables were recorded within each quadrat. Firstly, each quadrat was characterised by the percent cover of up to 12 variables (bedrock, boulder, cobble, sand, shell, silt, coralline algae, fine brown weed, silt on rocks, the sponge *Aplysilla sulfurea*, red algae, diatom mats, and encrusting ascidians). Second, the abundances of 53 different types of biota were recorded. These two data types are dealt with separately, because of their differing natures. Median and mean (average) abundances or covers are presented; medians are a robust measure of central location which influenced little by outliers, whereas means are more widely used. Medians are presented and discussed where data are skewed. Spearman rank correlations were calculated between percent covers and depth, and between abundances of common species and depth. We also used non-metric multidimensional scaling (e.g. Clarke & Warwick 2001) and principal component analysis (Legendre & Lengendre 1983) to summarise multivariate patterns in the datasets.

In two randomly chosen 5-m sections of each fish transect (see below), benthic habitat characteristics were also recorded during February 2003. These included information regarding substratum type (sand, cobbles, boulders, bedrock etc.), topographic complexity (qualitative scale from 1-5), seaweed cover and canopy composition (10 point qualitative scale) and height (m). These additional data, which included information from areas shallower than 12 m, were used to supplement the data collected above.

3.6. Fish Sampling on Rocky Reefs

Sampling of the fish fauna was first attempted in December, but poor visibility (< 1 m) prevented data being collected, and it was not until February 2003 that weather and sea conditions were suitable, with underwater visibility exceeding 5 m. Sampling was done using the methodology developed in NIWA's FRST-funded "Sustainability and Enhancement of Coastal Reef Fisheries of Economic and Cultural Importance" research programme. Tape transects (30 m x 4 m, with a 10-m uncounted lead-in) were sampled while laying the tape. Transects were distributed across the reef, among the following strata: Reef edge, barrens, *Carpophyllum flexuosum*, and shallow mixed algae. All large (i.e. non-triplefin) fish that were encountered as the divers swam the tape out were counted and their total lengths estimated to the nearest 1 cm. A further record was kept of species that were observed but did not occur in fish counts. These included triplefin species. Finally, to demonstrate relationships between North Nelson and other areas, we projected the fish count data from North Nelson onto principal component analyses for two existing datasets in the region, using Proc Score in SAS (SAS Institute Inc. 1989).

4. Results

4.1. Side-scan Sonar

The side-scan mosaic did not record sea floor features closer than 80-170 m from low tide due to the shallow depths and bedrock outcrops that made it too risky to tow the side-scan that close to shore. This prevented us from accurately mapping the nearshore reefs, but diver observations during fish sampling showed bedrock to be common in shallower parts of the area. The side-scan survey revealed a general pattern of relatively uniform hard substratum from 100 m to 250-350 m from shore along most of the area. This broadened to approximately 430 m in the southern portion of the area, where the Boulder Bank is more pronounced intertidally. This sea floor type was assumed to be boulders lying on sand. Along most of the coastline within the proposed reserve, the side-scan results showed an abrupt change to less reflective (i.e. soft) sediments seaward of the boulders, except at a few sites in the southern and central portion that appeared to represent coarser sediment, such as gravels or coarse sand. Several offshore features and bedrock in the northern part of the proposed reserve area were also evident in the side-scan mosaic off Ataata Point, and there were two rock pinnacle features close to shore near Mackay Bluff.

4.2. ROV Survey

A total of 22 ROV stations was completed during December 2002 and January 2003 (Figure 2). Although the geographic spread of these stations appears to be concentrated in the nearshore zone, this reflects the major habitat types identified from the side-scan sonar results. Stations covered a range of depths (approximately 4-26 m) and habitat types, including shallow reef/kelp forest, deeper reef/sponges, reef edge, gravel, sand, and mud. A summary of the depth and habitat type at each ROV station is shown in Table 1.

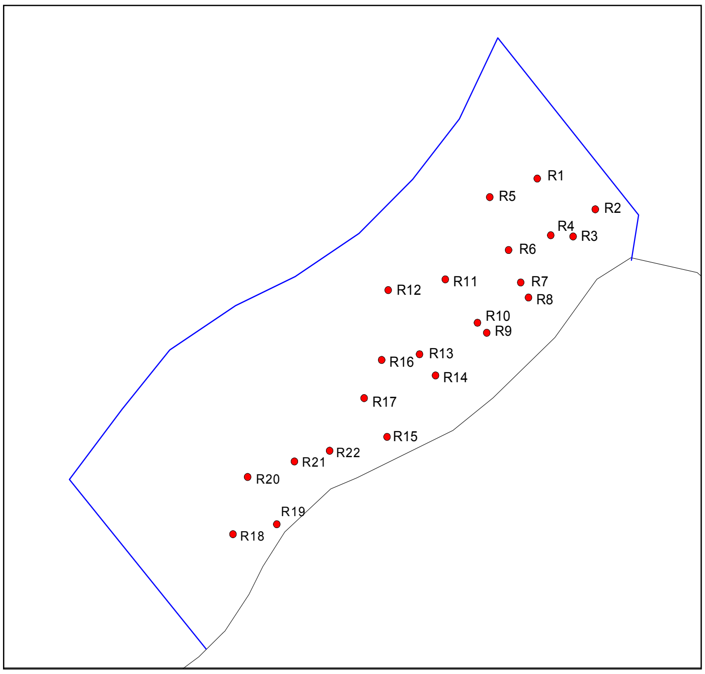

Figure 2. Positions of ROV stations, proposed marine reserve, Glenduan – Ataata Point.

Table 1. Depth and habitat description of each ROV station within proposed marine reserve.

ROV site	Depth (m)	Sediment type
1	25.6	mud, heart urchins, hermit crabs
2	20.5 - 21.2	shell gravel to reef edge
3	22.0 - 22.6	mud, horse mussels
4	24.2	mud, fine sand, heart urchins
5	26.4	mud, heart urchins
6	25.5	mud, heart urchins
7	23.9	mud, bivalve shells
8	13.8 - 14.6	rocky reef, sponges
9	17.8 - 19.1	boulders and reef outcrops on sand
10	23.5	shelly / gravel
11	25.1	mud,heart urchins
12	24.8	mud, heart urchins
13	23.5	sandy mud, horse mussels
14	17.2	reef, sand, sponges, starfish
15	9.0	rocky reef, sponges, urchins
16	21.6	mud, dead shells, sediment waves
17	20.9	sand, dead shell, bivalves
18	13.6	coarse sand, large ripples
19	3.6	shallow reef, macroalgal forest
20	22.9	sand, shell, sediment waves
21	22.2	sand, shell, sediment waves
22	10.9	rocky reef, sponges

A total of 80 species was recorded from the ROV video footage. The most widespread species were hermit crabs (*Pagurus* sp), the cushion star (*Patiriella regularis*), and the bivalve *Tawera spissa*. Algae were generally restricted to the shallow reefs (< 10 m) whereas reefs deeper than 9 m supported a relatively diverse sponge fauna (8 species). In terms of the species diversity of each habitat, the deeper reefs supported over 20 species per station. Both the deep mud habitat and the shell gravel/sediment wave habitat were the least diverse. Fewer than 5 species per station were recorded from these habitats, although these represent only those species able to be seen from the video footage and many more could be buried below the surface of the sediment. A list of the species recorded from the video footage at each ROV station is included as Appendix 1.

4.3. Dredge Survey

The position of each dredge station is shown in Figure 3. In general, these were further offshore than the ROV stations and were restricted to the mud or shell/gravel habitats, except D3, which was in the coarser shell gravel/sediment wave habitat. The dredge samples in the mud habitat collected 18-30 species, while the one in the coarser habitat collected 16, and only 14 species were collected in the sample from the gravel habitat, reflecting the instability of the sediment.

A full list of the species collected in each dredge sample is provided in Appendix 2. The most common and widespread species were the heart urchin *Echinocardium cordatum*, the nut shell *Ennucula strangei*, the bivalve *Dosinia lambata*, the introduced Japanese bivalve *Theora lubrica*, and the brittle star *Amphiura rosea*.

