Te Whanganui-a-Hei Marine Reserve Habitat Mapping

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Abstract

Side-scan sonar surveys allow a large area of seafloor to be surveyed within a limited amount of time and can provide much information on seafloor topography and extents of reef platforms. Side-scan imagery of the Te Whanganui-a-Hei Marine Reserve area exhibits a complicated arrangement of visually different acoustic/sedimentary facies including: bedrock overlain by sand; low rock/sand matrix; megarippled gravely-shelly coarse sands; and sands. The reef habitat types observed in the reserve were consistent with those generally found in north-eastern New Zealand coastal areas; i.e., *Ecklonia* forest, Foliose algae, Mixed algae, Turfing algae, and Sponge flats. The soft-sediment habitats were typical of those on exposed coasts in shallow waters; generally lacking in epifauna or flora and other biogenic structure (cf. Tonga Island Marine Reserve). While no habitat classification scheme yet exists for soft sediments, a number of distinct types were observed (cf. Tuinagara to Blackhead Point area): Medium sand with epifauna or flora (e.g., scallops, sponges, macrophytes, burrows); Medium sand without epifauna or flora; Fine sand; Fine-medium sand; and Megarippled coarse sands. Unfortunately, complex gradients in wave exposure and a gradient in water turbidity across the reserve, as well as the heterogeneous nature of the sedimentary/acoustic facies, complicated any simple community/depth/substrate relationships. That is, unlike the survey of the Te Angiangi Marine Reserve, habitats were not generally confined to a single sedimentary/acoustic facies, making it difficult to extrapolate the habitats from the sampled points to the rest of the Te Whanganui-a-Hei Marine Reserve area. These results limit the usefulness of the broad-scale side-scan-based habitat map in describing the ecological habitats and values of the area. More intensive sampling, targeted at specific areas for specific ecological components (e.g., lobster, fish, benthos), would be required for monitoring changes in the reserve.

Keywords:

Habitat mapping: Marine Surveys: Multi-resolution sampling strategies; Marine Reserves; Te Whanganui-a-Hei Marine Reserve

1. Introduction

In May 2004, the Department of Conservation (DOC) commissioned a habitat survey of the Te Whanganui-a-Hei Marine Reserve to ground truth an existing side-scan map. The work is part of the development of a detailed GIS habitat map of the Te Whanganui-a-Hei Marine Reserve. Specific objectives were to:

- Survey the benthic assemblages and physical habitats within the marine reserve using digital video in conjunction with other non-destructive methods, including diver-based observations.

- Combine the existing side-scan sonar and bathymetric maps with the survey data to produce a GIS habitat map.

- Incorporate the video footage with the habitat map, so that video images of the benthic community can be viewed by clicking on the survey sites.

Te Whanganui-a-Hei marine reserve comprises a 5 km stretch of coastline between Mussel Rock and Hahei Beach, on the east coast of the Coromandel Peninsula. The Reserve extends approximately 1 km offshore (Fig. 1). The subtidal area of the reserve is characterised by islands and sub-tidal rock reefs dispersed within a sloping sand matrix. A previous side-scan survey, completed by University of Waikato for DOC, was to provide the basis for the survey of benthic assemblages and physical habitats. The benthic assemblages were to be classified (see below) and correlated to the side-scan imagery. The continuous side-scan imagery was then to be used to interpolate between the benthic video sampling and a broad-scale habitat map produced.

Initially, the ecological habitats used as descriptors were to be those described in the fish monitoring programme of the area, together with habitats identified by Shears and Babcock (2000). Lately, however, a new classification system derived from a more extensive geographical area has been developed for hard substrates (Shears et al. in press, summarised in Appendix 1). In order to provide a habitat map that will be consistent with those produced from other regions, the hard substrate habitats identified in the Te Whanganui-a-Hei marine reserve will be those identified by the new classification system. The degree to which the survey data matches the new classification system will be discussed.

Soft sediment habitats are not addressed by Shears and Babcock (2000) or Shears et al. (in press) and the fish monitoring programme only describes them as sand flats > 6 m depth. However, a number of soft-sediment habitats are likely to occur in the reserve. Soft sediments will be classified by statistical classification techniques, consistent with methods applied by Shears et al. (in press), in order to provide more definition for these important areas.

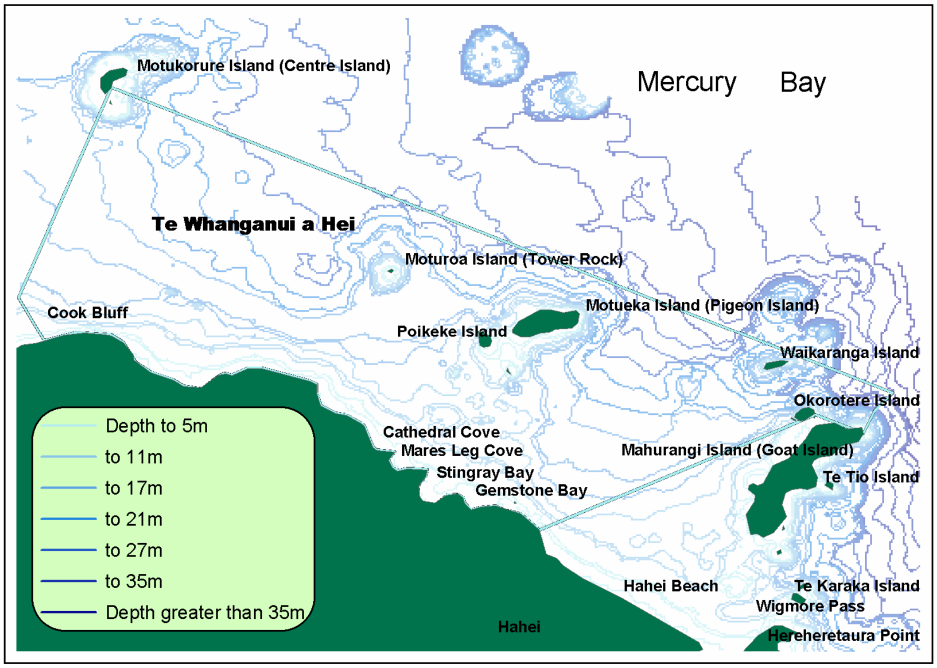

Figure 1: Map of Te Whanganui-a-Hei marine reserve.

2. Methods

2.1 Survey design

Sample design was determined in conjunction with DoC staff. Initially the side-scan imagery (Fig. 2) was related to likely sediment types based on expert opinion (T. Hume). Samples were dispersed throughout the sediment types using a stratified sampling technique, where strata were defined by: depth; wave exposure; exposure to turbid water from Whitianga; and size of the acoustic habitat. Transect sampling stations were located (Fig. 2) to provide information on type of transition zones between the acoustic habitats. A number of sites selected were outside the reserve to give information on habitats lacking within the reserve.

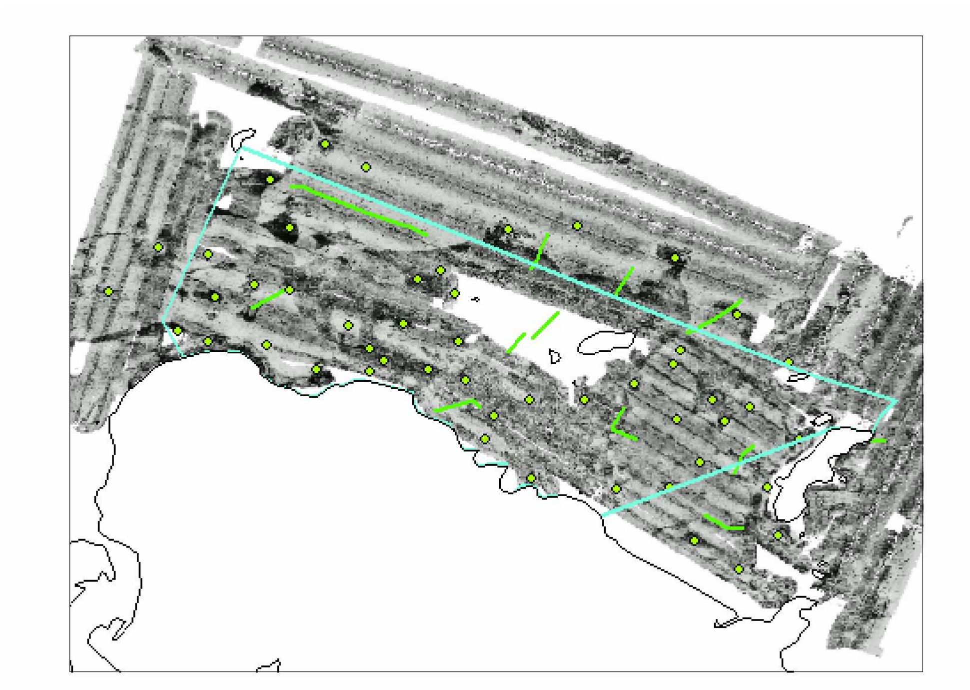

Figure 2: Side-scan produced by University of Waikato for the Department of Conservation. Sampling positions are marked by dots (10 min drop camera positions) and lines (camera transects).

