Marine habitats of the proposed Maunganui Marine Reserve, Cape Brett Peninsula

Vince Kerr, 2016

Cover Photo: A deep reef scene photographed by divers at Kariparipa Point showing the rich filter feeding community and elegant Gorgonian fans *Primnoides sp.* Photo: Northland Dive

For: Fish Forever, Bay of Islands Maritime Park Inc.

Report by: V.C. Kerr B.Sc.

Kerr and Associates, Whangarei

Citation: Kerr, V.C., 2016. Marine habitats of the proposed Maunganui Bay Marine Reserve. A report prepared for Fish Forever, Bay of Islands Maritime Park Inc.

ISBN 978-0-473-39499-8

Fish Forever
MARINE SANCTUARY • BAY OF ISLANDS
Ngā ika ake, ake ake, Ipipiri

Contents

Keywords: marine habitats, habitat classification, biological zonation, algal communities, wave exposure, kina barren, marine reserves, marine protected areas, Bay of Islands

1. Summary

A marine habitat map for the waters from near Cape Brett to Maunganui Bay, in the Bay of Islands, North-eastern Coastal Biogeographic region, New Zealand has been completed and is presented in a series of maps. The maps cover an area of 1,389 ha extending from shore as far as 2.0 km and the 80 m depth contour. Habitats were classified according to the Marine Protected Areas (MPA): Classification, Protection Standard and Implementation Guidelines. The MPA classification 'shallow rocky reef' was further defined into its primary biological communities of 'shallow mixed weed', 'kina barrens' *Evechinus chloroticus*, and '*Ecklonia* forest' *Ecklonia radiata*.

The survey takes in the marine reserve area proposed in 2014 by the community group Fish Forever, of the Bay of Islands Maritime Park Incorporated Society. Results of the survey support Fish Forever's proposal by demonstrating the special values of the area and its representation of outstanding examples of representative habitats and species for this bioregion. The area includes a high quality example of exposed shallow rocky reef and shores, adjacent deep reefs and a diversity of soft sediment areas adjoining the reefs. Habitats are described in some detail and illustrated with underwater photos.

The high resolution of mapping in this study made it possible to accurately delineate kina barrens as part of the shallow rocky reef environment in Maunganui Bay, but not in other areas. This study indicates that the extent of kina barrens in Maunganui Bay is a concern, as it covers 5% of shallow rocky reef.

The replacement of kelp forests with kina barren outside marine reserves can be compared to the recovery of kelp forest inside marine reserves with full protection from fishing at Cape Rodney to Okakari Point (Goat Island) and Tawharanui Marine Reserves. The authors recommend that the size and scale of this decline, and the threat it poses, becomes the focus of additional studies at the Cape Brett Peninsula. In this way the dynamics between kina, kelp and fishing, and the effects of establishing protected areas can be examined at a useful scale.

1 Introduction

In May 2014, Bay of Islands community group Fish Forever released a public consultation document proposing a marine reserve in an area encompassing Maunganui Bay and extending along the northern coast of the peninsula towards Cape Brett in the eastern Bay of Islands, Northland (Fish Forever, 2014). Analysis of the boundaries of the Maunganui Bay marine reserve proposal was supported by a technical report evaluating the proposed boundaries for the reserve (Kerr, 2014). Based on the strength of the proposal and the significant support documented in a report on consultation results (Kerr et al., 2014), Fish Forever decided to continue with a program of habitat and diversity studies at the proposed marine reserve area, thus initiating this project.