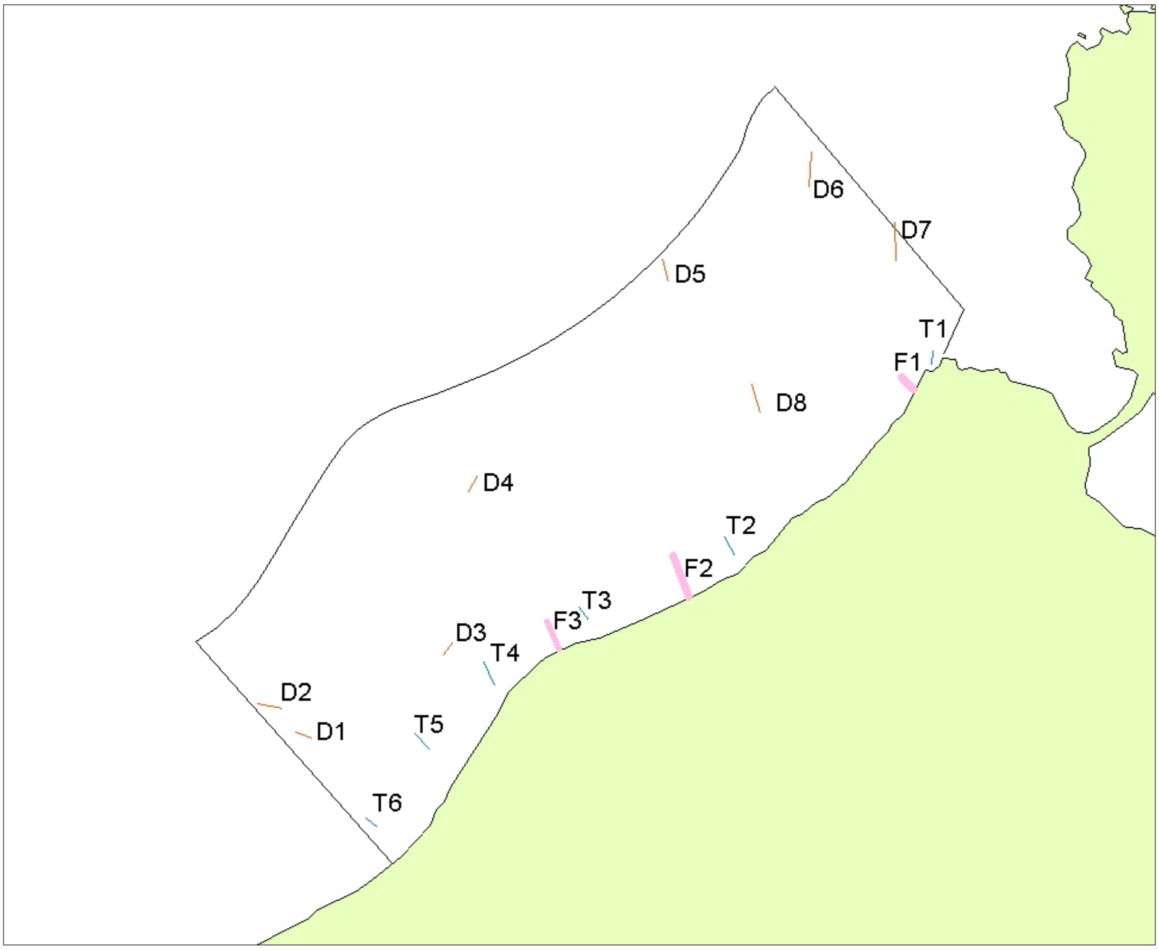

Figure 3. Positions of dredge stations (D1-D8), benthic habitat transects (T1-T6), and fish counting areas (F1-F3), proposed marine reserve, Glenduan – Ataata Point.

4.4. Benthic Habitats of Rocky Reefs

4.4.1. Percent covers on rocky habitat (12 m to reef edge)

Of the lithic habitat variables (i.e. bedrock, boulders, cobbles, sand, shell, and silt), only boulders, sand, and shell had non-zero medians. This indicates that most of the transects were distributed in areas of boulders, and that sand and shell is common on reefs throughout the 12-20 m depth range.

Coralline algae comprised the dominant habitat cover on rocky reefs, with a median value of 70% cover, and an average of 52% (s.d. = 36%). Of the remaining variables, fine brown algae (mean = 10.7%, s.d. = 22.6%) and diatom mats (mean = 4.7%, s.d. = 19.4%) comprised the greatest proportions; the other variables were represented in very small amounts.

Covers of sand (r = 0.35), shell (r = 0.39), and the sponge *Aplysilla sulphurea* (r = 0.31) were positively correlated with depth, whereas cover of fine brown alga was negatively correlated with depth (r = -0.37). Unsurprisingly, covers of coralline algae were negatively correlated with sand and shell, but percent cover of fine brown alga was positively correlated with occurrence of cobbles. (Its appearance on cobbles may be due to this alga being an early successional species that colonises uncovered space, or it may occur where grazers are unable to maintain steady contact with the seabed). Diatom mats were strongly positively correlated with shell (r = 0.71), and encrusting ascidians were positively correlated with percent cover of bedrock.

A principal component analysis on the correlation matrix of the percent cover data gave a first component accounting for 24% of the variation, and identified positive links among depth, sand, shell, and diatom mats, and a negative loading for coralline algae. The second component (17% of variation) had positive loadings for bedrock and encrusting ascidians, and negative loadings for cobbles and fine brown algae.

In summary, the percent cover variables showed weak relationships with depth, and identified a link between cobbles and fine brown alga.

4.4.2. Count data

A total of 53 discrete (i.e. countable) biotic variables was recorded in the 30 quadrats between 12 and 20 m (Table 2). In most cases these variables corresponded to species, but some hydroids, bryozoans and sponges were lumped. No species was very abundant, but several had mean abundances of greater than 1 m^{-2}. The cushion starfish *Patiriella regularis* had a mean abundance of 1.3 m^{-2} (s.d. = 1.0), the window oyster *Monia zelandica* had a very patchy distribution, with a mean abundance of 2.8 m^{-2} (s.d. = 31.6), and the saddle ascidian *Cnemidocarpa bicornuata* had a mean abundance of 3.2 m^{-2} (s.d. = 23.4). Other species were uncommon. Transects 3 (4.2 +/- 2.1) and 6 (7.8 +/- 2.7) had lower total abundances of individuals than the other transects, whose means were all greater than 12 m^{-2}.

One quadrat (quadrat 1, transect 3) contained no organisms at all, and was excluded from further analyses considered in this paragraph. MDS analysis of the 53 species x 29 quadrat dataset in presence - absence form (i.e. on Bray-Curtis similarities) produced a poor fit (stress = 0.20), indicating that there were few clear patterns of similarity among samples (results not shown). This conclusion was supported by a principal component analysis that produced a series of components accounting for less than 10% of the variability, but with small declines).

Table 2. The 53 biota variables whose abundances were recorded in quadrat samples, proposed marine reserve, North Nelson

Species
Evechinus chloroticus
Patiriella regularis
Stichopus mollis
Monia zelandica
Trochus viridis
Cookia sulcata
Stegnaster inflatus
Aplysilla sp.
Forsterygion lapillum
Cnemidocarpa bicornuta
Ancorina sp.
Galeolaria hystrix
Modiolarca impacta
Cellana sp.
Tethya ingalli
Actinothoe albocincta
Maoricolpus roseus
Pagurus sp.
Dosinia sp.
Cleidothaeras maorianus
Pentagonaster pulchellum
Ophiopsammus maculata
Buccinum lineum
Scorpis lineolatus
Celleporaria agglutinans
Forsterygion sp.
Cominella virgata
Carpophyllum flexuosum
Protula bispiralis
Balanus sp.
Hydroids
Notolabrus celidotus
Parapercis colias
Anomia trigonopsis
Encrusting bryozoan
Octopus maorum
Turbo smaragdus
Cryptoconchus porosus
Amphiura sp.
Orange encrusting ascidian
Corynactis haddoni
Didemnum sp.
Bryozoans
Magasella sanguinea
Cominella adspersa
Aulacomya maoriana
Yellow sponge
Brown encrusting sponge
Serpulorbis sp.
Raspailia topsenti
Chromodoris amoena
Suberites sp.
Polymastia sp

All discussion from this point on considers only the eight most abundant species: *Evechinus chloroticus*, *Patiriella regularis*, *Monia zelandica*, *Trochus viridis*, *Cookia sulcata*, *Cnemidocarpa bicornuata*, *Galeolaria hystrix*, *Anomia trigonopsis*, and *Magasella sanguinea*.

Variance component analysis indicated (as for percent cover variables) far more variability among quadrats than among transects for all taxa examined. Again, this justifies considering the quadrat data as a group, rather than identifying clear long-shore patterns.

Although none of the correlations with depth were statistically significant, there were moderate negative relationships for *Patiriella regularis* (r = -0.36) and *Galeolaria hystrix* (r = -0.34), and a weak positive relationship for *Cnemidocarpa bicornuata* (r = 0.22).

There were several conspicuous inter-relationships among the species, all of which were positive (i.e. high abundances of those species co-occurred). Abundances of *Patiriella regularis* and *Monia zelandica* (r = 0.43), *Trochus viridis* and *Galeolaria hystrix* (r = 0.37), *Cookia sulcata* and both *Galeolaria hystrix* (r = 0.44) and *Anomia trigonopsis* (r = 0.47), and *Cnemidocarpa bicornuta* and *Magasella sanguinea* (r = 0.65) were all positively linked.

A principal component analysis of the count data extracted three components, accounting for 24, 19, and almost 15 % of the variation. Examination of the plots did not suggest any clear biological interpretation, so they are not included here. The first component comprised mainly a straightforward loading of abundance, with *P. regularis*, *M. zelandica*, *T. viridis*, *C. sulcata*, and *G. hystrix* all having strong positive coefficients, and *M. sanguinea* a moderate negative coefficient. The second component (Prin2) had positive loadings for *C. bicornuta*, *G. hystrix*, and *M. sanguinea* and a weaker negative loading for *E. chloroticus*. The third component (Prin3) comprised strong negative loadings of *C. sulcata* and *A. trigonopsis*, and weak positive loadings for all other species. Component one (Prin1) scores were moderately negatively correlated with depth (r = -0.35), but the other two components were not (r = 0.17 and 0.06 for Prin2 and Prin3 respectively).