2.2 Data collection

Navigation to predefined locations for video sampling was accomplished using HydroPro navigation software and an Omnistar 3100LR differential GPS receiver (real-time accuracy of 2 to 5 metres). The Omnistar unit receives differential corrections from the Fugro system which broadcasts corrections via a communications satellite.

The video sampling was conducted using a high resolution (480 line) Simrad colour video camera with a 50watt light source. The camera was linked to the surface with an umbilical cable and the image recorded onto MiniDV video cassette tape using a Sony Digital Video Cassette recorder. Due to the rocky nature of the seafloor and the likelihood of snagging the camera or damage due to impact with rocks, a towed camera system was not used. Instead the camera set-up consisted of a depressor weight, bridle, camera frame, floatation for buoyancy/stability and a length of chain to provide for height adjustment and cushioning of the camera hitting the bottom. In stable conditions the frame is neutrally buoyant at approximately 30cm off the seafloor. Three red lasers (wavelength 633nm, 5mW) were mounted on the frame in a 12cm triangle, to provide scaling of seafloor objects. The camera was lowered to approximately 0.5-2m from the seafloor and video was recorded as the boat drifted over the site. This provided a good overview of the habitat characteristics and enabled estimates of canopy and sub canopy cover of algae and fauna. In addition, several times during the drift sample the camera was lowered to allow better identification of encrusting and sub-canopy species.

2.3 Video counts

For each length of video recorded, boat position and time of video recording were logged during the survey using HydroPro software and used to calculate the distance travelled by the video. Substrate for each length of video transect was described as sand or mud (ripples noted if present), pebbles, cobbles, boulders, rocky, bedrock or softrock and proportions of each substrate type were given for each video sample. For each length of video transect, a 10m segment of footage representative of the area covered was selected for analysis. If there were 2 or more obvious changes in habitat characteristics within the area, it was split into 2 or more 10m lengths for analysis. For example, if the camera travelled over sand ripples followed by a rocky area, then a ten-meter transect from each substrate was analysed. Once a segment had been chosen, analysis consisted of ranking the percent cover of canopy and subcanopy species (excluding fish) within the 10m segment. The ranking was based on the ranking system described by Braun-Blanquet (1964) where percent cover is ranked from 0-5 based on the following:

Rank	Cover
0	Absent
1	<1 to 10%
2	11 to 30%
3	31 to 50%
4	51 to 75%
5	76 to 100%

Quality assurance was conducted in two phases: (1) Estimates of cover from the video were conducted by one person. (2) Estimates on 10 % of all video clips were checked by comparison to estimates conducted by a second person.

2.4 Statistical analyses

For the hard substrata data, average linkage clustering was run, on the flora and fauna data, to determine similarities (Bray-Curtis) between sites. The video segments were then classified into habitat types, based on Shears et al. (in press). Once the video had been classified, an analytical classification procedure (SIMPER; Primer, Clarke 1993) was run on the rank cover data to determine within group similarity. Similarity matrices from counts of fauna/flora and environmental characteristics (depth, %rock, boulders, cobbles, pebbles and sand) were compared (RELATE; Primer, Clarke 1993).

For the soft sediment data, average linkage clustering was run on the flora and fauna and sediment data together, to determine similarities between sites. As the study area only included a limited number of soft-sediment habitat types and epifauna, originally we intended to broaden the classification by including data collected from the Tuingara to Blackhead Point survey. However, the soft-sediment habitats observed in that survey were less broad than the habitats observed here, so only the Te Whanganui-a-Hei survey data was used. A SIMPER analysis was run to determine within-habitat similarity and describe the habitat type.

3. Results

3.1 Side-scan

The side-scan imagery (Fig. 2) exhibits a number of visually different areas that the video data confirmed were related to major sedimentary types (Fig. 3).

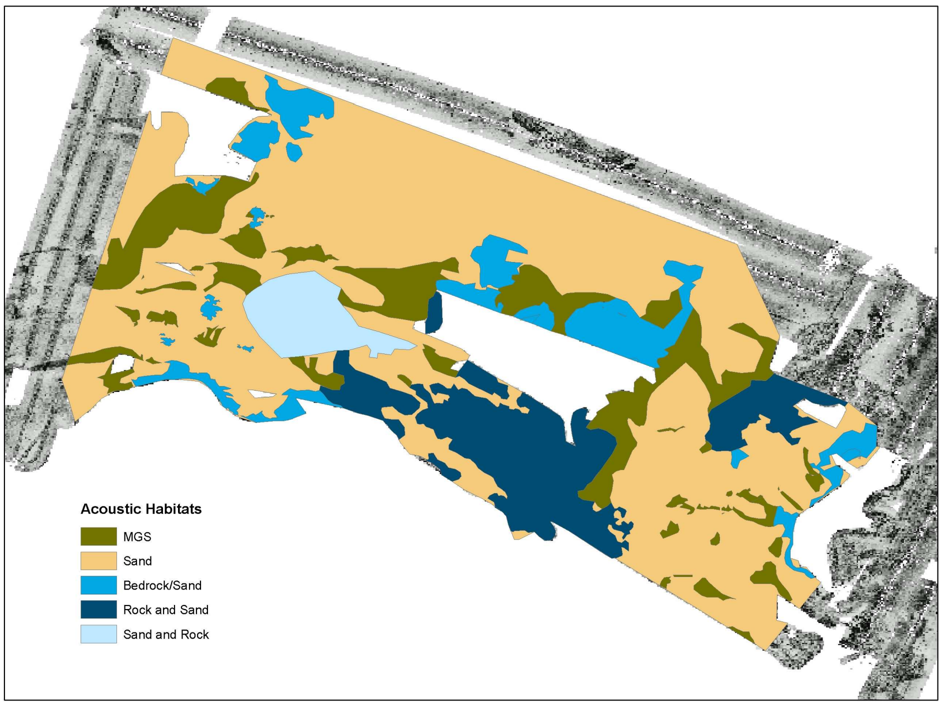

Figure 3: Acoustic habitats related to sedimentary facies, within the reserve, identified from the side-scan imagery, overlaying the side-scan. The “Rock and Sand” vs “Sand and Rock” habitats reflect the dominance of rock and sand respectively.

However, the “Rock and Sand” vs “Sand and Rock” habitats were difficult to differentiate based solely on sediment type. Differences in depth and variability in bottom topography were then used to further differentiate these groups (see Fig. 4 and descriptions of sedimentary facies).

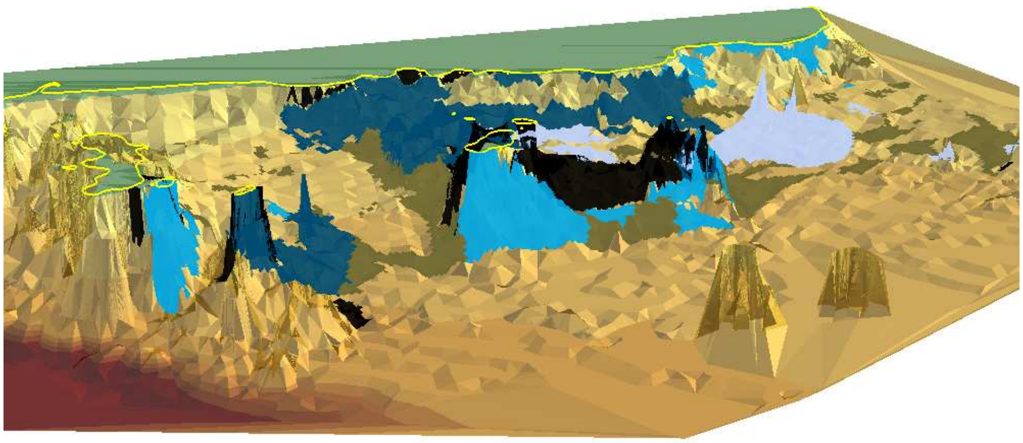

Figure 4: Three dimensional view of the bathymetry, with the sedimentary facies observed within the reserve overlain. ■The sand facies within the reserve are shaded yellow depending on depth. ■Black- areas were not covered by side-scan, ■dark blue = Rock-sand matrix (RSM), ■blue- Bedrock/sand, ■lilac = Flat rock-sand (FRS), ■ green = Megarippled gravely sand (MGS). Maximum depth is 20m.

■ Facies 1 (Bedrock/sand): Dark striated with light signature, interpreted as Beeson's volcanic rock, a flow-banded rhyolite. Sand is found in the crevices and striations are visible on the acoustic imagery (Fig. 5a). This facies is generally found around the islands and close to the shore and comprises ~ 62.7 ha of the reserve.

■ Facies 2 (Flat rock-sand (FRS)). The flow-banded rhyolite also forms low flat rock platforms, frequently covered by sand, in a sand matrix (described in Fig. 3 as sand and rock). This facies occurs down to 18 m and comprised ~75 ha.

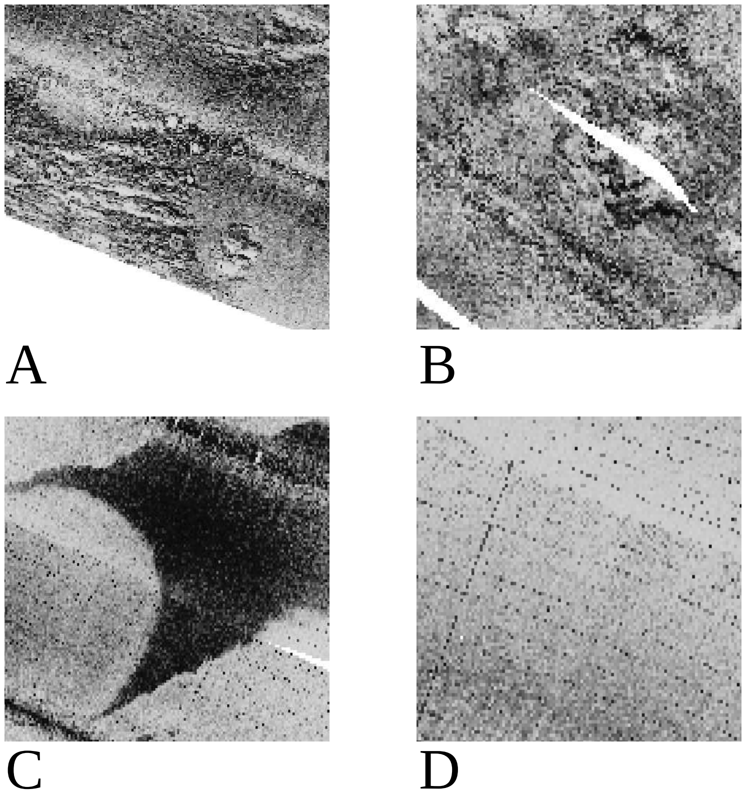

Figure 5: Selected side-scan imagery (~200 m across) demonstrating the visual differences in signature between the sedimentary facies.

■Facies 3 (Rock and sand matrix, RSM): Light to dark mottled signature, interpreted as low rocky outcrops protruding from a low fine sand plain (Fig. 5b). This facies is found shorewards of the middle of the reserve (Fig. 3). The large sand patches found within are likely to be relatively stable, with no change recorded between when the sidescan was taken and subsequent video sampling. This facies occurs down to 14 m and comprised ~140 ha.

■ Facies 4 (Megarippled gravely sand MGS): Dark highly reflective signature, interpreted as megarippled (normally several 10cm high, wavelength 0.5 – 1m) gravely-shelly, coarse sands (Fig. 5c). MGS areas often occurs in slight depressions (0.25 – 0.5 cm beneath sand layer). This facies occurs in latter areas from 12 -18 m and comprised ~127 ha. This sedimentary type is common on the east coast and contrary to previous expectations has proven to be remarkably stable over time (T. Hume, pers. comm.). They are maintained by turbulence enhanced by the roughness of the surface that reduces sand deposition. As the megaripples move, the seafloor is turned over to depths equal to the wave length.

■ Facies 5 (Sand): Light coloured highly reflective signature, interpreted as sandy plains (Fig. 5d). These are generally rippled (1-3cm high, wavelength ~10 cm), well sorted fine sands. This facies is the predominant sediment type in the reserve, comprising ~ 459 ha. Outside the reserve area, towards the north-west, is an area of sand ribbons associated with strong wind-driven currents (Fig. 6a). These are symmetrically aligned, approximately shore-parallel.

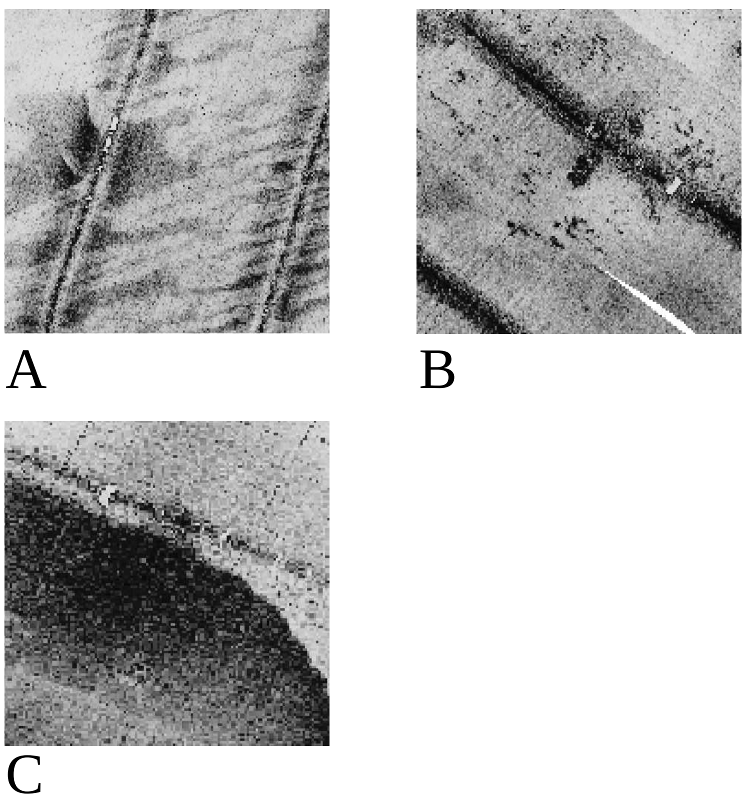

Figure 6: Selected side-scan imagery (~200 m across) demonstrating the visual differences in signature between the sedimentary facies.

The MGS facies are clearly differentiated from sand areas, with generally sharp boundaries occurring over < 5 m distance. (Fig. 5c). Boundaries between the rock facies (Bedrock/sand and RSM) and either sand or MGS are generally less distinct, with sand cover increasing over 10 – 100 m (Fig. 6c).

There were some areas of unclear acoustic differentiation (Fig. 6b). There were also areas around the islands that could not be surveyed and a large unsurveyed area between Moturoa and Motueka Islands.

3.2 Video

3.2.1 Hard-substrata habitats

Eight of the habitats identified by Shear et al. (in press) were found in the present survey: Ecklonia forest; Mixed algae; Urchin barrens; Turfing algae; Sponge flats; Foliose algae; Encrusting invertebrates and Cobbles. However, when density data was analysed these habitats were not particularly distinctive from each other (Table 1, Fig. 7). This is due to the categories used being subjective, with some overlap. As Shears et al. noted, it is not always practical to have specific densities of species that divide habitats due to variations in species size, morphologies and biomass. In particular, the Foliose algae and Sponge flats were generally difficult to separate using species densities. Average linkage cluster analysis revealed a number of small groups and singletons at 50% dissimilarity (Fig. 7). There were 4 major groups that contained at least 4 video samples each. Three groups consisted of only 2-3 video locations and 10 were isolated video locations. The three isolated video locations on the right side of Fig. 7 were predominantly sponge flats.

Note that the samples from the transect in the area unsurveyed by side-scan were not included in this analysis as the height at which it was surveyed precluded direct comparison with the other video estimates. However it was included in the overall habitat descriptions.

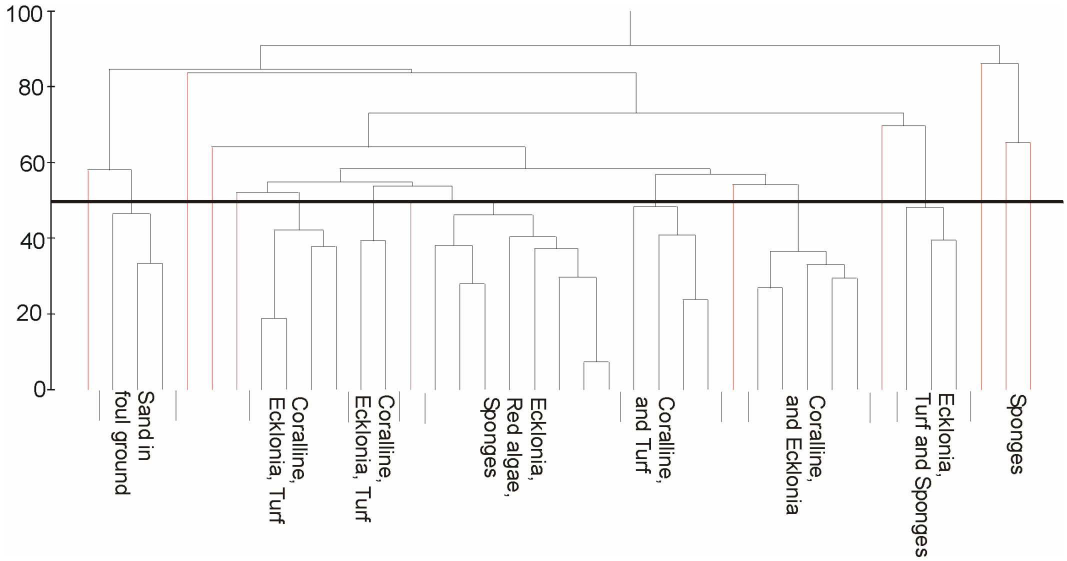

Figure 7: Cluster tree showing similarities between video data from hard substrate sites. Groups with 50% within-group similarity are described. Singletons are represented by red lines).