4.4.3. Benthic habitat complexity

Data on benthic species and habitats were also collected during the fish counting transects. There were few obvious patterns in the distribution of topographic complexity across reefs (Figure 4), except the obvious increase in sand and absence of bedrock in the reef edge habitat.

Seaweed covers were greatest in the inshore habitats, as expected, and canopy heights of plants were generally small (average about 0.4 m) and occurred in the inshore habitats dominated by the seaweeds *Carpohyllum* and *Cystophora* (Figure 5).

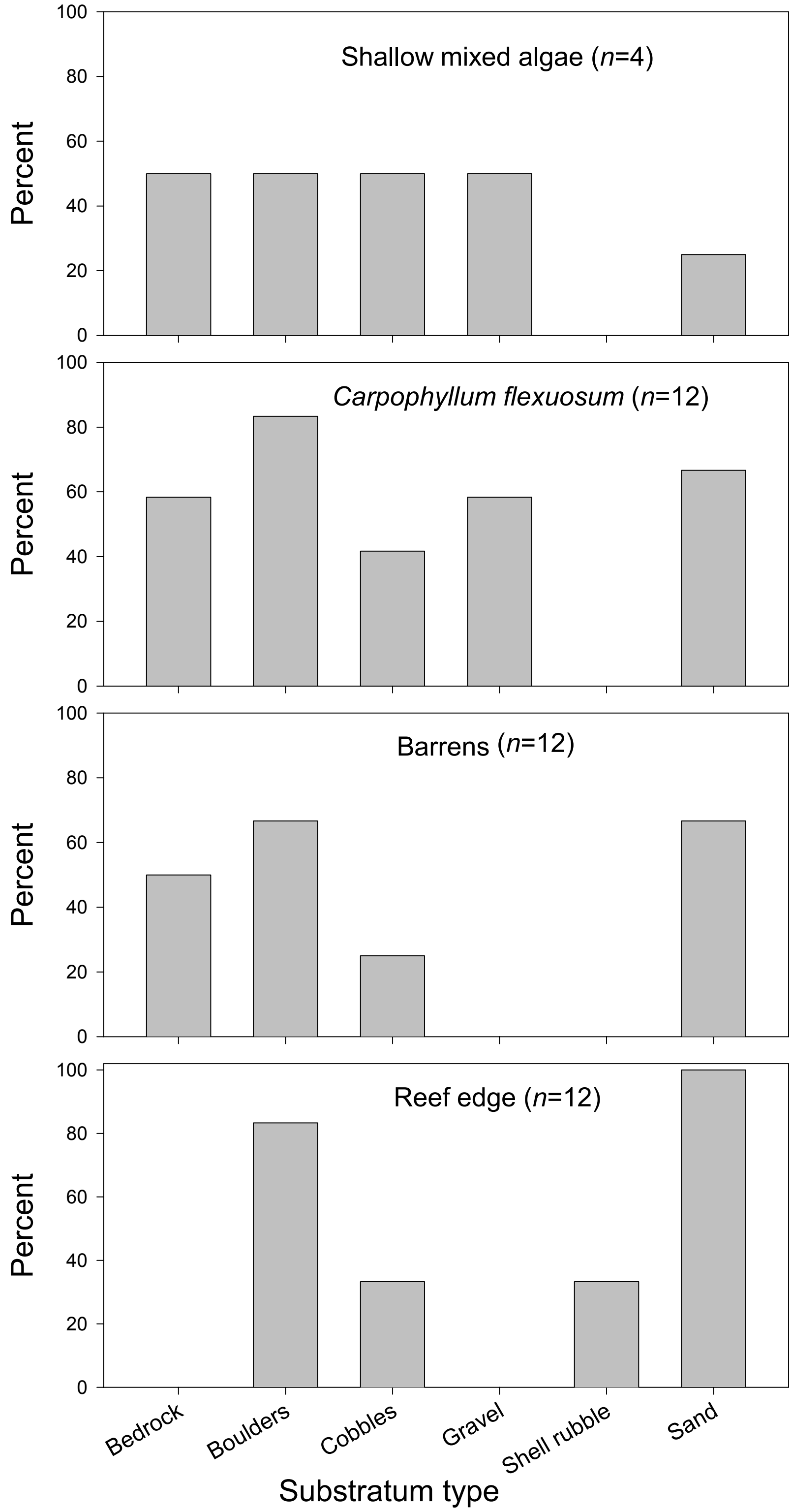

Figure 4. Representation of 6 lithic habitats in fish sampling (habitat data). Percent is the percentage of habitat transects which contained the substratum type, with a separate panel for each habitat.

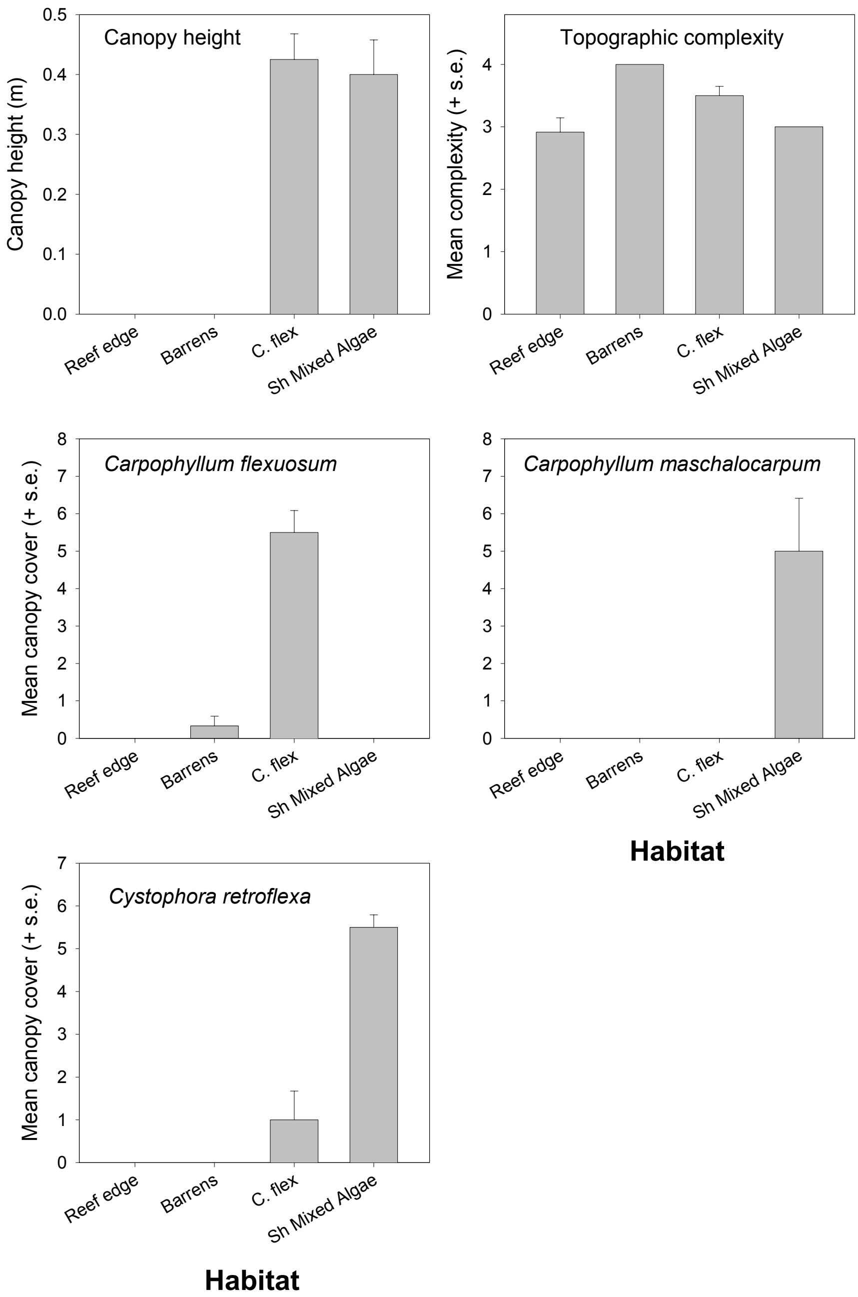

Figure 5. Habitat variables in four algal habitats, sampled during fish counts. Habitats are plotted from left to right in order of decreasing depth. Sample sizes are n=12 5 x 1 m transects, except ShMixedAlgae, where n=4. Topographic complexity estimated on 5-point qualitative scale from 0 = flat, to 5 = pinnacle and channel systems. For seaweeds Y-axis is qualitative 10-point scale, where 10 = complete cover and 0 = absence.

4.5. Fish sampling on rocky reefs

Transects were distributed across the reef, with 6 done at the reef edge, 6 done in the coralline barrens habitat, 6 done in *Carpophyllum flexuosum*, and 3 done in shallow seaweed areas. Eleven species were recorded in fish transects, and 25 species were observed by divers overall (Table 3). The most abundant fishes (excluding a school of about 200 jack mackerel *Trachurus novaezelandiae* which occurred in one transect) were spotties *Notolabrus celidotus* and tarakihi *Nemadactylus macropterus* (Figure 6).

Table 3. Fishes observed in the proposed marine reserve area, north Nelson.

Common name	Scientific name
Marblefish	*Aplodactylus arctidens*
Kahawai	*Arripis trutta*
Surge triplefin	*Cryptichthys jojettae*
Butterfly perch	*Caesioperca lepidoptera*
Red moki	*Cheilodactylus spectabilis*
Short-tailed stingray	*Dasyatis brevicaudata*
Common triplefin	*Forsterygion lapillum*
Mottled triplfin	*Forsterygion malcolmi*
Yellow-black triplefin	*Forsterygion maryannae*
Variable triplefin	*Forsterygion varium*
Blue moki	*Latridopsis ciliaris*
Eagle ray	*Myliobatus tenuicaudatus*
Spotty	*Notolabrus celidotus*
Banded wrasse	*Notolabrus fucicola*
Tarakihi	*Nemadactylus macropterus*
Butterfish	*Odax pullus*
Blue cod	*Parapercis colias*
Scarlet wrasse	*Pseudolabrus miles*
Leatherjacket	*Parika scaber*
Long-finned triplefin	*Ruanoho decemdigitatus*
Spectacled triplefin	*Ruanoho whero*
Yellowtail kingfish	*Seriola lalandi*
Sweep	*Scorpis lineolatus*
Jack mackerel	*Trachurus novaezelandiae*
Goatfish	*Upeneichthys lineatus*

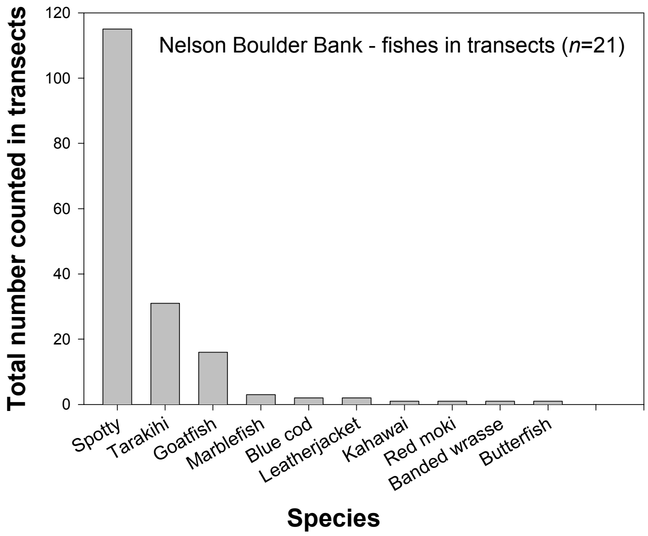

Figure 6. Species composition of fishes counted in 30 m x 4 m transects (n=21).

The main trend was for high variability in fish abundances within habitats, and for greatest abundances in shallow habitats and at the reef edge (Figure 7). Spotties *N. celidotus* occurred throughout the depth range, but were most abundant in shallow mixed algae, and then at the reef edge. That pattern was reflected in the overall number of fish, because of the numerical dominance of spotty. The two mid-depth habitats had low abundances of spotty, and of tarakihi *N. macropterus*, though that species occurred throughout the depth range. Number of species was slightly higher in reef edge habitat than in the other habitats.

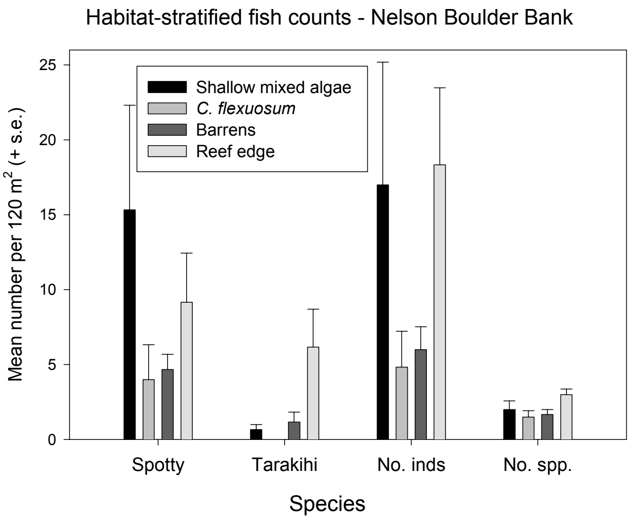

Figure 7. Densities of abundant species, number of individuals, and number of species in 30 x 4 m fish counts. Counts are segregated by habitat, and for each species bars are ordered from left to right with increasing depth. n = 6 transects for Reef Edge, Barrens, and *C. flexuosum*, and 3 transects for Shallow Mixed Algae.

The fish size distributions were dominated by individuals less than 20 cm estimated total length. The size distribution of the reef fish fauna sampled in transects had a mode near 14-15 cm, and extended from about 5 cm to 40 cm (Figure 8). The smallest fish observed was a banded wrasse *Notolabrus fucicola*. Spotties ranged from 10 to 22 cm, and tarakihi ranged from 6 to 26 cm. Sizes of tarakihi were clearly bimodal, with most of the fish being small individuals between 6 and 15 cm, and a smaller group between 21 and 26 cm.

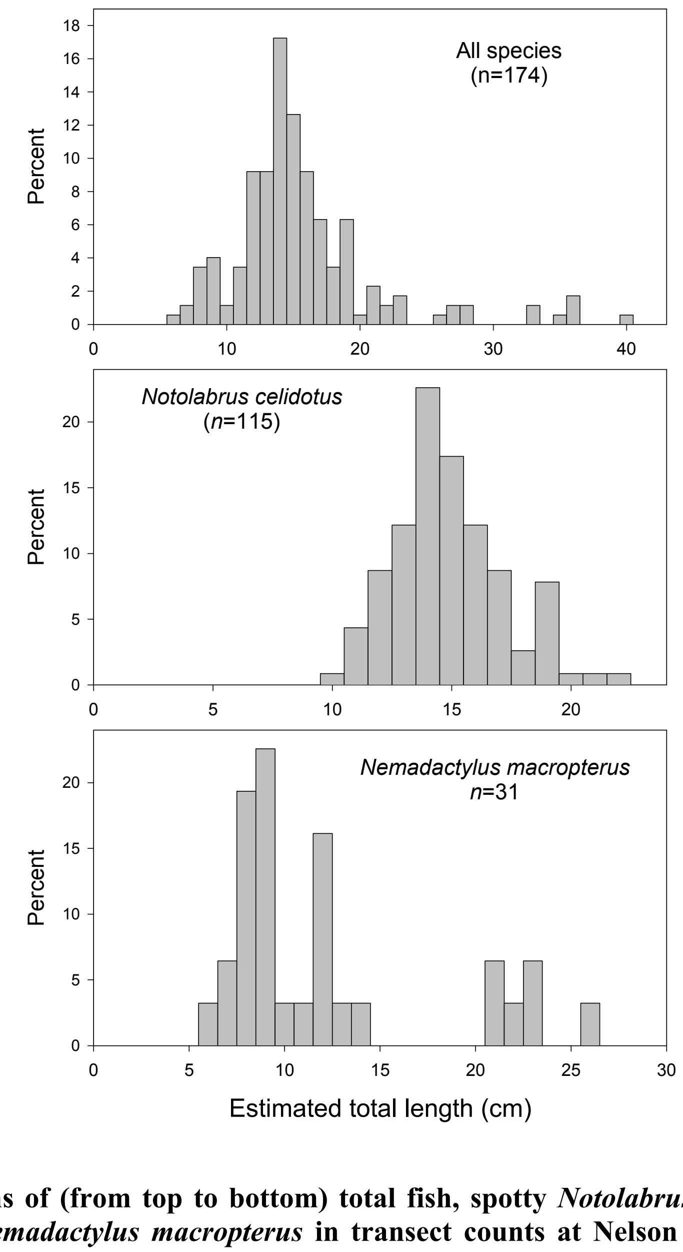

Figure 8. Size distributions of (from top to bottom) total fish, spotty *Notolabrus celidotus*, and tarakihi *Nemadactylus macropterus* in transect counts at Nelson Boulder Bank. Note varying x-axis scales.

5. Summary of Habitats

The extra sampling undertaken to produce this report reinforces and extends the work of McLean & Grange (1995) and Grange & Cole (1996). The proposed marine reserve area contains a large variety of sediment and reef habitats. Those include offshore mud, sands, sand and shell, reef edge with sponges, intermediate coralline-dominated reef, and shallow seaweed stands. A generalised profile of a transect from the shore to the seaward boundary of the proposed reserve is shown diagrammatically in Figure 9.