Hard substrata habitats were also not generally confined to a single sedimentary/acoustic facies; this was expected given their heterogeneous nature. Video samples taken from a single sedimentary/acoustic facies were less than 40 % similar to each other. An attempt was made to relate overall environmental information (depth, %rock, boulders, sand etc.) to the fauna and flora, however no significant relationships could be found ($p = 0.21$).

The RSM facies near the shore (Cathedral Cove area), were generally dominated by *Ecklonia* forest and Foliose algae, although sponges, turfing algae and sand were also found. The deeper or more sloping RSM and the FRS facies were comprised of a mix of Sponge flats, Foliose algae, Turfing algae and sand. The Bedrock/sand facies rarely had any *Ecklonia*, except close to land, and were more generally dominated by Foliose algae and sand, although some Sponge flats were present. Some patches of cobble habitats were also found.

Only one area classified as Urchin barren was observed, outside the reserve. The lack of these areas may be attributed to the lack of samples in areas < 5 m depth. Previous reports from this area suggest that the urchin barrens are confined to the 0 – 4 m depth range.

The only area containing Encrusting invertebrate habitat was also located outside the reserve just east of Mahurangi Island. This area was very interesting, containing a mix of Encrusting invertebrate and Sponge flat habitat, unrepresented in the reserve. The area between Motueka and Moturoa Islands, unsurveyed by side-scan, was sampled by two video transects. They revealed a mix of MGS, rock and sand facies, containing *Ecklonia* forest, Foliose algae and Sponge flat habitats.

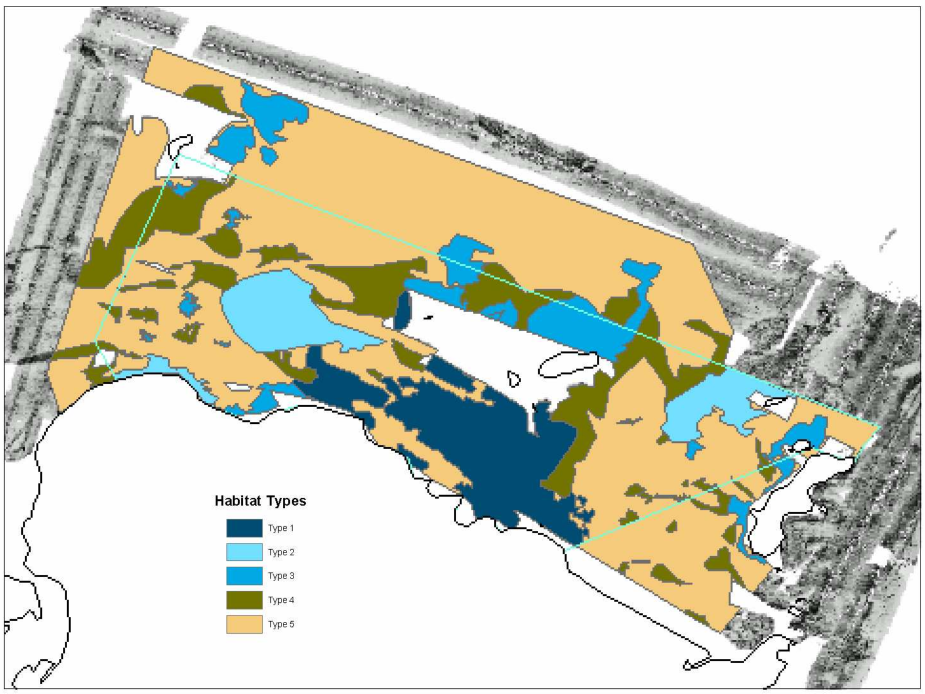

Figure 8: Habitats observed by video within the sedimentary facies. Dominant flora and fauna found within each habitat were as follows. Type 1 = *Ecklonia* forest and Foliose algae, with some sponges, turfing algae and sand. Type 2 = Sponge flats, Foliose algae, Turfing algae and sand. Type 3 = Foliose algae and sand, and some Sponge flats. Type 4 = MGS. Type 5 = sand. See Figure 9 for pictures of each type.

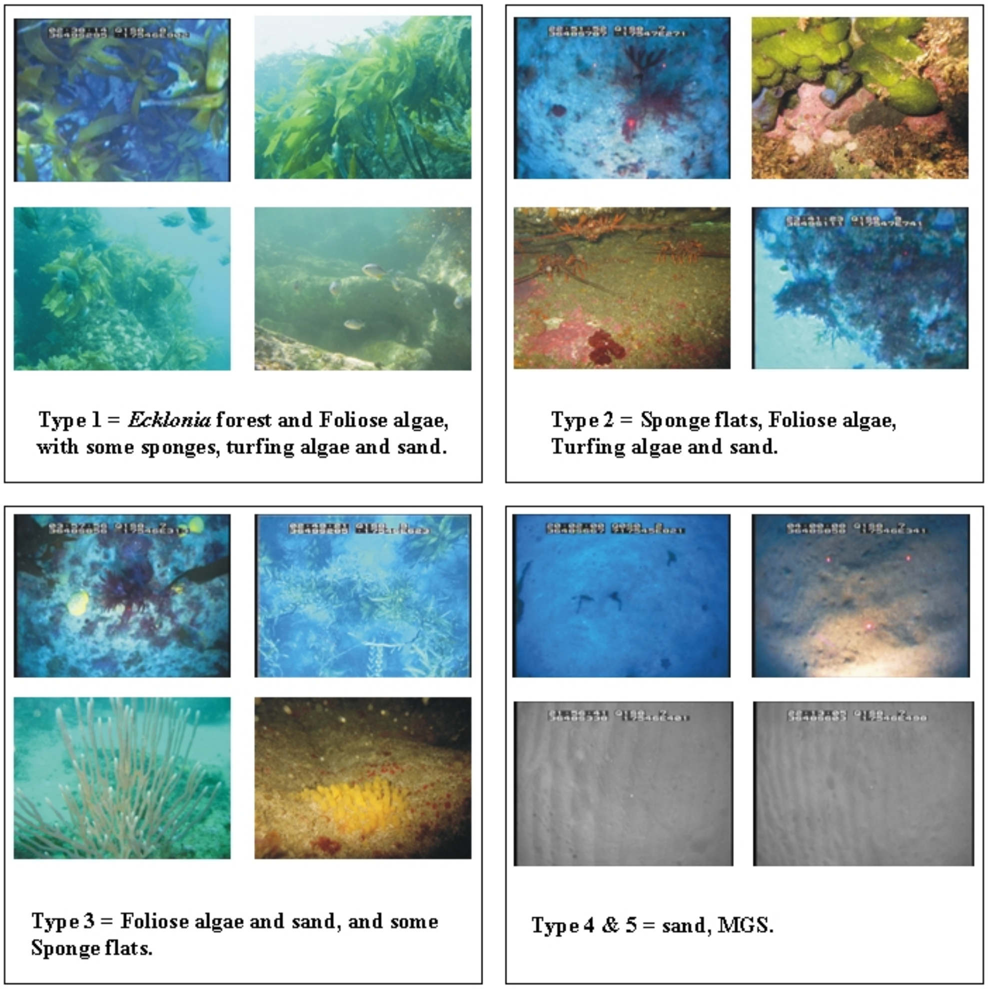

Figure 9: Examples of habitats observed within the sedimentary facies. Images taken from video and still photography (R. Budd, C. Hickey). MGS images shown in greyscale to enhance visibility.

3.2.2 Soft-substrata habitats

The soft sediments could be split into a number of different habitats, initially into MGS, sand and fine sand habitats and two samples representing a transition zone between MGS and RSM comprising very coarse sediment (Fig 10, level 1 40% similarity). Once this initial split had been made, the MSG sediments were further split into categories dependent on the coarseness of the sediment and the amount of shell hash into 3 main groups, one pair and one singleton (Fig. 10, level 2, 70% within group similarity). The fine sand habitat had a within group similarity of > 80%, but the sand habitat split up into 1 group, 2 pairs and 3 singletons (Fig. 10, level 2). The pairs and singletons were mainly transition zones, though two samples (extreme right of Fig. 10) had a mixture of fine and medium sand. The largest sand habitat was composed of high medium sand content and the presence of mounds, burrows and small ripples on the surface. A small group, predominantly biogenic, breaks away from this large medium sand habitat at ~80% similarity (Fig. 10, level 3) composed of samples with sponges, turfing and foliose algae, and one with scallops.