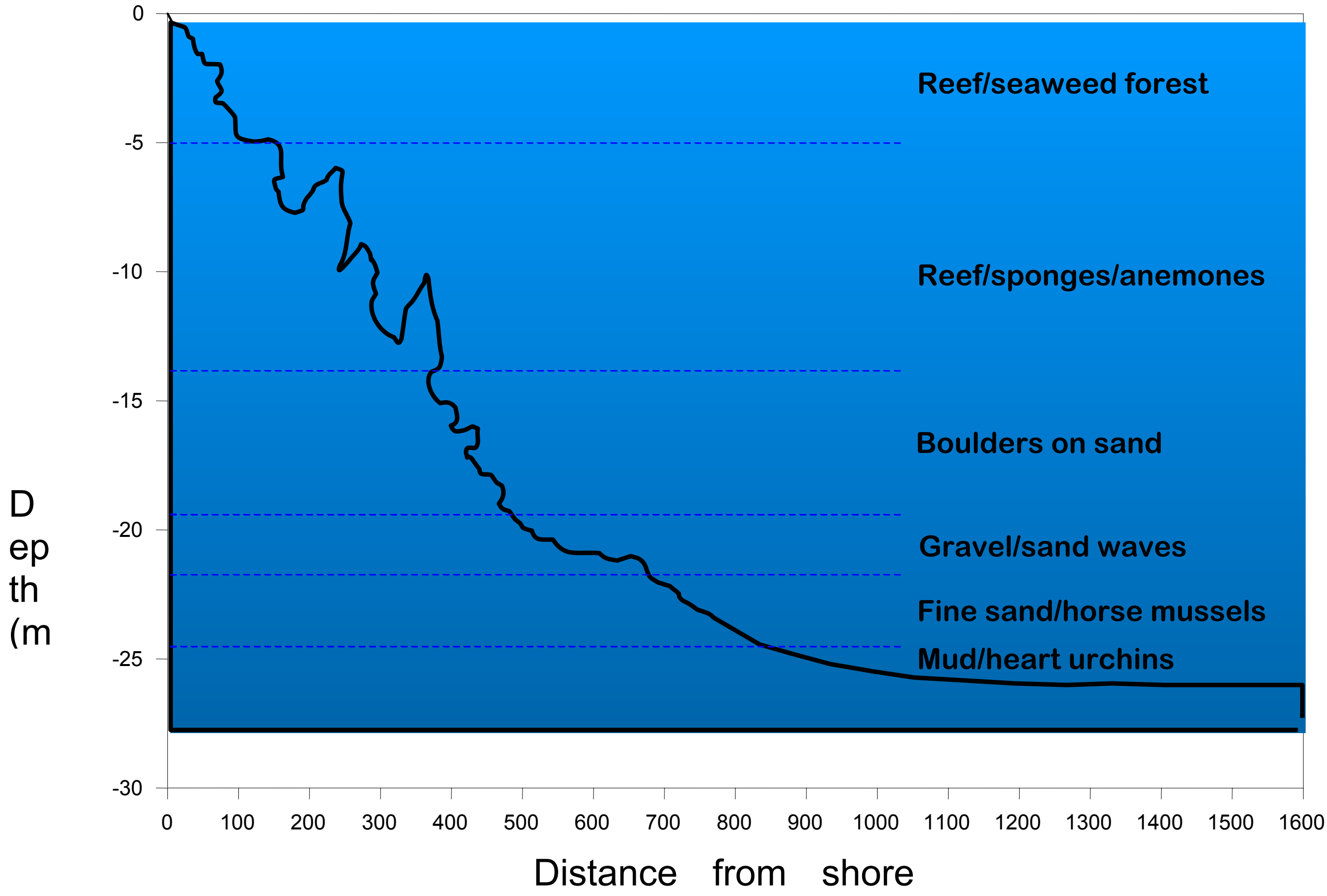

Figure 9. A generalised profile across the proposed marine reserve, north Nelson.

Shallow reef from low tide to around 5 m deep is dominated by seaweed, including *Carpophyllum* and *Cystophora* species, along with a sparse understory. Invertebrates in this habitat are dominated by limpets (*Cellana*) and kina. Below 5-6 m, the seaweed plants become less dense and the reef/boulders are covered with crustose coralline algae. In the shallower zones within this deeper reef habitat the stony coral *Culicea* covers large areas of rock, particularly on shaded surfaces, while the dominant invertebrate on the exposed surfaces is the anemone *Actinothoe*. Reef and boulder habitat continues to around 20 m depth and these deeper parts are characterised by a variety of sponge species. The visually dominant sponge is the large grey *Ancorina* that can reach over 30 cm tall and 20 cm across. Other more colourful sponges include the bright yellow *Aplysilla sulphurea*, the red *Crella incrustans*, and the pink golf ball sponge *Tethya ingalli*. Beyond the reef edge (below 20 m depth) all habitats are dominated by soft sediments that grade from coarse gravel to sand to soft mud with increasing depth and distance from shore. Swells appear to frequently impact to depths of around 22m and move the gravel sediment into large waves running parallel with the shoreline. This habitat supports the least number of benthic species and fish, being dominated by hermit crabs. In places there are beds of dog cockles (*Glycymeris*) as well. Deeper than 24 m, the sediment is best described as soft, easily disturbed, mud. Large numbers of heart urchins (*Echinocardium*) and the flat urchin *Fellaster* are dominant in this habitat, along with hermit crabs, brittle stars (*Amphiura*) and opal fish. Examples of each habitat, frame-grabbed from ROV video footage, are shown in Figures 10 and 11. Video footage from each ROV station, and examples from each habitat, are also available in CD-ROM format (Microsoft PowerPoint files) are available from the authors.

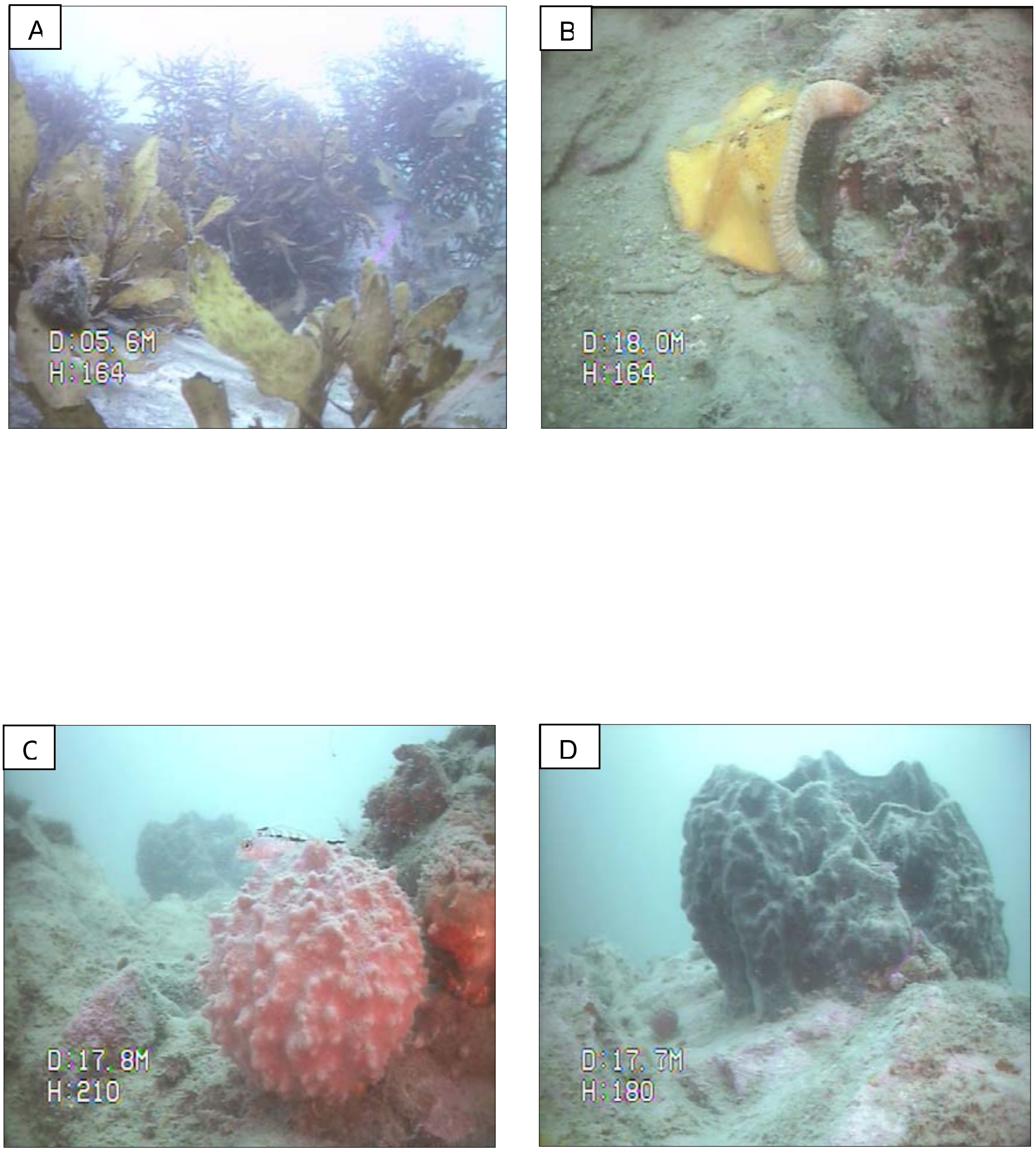

Figure 10. Video grab images from ROV footage, showing hard-shore habitats, proposed marine reserve, North Nelson. A. Shallow reef with *Carpophyllum*. B. Reef edge, showing ambush starfish *Stegnaster*. C. and D. Deep reef, with characteristic sponges (pink = *Tethya*; grey = *Ancorina*).