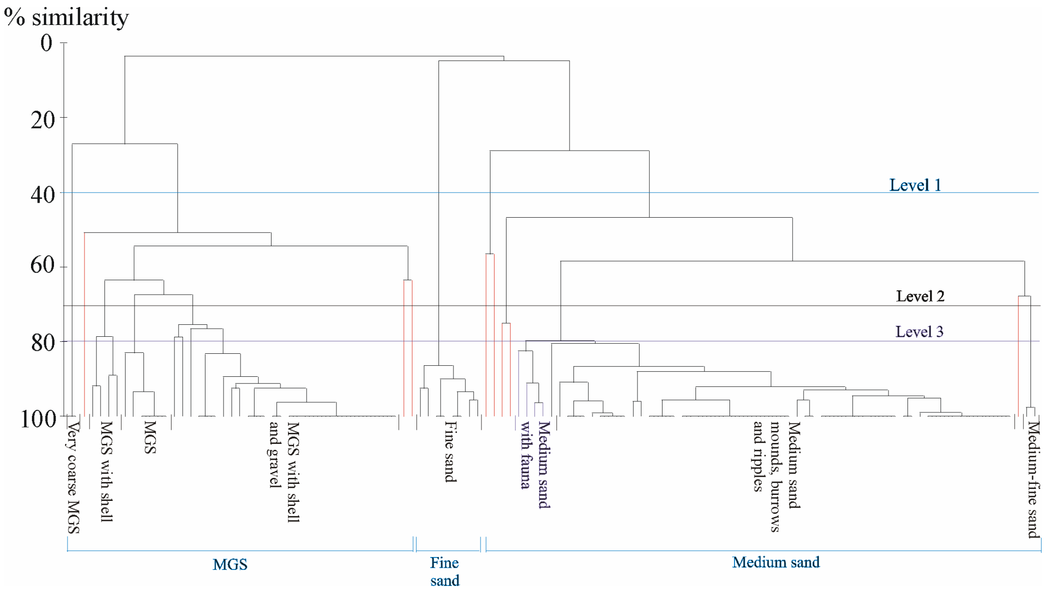

Figure 10: Soft-sediment habitats revealed by cluster analysis. Red lines represent sites exhibiting a transition between soft and hard sediments. Blue are groups that are <40 similar to each other (Level 1), black are groups that >70%self-similar (Level 2).

The majority of the reserve was Medium sand and MGS (Fig. 11). Finer sand was scattered throughout the reserve. Generally there were no large scale patterns in the distribution of sand habitats observed within the reserve. A large area of Scallop habitat and another of Sponge flat was found in the eastern area of the reserve between Mahurangi and Motueka Islands.

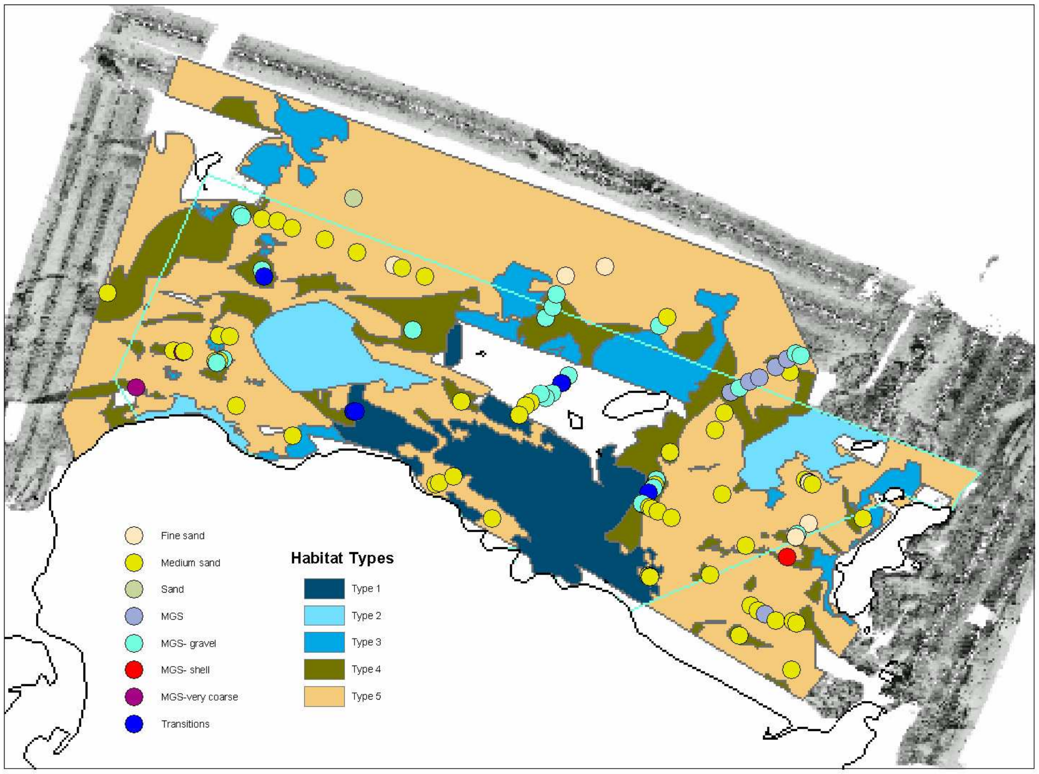

Figure 11: Location of soft sediment habitats observed by video.

4. Discussion

Side-scan surveys allow a large area of seafloor to be covered within a short space of time and can provide much information on seafloor topography and extents of reef platforms. However, to prepare ecologically relevant maps, a sampling strategy is required that nests finer scale sampling within the broad scale side-scan survey (Hewitt et al. 2002, 2004). Previous studies have shown that video is a cost effective and appropriate way to carry out the finer scale sampling, compared to dive surveys where cost and safety considerations are restrictive over the large areas of interest (Thrush et al. 2003).

4.1 Comparison with previous studies

Previous studies in this area have been done by diving (Bay of Plenty Polytechnic, 1991; Shears and Babcock, 2000) and have been confined to a few transects. These have generally run from the land, or islands, over a limited depth range; frequently only down to 5 or 10 m, and have concentrated on hard substrates. There was little overlap between these previously surveyed areas and this study for a number of reasons. (1) Our focus was on ground truthing the side-scan and this restricted sampling to > 3 m. (2) Problems with the GPS coordinates given in Bay of Plenty Polytechnic (1991) and the variability they reported suggested that revisiting those sites would not be profitable. However, two sites from Shears and Babcock (2000), site 2 &3, were resampled and our classification in the deeper waters matched theirs (*Ecklonia* forest).

An interesting point of difference between the overall picture suggested by Shears and Babcock (2000) and this study was the variability in habitat type. Generally this study observed changes in hard-substrate habitat type over 10 – 50 m such that it was difficult to assign habitat types to large areas. This is probably a function of the increased types of areas sampled; Shears and Babcock were concentrating on shore to sea transects, where depth control should be greatest. However, investigation of their data (from their Table 2) does suggest variability between transects could be high.

4.2 Biological Variability

A feature of the reserve is the high variability in communities found within its boundaries. Three factors have been identified as potentially influencing biological variability; sand inundation, terrigenous sediment deposition, and natural habitat variability.

Disturbance by sand inundation may cause variability since the communities may be in various stages of recovery from disturbance. However, many of the sand patches observed on the side-scan images seem to be relatively stable as they were still present when the video sampling was conducted.

A gradient of increased suspended sediment loads and deposition has been observed through the reserve area, with concentrations greatest in Whitianga (Schwarz et al. 2004). Such gradients may have both indirect (water clarity) and direct effects (sediment effects on filter feeders) on benthic communities. A reduction in the photosynthetic potential associated with elevated levels of suspended sediment was observed pointing to a reduced production in all primary producers, including epiphytes (Schwarz et al. 2004). A lower density of *Ecklonia radiata* was suggested near Cook's Bluff, however individual plant biomass was not affected. The lack of *Ecklonia* Forest Habitat near Cooks Bluff may be a reflection of this gradient. A change in understory fauna and flora was also observed along the suspended sediment gradient with an increase in crustose coralline algae. Schwarz et al. (2004) also observed that a number of the filter feeders in the area, such as oyster and sponges, displayed signs of physiological stress when placed in elevated suspended sediment concentration in laboratory conditions, including altered feeding rates and loss in condition. Laboratory tests on paua and kina, in the same study, revealed that increased suspended sediment levels, similar to those observed on occasion near Whitianga, increased larval mortality.

Regardless, of the three factors, habitat variability would seem to be the main factor influencing biological community structure in the reserve as, although suspended sediment has been found to influence primary productivity, and potentially community structure in rocky reef communities within the northern reaches of the reserve, it does not explain variability within the communities of the reserve as a whole. Habitat diversity would seem to be a more logical explanation for biological variability, given the variety of habitat types found within the area under study.

4.3 Areas of interest

The habitat types observed by this survey are consistent with those generally found in north-eastern New Zealand coastal areas (Shears et al. in press). However, an area particularly rich in sponges and encrusting invertebrates was found outside the reserve to the east of Mahurangi Island (Fig. 12, Area A).

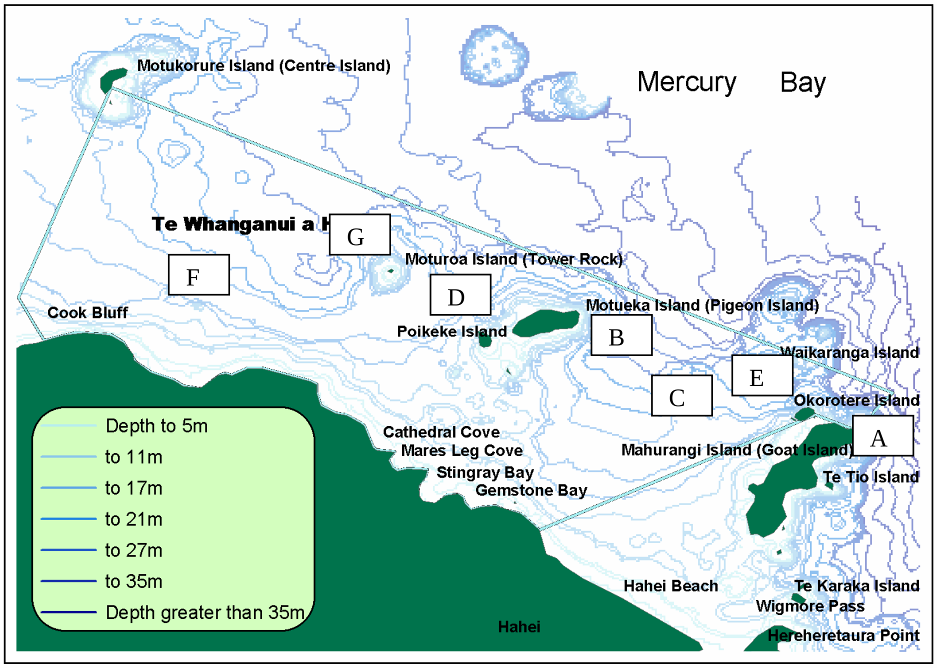

Figure 12: Areas of interest within and near the marine reserve.

Transitions between sedimentary facies were interesting. Transitions between sand and MGS were reasonably abrupt, taking place over < 5 m, a characteristic of the MGS facies. Abrupt transitions between rock and sand were also observed within the Bedrock/sand and RSM facies. However, transitions between either Bedrock/sand or RSM and sand or MGS were generally much more diffuse (taking place over 5 – 50 m) as the sand quantities slowly increased. Transition between habitat types based on video sampling also varied from abrupt to diffuse and the suddenness of the transition appeared dependent on location rather than habitat type.

The soft-sediment habitats are typical of those on exposed coasts in shallow waters and, are largely lacking in epifauna or flora and other biogenic structure (cf. those in Tonga Island Marine Reserve, Thrush et al. 2003, Hewitt et al. in press). Bioturbation of the medium sand sediments was observed by worms and crabs, although rates were generally low. While no habitat classification scheme yet exists for soft sediments, the soft sediments, though generally distinguishable by sedimentary characteristics only (e.g., particle size, ripples) comprise a number of distinct types (unlike those in the Tuinagara to Blackhead Point area, Funnell et al. 2004). Two areas of significance were suggested by the side scan images and observed, both between Mahurangi and

Motueka Islands. (1) An area of scallops suggested by one drop-camera sample and local knowledge (Fig. 12, Area B). And (2), an interesting area of sponges, again confirmed by local knowledge (Fig. 12, Area C).

Within the reserve itself, given the nature of the habitat, there are few areas that stand out as requiring protection from anchoring at the present time. One is the area off Mares leg cove, Stingray bay and Gemstone bay, that collectively make up a 'snorkel trail' popular with local tourist operators. The volume of boats that anchor in this area make a permanent mooring potentially advantageous. Although the habitat is mostly macro algae forest and not especially vulnerable to anchor damage, the 'scuffing' from high numbers of anchors and associated chains/ ropes could cause a significant impact. Other areas of concern are the areas of sponge and possibly the scallop area noted in the preceding paragraph (Fig. 12, Area's B & C). Sponge areas along the surveyed transect between Motueka and Moturoa Islands are also worthy of protection, as is the steep wall that runs through this area (Fig. 12, Area D). Finally, the sponge beds and encrusting invertebrates on the south east of Mahaurangi island (Fig. 12, Area A) are worthy of protection. Although technically outside the reserve, this area represents a fragile biological community, both vulnerable to anthropogenic disturbance and slow to recover, and would benefit from protection from anchor damage.

The rocky reef area to the east of Motueka Island and near Waikaranga Island (Fig. 12, Area E) is only partially inside the reserve. This means that mobile species such as crayfish and most finfish are only afforded partial protection from fishing effort. Although at first glance this would seem to provide 'spillover' benefits to local fishers, it may in the long run degrade the effectiveness of that portion of the reserve.

4.4 Monitoring

Currently, monitoring of the Te Whanganui a Hei marine reserve has surveyed rock lobsters, reef fish, and benthic populations (Haggitt and Kelly 2004), with lobster surveys annually since 1996, except for 1999 and 2002, and reef fish surveys annually since 1997. Benthic surveys were carried out only in 1999 and 2000. A report (Haggitt and Kelly 2004) on monitoring of the reserve recommends continuing present annual surveys and expanding the monitoring with biannual monitoring of sediment collectors and benthos, annual documentation of physical factors, 5 yearly habitat mapping, a one-off lobster tracking study, and annual monitoring of visitor numbers.

The results of this study confirm the need of a one-off lobster tracking study, especially for lobsters in the rocky area just inside the reserve near Waikaranga Island (Fig. 12, Area E). Mobile animals in this area of the reserve utilising both rocky and sandy habitats may be using the sandy areas outside the reserve and thus not gaining maximum benefit from the reserve. Expansion of the lobster tracking to monitoring general faunal usage of the sandy area could thus prove useful.

This study can also be used to locate sites for biannual monitoring of sediment collectors and benthos. While monitoring should revisit sites previously used for other surveys, we would recommend including monitoring of Area A, B, C, and E. We also consider that the flat rock sand (FRS) areas (Fig. 12, Area F) and the area of Bedrock/sand to the west of Moturoa Island (Fig. 12, Area G) should be included. Collection of infaunal soft-sediment animals from different soft-sediment types would be useful. Following the Mfish report (Schwarz et al. 2004) detailing a suspended sediment gradient running through the reserve and the potential for long-term effects on flora and fauna, sites should also be located to detect changes along this gradient.

Our results suggest that broad-scale side-scan-based habitat maps are of limited use in describing the ecological habitats and values of this reserve. Broad-scale changes over time in the ecological habitats and values may thus best be monitored by a combination of biannual benthic monitoring and 5-yearly video transects covering larger areas. This approach would require careful design and selection of sites for bi-annual benthic monitoring.

4.5 Caveats

The objective of this report was the identification of broad habitat types, preferably linked to acoustic imagery. However, the nature of the sedimentary habitats made this latter point difficult. The two major hard-substrate facies comprise various mixtures of rock and sand, frequently in a broken ground arrangement. The two major soft-sediment facies, although occurring over similar depth ranges, occur in a complex pattern of patch sizes and shapes. Complex gradients in wave exposure and a gradient in water turbidity also complicate any simple community/depth/substrate relationships. The resultant changes in substrate and depth make broad-scale classification linked to acoustic imagery difficult at all but a general level. This limits, but does not preclude, the usefulness of the habitat map. It is useful as a description of the area and the habitat types found. But, without more intensive sampling, the habitat map cannot be used a basis for monitoring changes in the reserve.

It is also important to note that the species identification has been done from video footage in consultation with lists of taxa previously found in this area, identification to species level was often not possible, due to environmental conditions.

5. References

Bay of Plenty Polytechnic (1991). Contribution to the selection of control sites Cathedral Cove proposed marine reserve. Bay of Plenty Polytechnic.

Funnell, G.A.; Hancock, N.; Williston, T.; Drury, J. (2004). Tuingara to Blackhead Point Habitat Mapping. Prepared for Department of Conservation NIWA Client Report: HAM2004-094

Hewitt, J.E.; Thrush, S.F.; Legendre, P.; Cummings, V.J. & Norkko, A. (2002). Integrating heterogeneity across spatial scales: interactions between *Atrina zelandica* and benthic macrofauna. *Marine Ecology Progress Series 239*: 115-128.