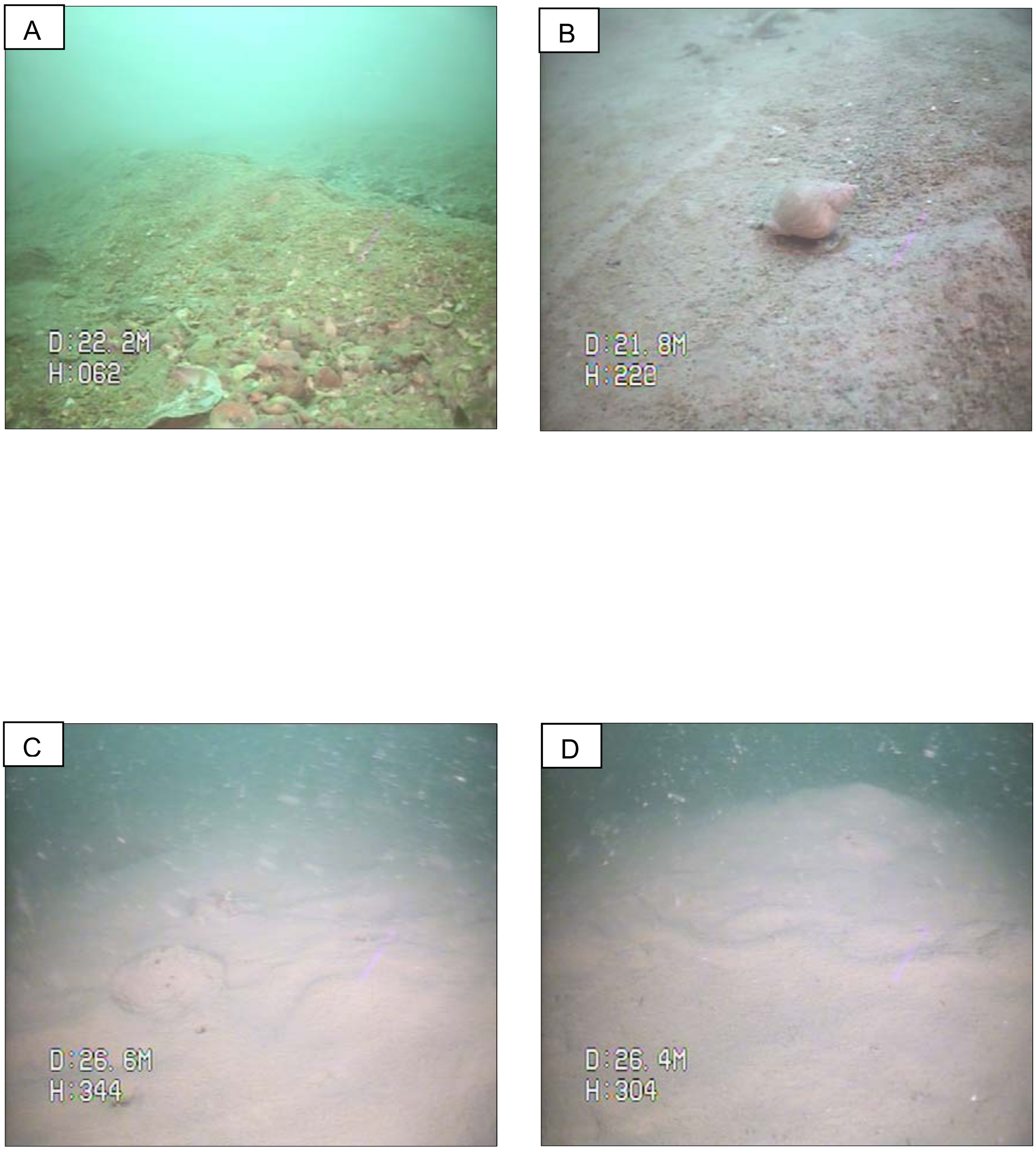

Figure 11. Video grab images from ROV footage, showing soft-sediment habitats, proposed marine reserve, North Nelson. A. Coarse gravel with large sediment waves. B. Fine-medium sand, with whelk *Cominella*. C. Soft mud showing flat urchin (*Fellaster*) partially buried. D. Soft mud with characteristic burrows of heart urchins *Echinocardium*.

6. Discussion

6.1. Relative diversity of habitats and biota at the proposed marine reserve

Owing to the limited range of wave exposure - no very sheltered or very wave-exposed shores are included in the proposed marine reserve - extremes of habitat type are not present. The data of Shears & Duffy (see Appendix 3) indicate that the fauna of shallow reefs in the proposed reserve is more similar to areas on the west coast of North Island, yet the wave climate of Tasman Bay is much milder than the Taranaki and Raglan coasts.

The reefal habitats of the North Nelson coast are clearly distinct from those of the Abel Tasman coast, in terms of sedimentation, the representation of habitats with depth, and their species composition. In our experience, the shores of Abel Tasman are heavily influenced by sediment from rivers; underwater visibility seldom exceeds 3 m, there is a layer of sediment on the rocks, and few areas of reef extend below 15 m. The deeper reefs in North Nelson appear to be little-influenced by sediments (probably reflecting distance from rivers), as there was little visible influence of sediments on the reefs, and the main sediment near reefs is sand. There are few large brown seaweeds on the Abel Tasman coast, being predominantly *Carpophyllum flexuosum*, whereas at North Nelson there are three other species - *Carpophyllum maschalocarpum*, *Cystophora retroflexa*, and *Sargassum sinclairii* also in shallow areas. although *C. maschalocarpum* occurs in shallow areas of the Abel Tasman coast, Davidson & Chadderton (1994) estimated its percentage cover as only 4% over the 0-6 m depth interval.

Shears & Duffy (see Appendix 3) found that the seaweed fauna of Nelson reefs was moderately diverse compared to other parts of New Zealand. Their analysis identified seaweed composition as being similar to North Island areas, including Gannet Rock and Taranaki. Tasman Bay lacks (as far as we are aware) *Ecklonia radiata*, which occurs further north at D'Urville Island. That seaweed probably contributes considerable amounts of primary productivity to coastal reefs (e.g. Babcock et al. 1999).

The depth-stratified quadrat data of Shears & Duffy indicate that biomasses of seaweeds are clearly higher on the Nelson coast than those on the Abel Tasman coast, and slightly higher than those near Long Island in the Queen Charlotte Sound. The occurrence of finely divided seaweeds such as *Cystophora retroflexa* inshore is significant; Taylor (1998) has shown that such habitats have high secondary productivity in north-eastern New Zealand. It is unknown whether the patterns described by Taylor (1998) apply elsewhere in New Zealand and that information is necessary before comparing the secondary productivity of reef systems among areas.

Grazers are common at North Nelson, and the data of Shears & Duffy indicate that sea urchins may be locally abundant, though their size distributions lack larger individuals. The impact of grazing by sea urchins is usually more obvious than that of gastropods, as the former may actively remove large seaweeds from reefs, whereas gastropods more usually remove spore stages. Sea urchins may actively remove seaweed stands from reefs, whereas gastropods may prevent spores from becoming established. Davidson & Chadderton (1994) sampled seaweeds and grazers on granite shores in parts of the Abel Tasman coast, and noted the absence of large brown seaweeds in the Abel Tasman, and their presence on limestone shores of Golden Bay. Experiments are required to clarify whether limitation of grazers by wave action is responsible for the distribution of habitats along depth gradients.

Airoldi (in press) reviewed the influence of sediments on reef ecology, concluding that the effects were poorly documented but likely important and pervasive. Low abundances of fine sediments are likely to enhance secondary productivity. Sand occurred across all habitats on North Nelson reefs, whereas reefs in the Abel Tasman area have high loads of fine sediments, especially in deeper areas (authors' pers. obs.). It seems likely that the low abundances of finer sediments on reefs contribute to the differences in invertebrate fauna that occur between North Nelson and Abel Tasman coasts. The nearest estuarine source of sediments is the Delaware Estuary, further east. During fieldwork the currents encountered flowed along the boulder bank eastward, as noted by Barter & Forrest (1998), suggesting that sediment sources are distant and likely to direct material elsewhere. For completeness we note that loss of vegetation shoreward of the proposed marine reserve (for example for forestry) could have profound effects on the fauna of reefs, particularly the reef edge, via mud accumulation.