Hewitt, J.E.; Thrush, S.F.; Legendre, P.; Funnell, G.A.; Ellis, J.; Morrison, M. (2004) Remote mapping of marine soft-sediment communities: integrating sampling technologies for ecological interpretation, *Ecological Applications 14*: 1203-1216.

Hewitt, J.E.; Thrush, S.F.; Halliday, J.; Duffy, C. (in review). The importance of small-scale biogenic habitat structure for maintaining beta diversity. *Ecology*.

Schwarz, A.; Taylor, R.; Hewitt, J.; Phillips, N.; Shima, J.; Cole, R. (2004) Draft Marine Biosecurity Report: Impacts of terrestrial runoff on the biodiversity of rocky reefs. Prepared for Ministry of Fisheries NIWA.

Shears, N. & Babcock, R. (2000). Te Whanganui A Hei Marine Reserve Benthic community monitoring program. Report to the Department of Conservation.

Shears, N.T.; Babcock, R.C.; Duffy, C.A.J.; Walker, J.W. (in press). Reef habitats in north-eastern New Zealand.

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 Prepared for Department of Conservation NIWA Client Report: HAM2003-118.

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7. Appendix 1: Habitat classes used to describe shallow rocky reef assemblages in north-east New Zealand (after Shears & Babcock 2000).

Habitat	Depth Range (m)	Description
Shallow *Carpophyllum*	<3	Dominated by high abundances (≥20 adult plants m^{-2}) of *Carpophyllum maschalocarpum*, *C. plumosum* and *C. angustifolium*. *Ecklonia* and *Pterocladia* are also common. Urchins at low numbers and generally cryptic.
Ecklonia forest	5-20	Generally monospecific stands of mature *Ecklonia* forming a complete canopy (≥4 adult plants m^{-2}), occasional *C. flexuosum* plants. Urchins at low numbers, usually cryptic.
C. flexuosum forest	3-10	*C. flexuosum* plants dominate (≥4 adult plants m^{-2}), on sheltered reefs plants are large and associated with high levels of sediment. On more exposed reefs plants are short and generally associated with *Evechinus*.
Mixed Algae	2-10	Mixture of large brown algal species. No clear dominance of one particular species, usually only partial canopy (≥4 adult plants m^{-2}) and urchins may also be common.
Red foliose algae	2-9	Substratum predominantly covered (>40 %) by red foliose algae such as *Pterocladia* or *Osmundaria*. Low numbers of large brown algae
Turfing algae	3-9	Substratum predominantly covered by turfing algae (e.g., articulated corallines (Coralline turf) and other red turfing algae.) (>30 % cover). Low numbers of large brown algae (<4 adult plants m^{-2}) and urchins may occur.
Caulerpa mats		Areas where green algae, usually *Caulerpa flexilis* forms a dense mat over the substratum (>40 %).
Urchin barrens	3-9	Very low numbers of large brown algae are present (<4 adult plants m^{-2}) and substratum typically dominated by crustose coralline algae. Usually associated with the grazing activity of *Evechinus* (>2 adults m^{-2}) which leaves the substratum relatively devoid of macroalgae, *C. flexuosum* and *Sargassum sinclairii* may occur. In sheltered areas urchins are often absent from this habitat and there is a high cover of sediment and bare rock.
Cobbles		Cobble areas, unstable and subject to high levels agitation from wave exposure - in these areas crustose coralline algae are dominant along with a high cover of bare rock and sand, very low numbers of algae.
Encrusting communities		Usually vertical walls where substrate predominantly covered by community of encrusting ascidians, sponges, hydroids and bryozoans. Low numbers of large brown algae.
Sponge flats	>10	Sponges are the dominant organism, high cover of sediment. Usually occurs on the reef-sand interface. Low numbers of *Ecklonia* may be present (<4 adult plants m^{-2}).

8. Appendix 2: Position of drop camera stations as WGS84 and NZ map co-ordinates.

Runline	Easting	Northing	Latitude	Longitude
1	2761291.46	6481066.33	-36.83837	175.81300
2	2761606.29	6481369.48	-36.83555	175.81642
3	2761518.67	6481844.14	-36.83130	175.81527
4	2761534.30	6481830.33	-36.83142	175.81545
5	2761526.78	6481818.35	-36.83153	175.81537
6	2761786.25	6482260.93	-36.82747	175.81812
7	2761738.24	6482999.71	-36.82083	175.81732
8	2761424.12	6482579.95	-36.82470	175.81395
9	2761445.89	6482562.61	-36.82485	175.81420
10	2761452.92	6482559.05	-36.82488	175.81428
11	2761467.76	6482548.59	-36.82497	175.81445
12	2761234.26	6482447.16	-36.82595	175.81187
13	2761241.29	6482443.61	-36.82598	175.81195
14	2761028.67	6482070.60	-36.82940	175.80970
15	2760787.59	6481841.71	-36.83153	175.80708
16	2760962.99	6481347.63	-36.83593	175.80922
17	2760392.44	6481849.73	-36.83157	175.80265
18	2760402.96	6481843.85	-36.83162	175.80277
19	2760403.68	6481838.27	-36.83167	175.80278
20	2760888.25	6482485.85	-36.82570	175.80798
21	2761140.76	6482652.20	-36.82413	175.81075
22	2760563.62	6482834.74	-36.82265	175.80422
23	2760168.85	6482686.18	-36.82410	175.79985
24	2759749.11	6481969.90	-36.83067	175.79540
25	2759401.87	6482338.33	-36.82745	175.79138
26	2759477.57	6482560.24	-36.82543	175.79215
27	2759276.12	6482910.76	-36.82233	175.78977
28	2759234.13	6483279.59	-36.81902	175.78917
29	2758965.37	6483021.54	-36.82142	175.78625
30	2758976.76	6483014.52	-36.82148	175.78638
31	2758982.93	6483012.11	-36.82150	175.78645
32	2758994.42	6483008.42	-36.82153	175.78658
33	2758997.92	6483006.09	-36.82155	175.78662
34	2759007.62	6483002.45	-36.82158	175.78673
35	2759016.40	6482997.74	-36.82162	175.78683
36	2759037.60	6482990.41	-36.82168	175.78707
37	2758834.50	6483488.64	-36.81725	175.78462
38	2758404.85	6483452.12	-36.81770	175.77982
39	2758536.08	6483223.74	-36.81972	175.78137
40	2758553.91	6483223.18	-36.81972	175.78157
41	2758577.17	6483224.67	-36.81970	175.78183
42	2758644.22	6483113.76	-36.82068	175.78262

Runline	Easting	Northing	Latitude	Longitude
43	2758667.17	6483105.27	-36.82075	175.78288
44	2758686.37	6483091.35	-36.82087	175.78310
45	2758556.38	6483016.58	-36.82158	175.78167
46	2758138.82	6483051.84	-36.82138	175.77698
47	2758142.97	6483041.72	-36.82147	175.77703
48	2758147.42	6483041.58	-36.82147	175.77708
49	2757783.77	6483288.32	-36.81935	175.77292
50	2757335.26	6483333.38	-36.81907	175.76788
51	2757374.47	6483331.05	-36.81908	175.76832
52	2757103.24	6483479.39	-36.81782	175.76523
53	2757144.61	6483460.34	-36.81798	175.76570
54	2757394.59	6483747.90	-36.81532	175.76840
55	2757452.29	6483737.22	-36.81540	175.76905
56	2757463.98	6483740.19	-36.81537	175.76918
57	2757667.57	6483855.98	-36.81427	175.77142
58	2757688.15	6483857.55	-36.81425	175.77165
59	2757690.89	6483859.69	-36.81423	175.77168
60	2757701.53	6483857.14	-36.81425	175.77180
61	2757726.33	6483850.81	-36.81430	175.77208
62	2757752.19	6483850.01	-36.81430	175.77237
63	2757762.07	6483851.92	-36.81428	175.77248
64	2757967.71	6483804.42	-36.81465	175.77480
65	2757716.23	6483670.15	-36.81593	175.77203
66	2757686.49	6483661.08	-36.81602	175.77170
67	2757665.77	6483655.07	-36.81608	175.77147
68	2757670.70	6483641.59	-36.81620	175.77153
69	2756988.12	6484226.88	-36.81112	175.76368
70	2757955.93	6485229.32	-36.80182	175.77417
71	2758286.82	6485160.14	-36.80235	175.77790
72	2758589.65	6484936.38	-36.80428	175.78137
73	2757858.80	6484834.86	-36.80540	175.77322
74	2757869.70	6484812.31	-36.80560	175.77335
75	2757982.97	6484379.09	-36.80947	175.77477
76	2757995.64	6484327.62	-36.80993	175.77493
77	2757995.57	6484325.40	-36.80995	175.77493
78	2759643.91	6484303.76	-36.80968	175.79340
79	2759693.14	6484307.77	-36.80963	175.79395
80	2759647.14	6484321.43	-36.80952	175.79343
81	2759642.99	6484331.55	-36.80943	175.79338
82	2759642.73	6484351.55	-36.80925	175.79337
83	2758940.06	6483866.17	-36.81382	175.78567
84	2759113.09	6483946.24	-36.81305	175.78758
85	2759123.68	6483942.58	-36.81308	175.78770
86	2759219.75	6483731.94	-36.81495	175.78885
87	2760191.34	6484336.52	-36.80923	175.79952

Runline	Easting	Northing	Latitude	Longitude
88	2760927.54	6484013.53	-36.81193	175.80788
89	2761353.56	6483453.79	-36.81685	175.81285
90	2760858.94	6482999.74	-36.82108	175.80747
92	2760922.18	6483136.54	-36.81983	175.80813
93	2759758.92	6482707.96	-36.82402	175.79525
94	2759782.48	6482690.56	-36.82417	175.79552
95	2759789.33	6482681.46	-36.82425	175.79560
96	2762429.00	6482234.99	-36.82752	175.82533
97	2762437.74	6482229.16	-36.82757	175.82543
98	2762479.72	6482230.05	-36.82755	175.82590
99	2762482.40	6482229.97	-36.82755	175.82593
100	2762512.47	6482221.24	-36.82762	175.82627
101	2762515.11	6482220.04	-36.82763	175.82630
102	2762599.33	6482201.82	-36.82777	175.82725
103	2762619.84	6482201.17	-36.82777	175.82748
104	2762683.87	6482193.59	-36.82782	175.82820
105	2761437.22	6482232.00	-36.82783	175.81422
106	2761361.47	6482151.13	-36.82858	175.81340
107	2761349.00	6482123.76	-36.82883	175.81327
108	2761288.73	6481968.00	-36.83025	175.81265
109	2761044.56	6481584.88	-36.83377	175.81005
110	2761090.59	6481544.57	-36.83412	175.81058
111	2761131.69	6481517.73	-36.83435	175.81105
112	2761201.38	6481463.34	-36.83482	175.81185
113	2761312.55	6481450.95	-36.83490	175.81310
114	2761331.74	6481437.02	-36.83502	175.81332
115	2760470.02	6482612.29	-36.82468	175.80325
116	2760457.24	6482574.95	-36.82502	175.80312
117	2760443.13	6482552.07	-36.82523	175.80297
118	2760448.48	6482551.91	-36.82523	175.80303
119	2760415.87	6482508.52	-36.82563	175.80268
120	2760376.55	6482422.04	-36.82642	175.80227
121	2760370.45	6482426.68	-36.82638	175.80220
122	2760416.84	6482397.46	-36.82663	175.80273
123	2760429.01	6482387.08	-36.82672	175.80287
124	2760469.15	6482358.06	-36.82697	175.80333
125	2760554.07	6482305.42	-36.82742	175.80430
126	2759046.63	6482623.72	-36.82498	175.78730
127	2759071.95	6482634.03	-36.82488	175.78758
128	2759166.19	6482678.82	-36.82445	175.78862
129	2759269.26	6482692.24	-36.82430	175.78977
130	2759300.40	6482689.05	-36.82432	175.79012
131	2759363.20	6482670.42	-36.82447	175.79083
132	2759375.16	6482653.39	-36.82462	175.79097
133	2760967.56	6483301.65	-36.81833	175.80858

Runline	Easting	Northing	Latitude	Longitude
134	2761023.91	6483333.19	-36.81803	175.80920
135	2761092.48	6483384.32	-36.81755	175.80995
136	2761157.74	6483415.56	-36.81725	175.81067
137	2761267.46	6483497.59	-36.81648	175.81187
138	2761340.77	6483557.45	-36.81592	175.81267
139	2761395.69	6483600.13	-36.81552	175.81327
140	2761427.23	6483581.37	-36.81568	175.81363
141	2757998.52	6484791.63	-36.80575	175.77480
142	2758100.40	6484766.25	-36.80595	175.77595
143	2758187.94	6484710.22	-36.80643	175.77695
144	2758396.49	6484612.66	-36.80725	175.77932
145	2758601.09	6484503.00	-36.80818	175.78165
146	2758838.62	6484390.09	-36.80913	175.78435
147	2758887.02	6484367.48	-36.80932	175.78490
148	2759029.32	6484293.07	-36.80995	175.78652
149	2759799.40	6483939.14	-36.81292	175.79527
150	2759846.68	6484023.14	-36.81215	175.79577
151	2759874.86	6484124.41	-36.81123	175.79605
152	2759939.19	6484267.84	-36.80992	175.79672
153	2760443.39	6483693.48	-36.81495	175.80257
154	2760461.65	6483706.22	-36.81483	175.80277
155	2760464.71	6483718.34	-36.81472	175.80280
156	2760496.34	6483730.67	-36.81460	175.80315
157	2760528.66	6483849.57	-36.81352	175.80347
158	2760579.98	6483920.12	-36.81287	175.80402
159	2759994.65	6483533.28	-36.81652	175.79760
160	2759977.20	6483489.42	-36.81692	175.79742
161	2759930.20	6483470.91	-36.81710	175.79690
162	2759917.32	6483430.23	-36.81747	175.79677
163	2759888.08	6483408.95	-36.81767	175.79645
164	2759880.84	6483405.84	-36.81770	175.79637
165	2759880.25	6483386.99	-36.81787	175.79637
166	2759820.36	6483327.80	-36.81842	175.79572
167	2759821.08	6483322.23	-36.81847	175.79573
168	2759802.79	6483308.37	-36.81860	175.79553
169	2759777.19	6483289.19	-36.81878	175.79525
170	2759736.06	6483343.78	-36.81830	175.79477
171	2759747.13	6483326.77	-36.81845	175.79490
172	2759679.93	6483262.27	-36.81905	175.79417
173	2759647.74	6483232.19	-36.81933	175.79382
174	2759665.46	6483199.43	-36.81962	175.79403
175	2759641.93	6483189.07	-36.81972	175.79377
176	2759608.30	6483170.14	-36.81990	175.79340
177	2759603.60	6483162.51	-36.81997	175.79335

9. Appendix 3: Position of hard substrate video counts as WGS84 and NZ map co-ordinates.

Sample ID	Easting	Northing	Latitude	Longitude
1	2761273.955	6480871.136	-36.83830	175.81305
13	2761123.173	6482454.385	-36.82408	175.81080
15	2760165.583	6482469.778	-36.82421	175.80007
16	2759745.930	6481755.732	-36.83076	175.79562
18a	2759477.405	6482347.073	-36.82551	175.79240
18c	2759484.369	6482332.051	-36.82565	175.79248
19a	2759269.838	6482701.480	-36.82238	175.78995
2	2761585.308	6481168.470	-36.83553	175.81643
23a	2758527.100	6483022.675	-36.81970	175.78152
23b	2758561.291	6483021.605	-36.81970	175.78190
24a	2758642.539	6482908.034	-36.82070	175.78285
24b	2758654.137	6482898.418	-36.82078	175.78298
25	2758545.954	6482816.681	-36.82155	175.78180
26b	2758128.595	6482838.979	-36.82146	175.77712
28a	2757332.644	6483124.718	-36.81911	175.76810
28b	2757356.649	6483131.372	-36.81905	175.76837
29	2757096.058	6483267.166	-36.81790	175.76540
30	2757440.833	6483541.406	-36.81533	175.76917
31a	2757657.197	6483656.796	-36.81423	175.77155
31b	2757685.433	6483655.916	-36.81423	175.77187
31c	2757722.596	6483654.757	-36.81423	175.77228
33	2757928.107	6485043.610	-36.80166	175.77410
5	2761740.901	6482793.847	-36.82085	175.81760
6b	2761425.150	6482359.717	-36.82485	175.81422
7b	2761224.999	6482240.209	-36.82598	175.81202
7c	2761233.683	6482232.533	-36.82605	175.81212
J1	2762405.679	6482036.264	-36.82748	175.82532
j10	2762660.239	6481994.869	-36.82778	175.82818
j11	2759958.126	6483299.778	-36.81680	175.79745
j13	2759890.976	6483246.374	-36.81730	175.79672
J15	2759855.515	6483206.778	-36.81766	175.79633
j16	2759851.906	6483186.536	-36.81785	175.79630
j18	2759794.759	6483119.864	-36.81846	175.79568
J2	2762414.419	6482030.435	-36.82753	175.82542
j25	2759642.407	6483006.219	-36.81953	175.79402
j26	2759621.079	6482990.234	-36.81968	175.79378
j27	2759586.375	6482974.670	-36.81983	175.79340
J5	2762487.067	6482022.577	-36.82758	175.82623
J7	2762527.075	6482017.605	-36.82761	175.82668
J8	2762577.430	6482010.454	-36.82766	175.82725