In order to evaluate the fish fauna, we compared the results of the present sampling with other northern South Island studies. Two sources of data (from FRST-funded projects being undertaken by NIWA) are available for comparison with the fish counts carried out in the present study. The first (Project SRA) comprises a survey of 32 sites between Port Hardy and Long Island in outer Cook Strait, carried out in December 2001. The second (Project SRB) comprises scuba surveys of reef fish inside and outside Long Island - Kokomohua Marine Reserve, and Tonga Island Marine Reserve. As differences in species composition between adjacent reserve and fished areas are small (the major differences lie in the size structure of the fishes), we are justified in pooling across adjacent reserve and non-reserve sites. Project SRA sampled across the entire reef, whereas Project SRB sampled between 10 and 15 m depth. The proportions of tarakihi *Nemadactylus macropterus* and goatfish *Upeneichthys lineatus* are much higher at the Tasman Bay sites than in outer Cook Strait, and the abundance of blue cod is much lower (Figure 12).

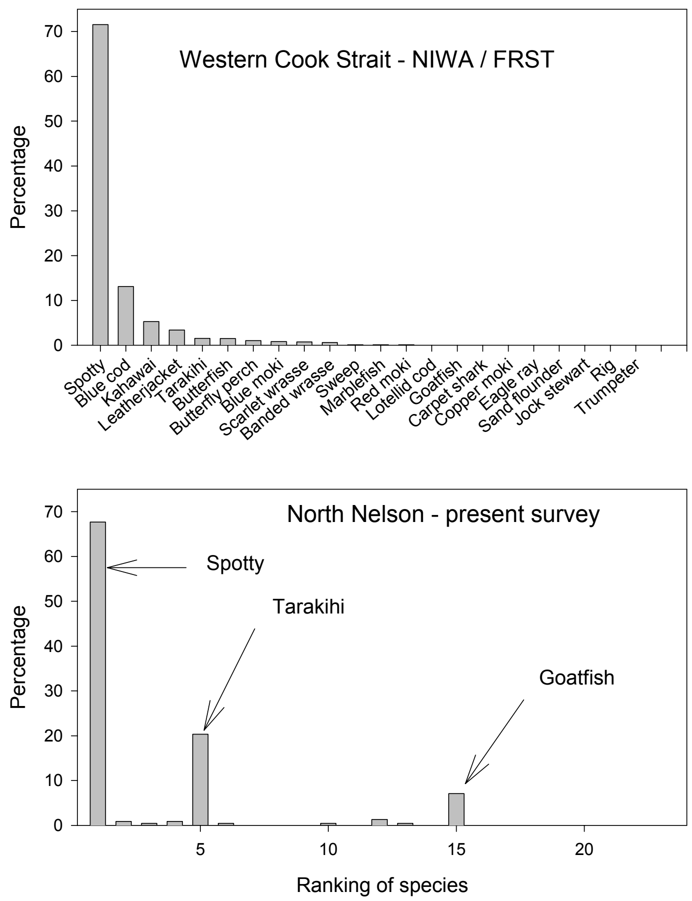

Figure 12. Relative abundances of reef fish from sampling undertaken in greater Cook Strait (see text for details), compared with results from this study.

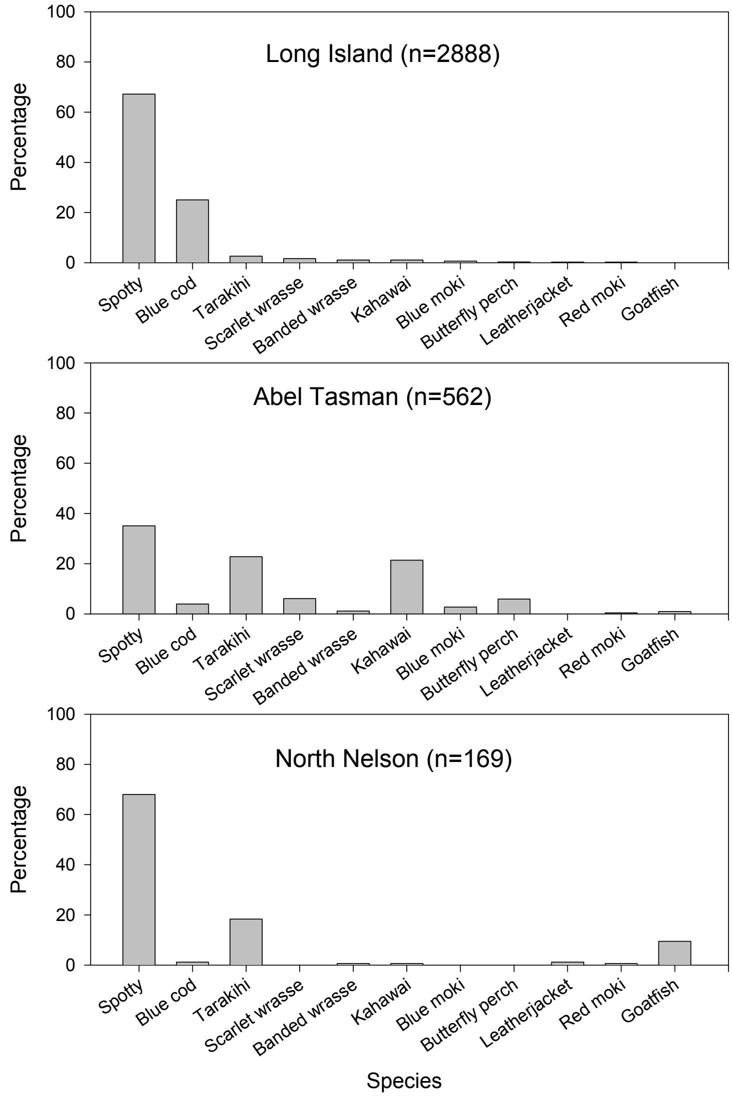

Figure 13. Comparison of reef fish abundances and species recorded from scuba counts, Queen Charlotte Sound, Abel Tasman coast, and this study.

We consider it unlikely that fishing pressure influences the species composition of fish assemblages, for example by killing undersized blue cod, because that would require very high fishing pressure, and consistently poor handling of undersized cod. A more likely explanation is that recruitment of blue cod in Tasman Bay is lower than that in Marlborough Sounds.

The second dataset, comprising fish counts done with scuba at depths between 10 and 15 m at Long Island - Kokomohua Marine Reserve and adjacent Queen Charlotte Sound coasts, and at Tonga Island Marine Reserve and adjacent fished coast, also emphasises the similarity of the fish fauna of North Nelson to that of the Abel Tasman coast (Figure 13). The representations of scarlet wrasse *Pseudolabrus miles* and butterfly perch *Caesioperca lepidoptera* at North Nelson are somewhat lower than the Abel Tasman, whereas that of goatfish *Upeneichthys lineatus* is somewhat higher. Kahawai (*Arripis trutta*) are probably under-represented in our sampling, because they are pelagic and have clumped distributions.

Examination of those data in more detail by plotting them on ordinations of the original count data indicated that for Project SRB the North Nelson sites were outliers on the plot regardless of habitat (i.e. outliers came from a number of habitats), and that for project SRA, the reef edge transects were outliers, probably owing to the occurrence of *U. lineatus* (Figure 14).

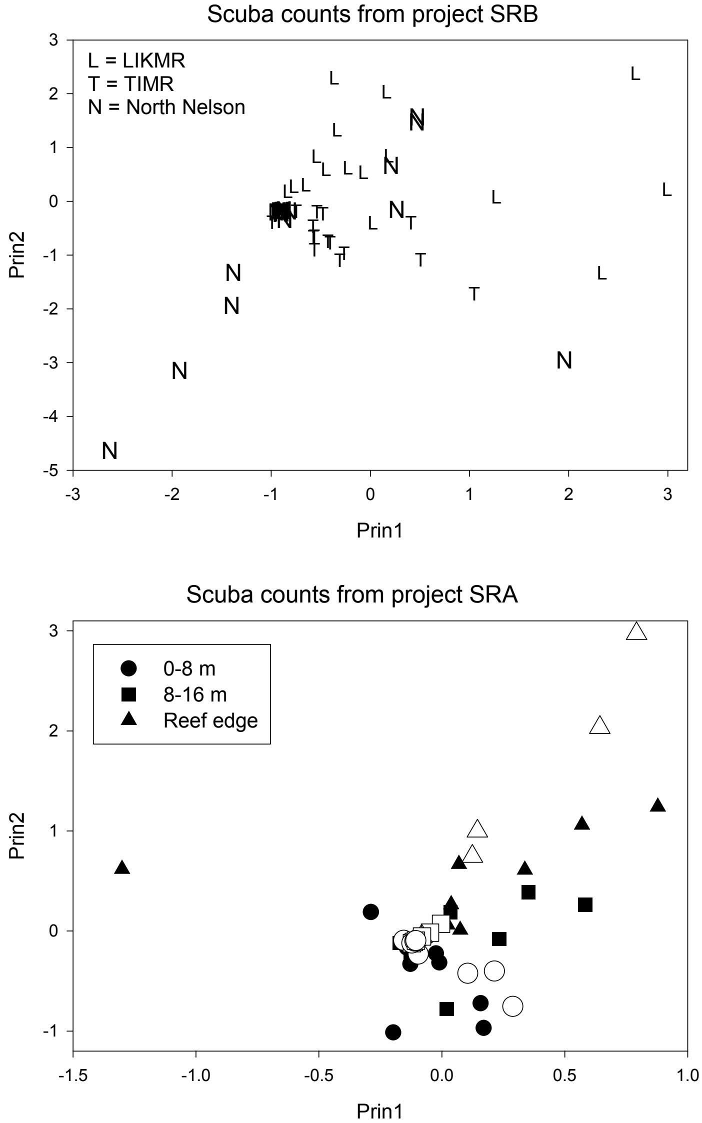

Figure 14. Projections of North Nelson fish count data onto principal component plots of two fish surveys (upper panel - Project SRB, lower panel - Project SRA). Project SRB: scuba counts at 10-18 m depth at Long Island Kokomohua Marine Reserve and adjacent fished coasts, and at similar depths at Tonga Island Marine Reserve and adjacent fished areas. Project SRA comprises fish counts across the entire reef at 32 sites between Port Hardy and Long Island - Kokomohua Marine Reserve, in western Cook Strait. Open symbols = North Nelson, filled symbols = Western Cook Strait.

The occurrence of areas of seaweed habitat is significant to fishes. Shallow water seaweeds will be important habitats for recruits of reef fishes such as *Notolabrus celidotus* (Jones 1984), will provide food for *Odax pullus* and may also affect the occurrence of triplefin fishes (Syms & Jones 1999).

7. Acknowledgements

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Appendix 1. Species recorded in each ROV video.

									ROV Site														
Group	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
Algae																							
	Carpophyllum flexuosum																			1			
	Carpophyllum maschalocarpum																			1			
	Cystophora torulosa																			1			
	Apophloea lyalli																			1			
	pink coralline algae								1	1					1	1				1			1
Sponges																							
	Callyspongia			1		1			1	1													
	Ancorina alata		1						1	1					1	1							
	Iophon sp		1						1	1					1								
	Crella incrustans								1	1				1	1	1							1
	Tethya ingalli								1	1					1	1							1
	Aplysilla sulphurea														1	1							1
	Suberites sp																	1					
	Polymastia sp															1							
Hydroid																							
	Plumularia sp									1													
Anemones																							
	Actinothoe albocinata								1						1								
Stony corals																							
	Culicea rubeola		1						1	1						1							1
Soft corals																							
	Alcyonium aurantiacum			1																			
Tube worms																							
	Galeolaria hysrix		1													1							1
	Sabellidae				1			1														1	
Crustacea																							
	Pagurus sp.	1		1	1	1	1				1	1		1			1	1					
Chitons																							
	Cryptoconchus porosus								1														1
Gastropods																							
	Strutholaria vermis	1												1									
	Cookia sulcata															1							
	Amalda mucronata	1									1	1											
	Austrofusus glans	1		1								1					1						
	Maoricrypta monoxyla	1																					
	Maoricolpus roseus	1		1											1								
	Poirieria zelandica			1				1															
	Alcithoe swainsoni					1																	
	Maurea punctulata								1														
	Trochus viridis									1					1	1				1			
	Cellana radians									1						1				1			
	Natica zelandica										1												
	Cominella adspersa																1						
Sea slugs																							
	Archidoris wellingtonensis																	1					
Bivalves																							
	Atrina zelandica	1		1	1	1		1						1									
	Monia zealandica		1						1	1						1							1
	Pecten novaezealandiae				1			1			1		1	1				1					
	Tawera spissa		1					1			1						1	1	1		1	1	
	Glycymeris laticostata										1						1	1			1	1	
	Glycymeris modestus		1					1															
	Cleidothaerius maorianus		1							1													
	Divaricella huttoniana		1																				
	Limaria orientalis			1	1									1				1					
	Gari stangeri				1			1			1							1					
	Nemocardium pulchellum							1															
	Barbatia novaezelandiae								1														
	Venericardia purpurata										1						1						

Appendix 1. Contd.

		ROV Site																					
Group	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
Brachiopods																							
	Neothyris lenticularis				1					1	1												
	Waltonia inconspicua															1							
Sea stars																							
	Stegnaster inflatus		1						1	1					1	1							
	Stichaster australis														1	1							
	Patiriella regularis		1	1			1	1	1	1						1	1						1
	Astrostole scabra		1																				
	Pentagonaster pulchellus														1								
	Coscinasterias muricata							1										1					
Sea urchins																							
	Evechinus chloroticus		1						1	1					1	1				1			1
	Echinocardium cordatum	1			1	1	1					1	1										
	Fellaster zelandiae	1			1	1						1	1										
Brittle stars																							
	Ophiopsammus maculatus		1																		1		
	Ophionereis fasciata															1							
	Amphiura sp			1	1		1					1											
Sea cucumbers																							
	Stichopus mollis		1						1	1					1								
Sea squirts																							
	Cnemidocarpa bicornuta								1	1					1	1							
	Asterocarpa sp											1											
	Aplidium sp															1							
Fish																							
	Hemerocoetes monopterygius	1			1						1						1				1		
	Nemadactylus macropterus		1						1	1									1				1
	Upeneichthys lineatus		1						1														
	Notolabrus celidotus		1	1					1	1						1				1			1
	Parapercis colias		1												1								
	Parika scaber								1														
	Notolabrus fuciola								1														
	Chelidonicthys kumu							1															
	Cheilodactylus spectabilis								1														
	Forsterygion sp.								1	1					1	1	1						1
	Rhombosolea plebeius											1											
	Latridopsis ciliaris																			1			
	Total no species	**3**	**10**	**3**	**5**	**2**	**3**	**3**	**12**	**9**	**2**	**4**	**2**	**0**	**8**	**10**	**3**	**1**	**1**	**2**	**2**	**0**	**5**

Appendix 2. Species recorded in each dredge sample.

Class	Species	Common name	D1	D2	D3	D4	D5	D6	D7	D8
			mud	**mud**	**gravel**	**m/gr**	**mud**	**mud**	**mud**	**mud**
Hydroida	unid (1)	Feather hydroid							1	
	unid (2)	Fan hydroid						1		
Polychaeta	*Lepidonotus polychroma*	Sea mouse							2	
	Aglaophamus sp.	Worm		6		5		10	6	
	Armandia maculata	Worm	1							
	Eononidae	Worm			2					
	Flabelligeridae	Worm							1	
	Glycera sp.	Worm			1		2			
	Lumbrineridae	Worm							1	
	Maldanidae	Worm							1	
	Onuphidae	Worm		1			3	3		
	Sigalioniodae	Worm	14	12	1	3	21	5	9	1
	Sternaspidae	Worm	6	14		2	9	12	13	
	Terebellidae	Worm			3					
Crustacea	*Cirolana* sp.	Sea louse						4	1	
	Ebalia laevis	Crab		1			1	1	1	
	Halicarcinus sp.	Pillbox crab			3			2	1	
	Nectocarcinus antarcticus	Crab		1						
	Notomithrax minor	Decorating crab			1					
	Squilla armata	Mantis shrimp	3	6		4	5			
	Pagurus sp.	Hermit crab	1	8	4	1	1	12	3	6
	Periclimenes yaldwyni	Shrimp						8		
	unid amphipod		4	4		2	5	17	7	
	unid shrimp									2
	unid					11	1			
Gastropoda	*Alcithoe swainsoni*	Volute shell	1							
	Amalda mucronata	Olive shell		2			1	3	1	
	Amalda novaezelandiae	Small olive shell	8	11			3	2	7	4
	Austrofusus glans	Whelk	5	9		3	22	6	10	9
	Maoricolpus roseus	Turret shell			2					
	Philine sp.	Shelled slug	1		1			3		
	Struthiolaria vermis	Ostrich foot shell					1	1		
	Zeacolpus vittatus	Turret shell						3		1
Bivalvia	*Corbula zelandica*	Bivalve			3				1	
	Dosinia greyii	Venus shell		2			1	7		3
	Dosinia lambata	Venus shell	20	23		8	37	59	11	7
	Ennucula strangei	Nut shell	23	19		4	46	43	22	3
	Gari lineolata	Sunset shell						5	10	2
	Limaria orientalis	File shell			1					
	Neilo australis		10	7		2	2	4	3	
	Nemocardium pulchellum	Strawberry cockle	4	2	1		3	4	4	3
	Nucula hartvigiana	Nut shell		2		5	4	4	1	1
	Tawera spissa	Morning star shell			2					
	Theora lubrica	Japanese bilvalve	19	16		4	8	32	5	2
	Sacella bellula	Nut shell	1							
Scaphopoda	*Dentalium nanum*	Tusk shell	7	31	1	6	6	7	3	2
Brachiopoda	*Neothyris lenticularis*	Pink brachiopod						1		
Ophiuroidea	*Amphiura rosea*	Brittle star	15	12		7	20	13	11	1
Echinoidea	*Echinocardium cordatum*	Heart urchin	58	110		35	43	44	23	86
	Pseudechinus huttoni	Pink urchin							1	1
Holothuroidea	*Heterothyone alba*	White sea cucumber	2	2					1	1
Bryozoa	many unid	Lace coral						> 1		
Pisces	*Hemerocoetes monopterygius*	Opal fish							1	
		Total no species	**20**	**23**	**14**	**16**	**23**	**29**	**30**	**18**