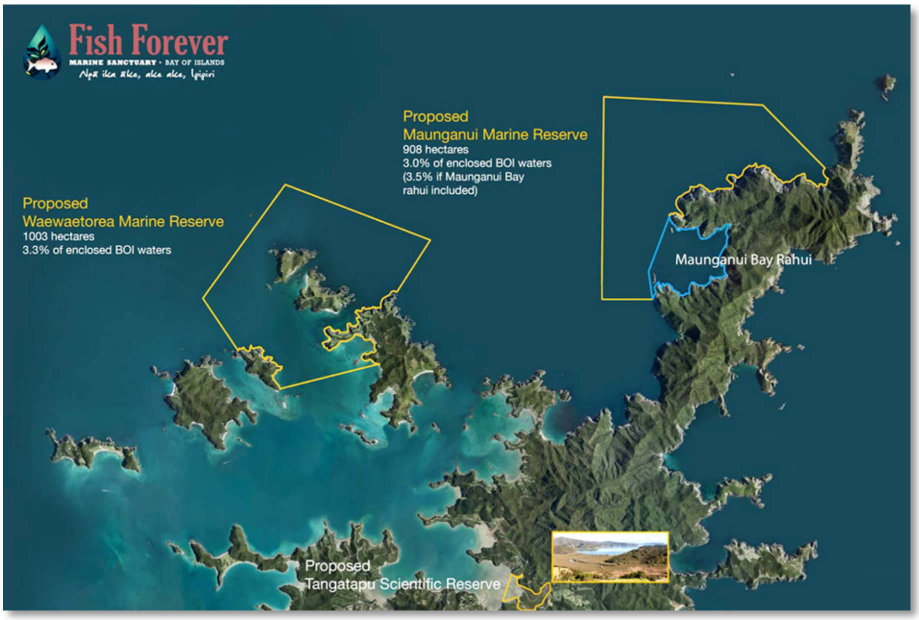

Figure 1 The marine reserves proposed by Fish Forever in 2014. Note that the area on the north and west coast of the Cape Brett Peninsula is the area of interest for this study.

Previous habitat mapping in Northland, including the methods used, and mapping classifications is provided in the Northland Marine Habitat Map (Kerr, 2010). Variations on the approaches used previously are presented here in the methods section. Because this study is designed primarily to support MPA planning, emphasis is placed on the habitat classification introduced in the Marine Protected Areas: Classification, Protection Standard and Implementation Guidelines (DOC & MFish, 2008) (MPA Guidelines) shown here in Table 1.

Table 1 Habitat classification from the Marine Protected Areas Implementation Plan (Reference).

Level 2	**Factor**	**Marine**						
Level 3	**Depth**	**Intertidal (MHWS MLWS)**			**Shallow Subtidal (MLWS – 30m)**			**Deep Subtidal (30m – 200m)**
Level 4	**Exposure**	low	med	high	low	med	high	low
Level 5	**Substrata**	Mud flat	Sandy beach	Sandy beach	Shallow mud	Shallow sand	Shallow sand	Deep mud
			Gravel beach	Gravel beach		Shallow gravel field	Shallow gravel field	Deep sand
			Cobble beach	Cobble beach		Shallow cobble field	Shallow cobble field	Deep gravel field
			Boulder beach	Boulder beach		Shallow boulder reef	Shallow boulder reef	Deep cobble field
			Rocky platform	Rocky platform		Shallow rocky reef	Shallow rocky reef	Deep boulder field
						Shallow biogenic reef	Shallow biogenic reef	Deep rocky reef
								Deep biogenic reef

The intention of the MPA classification is to provide a basic classification founded on primary physical substrata, exposure and depth zones that drive community and ecosystem structure, thereby acting as a proxy for more complex ecosystems or biological communities.

Last year, Fish Forever completed a habitat mapping project for the proposed marine reserve that surrounds the waters of Waewaetorea Island in the central region of the Eastern Bay of Islands. The approach to classification used in the Maunganui Bay habitat survey closely follows that outlined in the Waewaetorea project (Kerr and Grace 2015). In this approach mapping is attempted at a relatively fine scale and a special focus is placed on significant biological habitats. This approach is supported by work done by Shears et al. (2004 and 2007). The Shears study examines the degree of concordance between qualitative habitat descriptors and quantitative species data from various locations along the northeast coast. The authors concluded that qualitative habitat descriptors for rocky reefs do accurately define biologically distinct species assemblages and are an efficient means of mapping subtidal rocky reef habitats.

Resulting from these considerations the basic MPA classification is applied to this project but adds a further definition of major depth-related zonation of biological communities.

2 Methods

2.1.1 Habitat Surveys

Each summer between 2012 and 2016, habitat information was recorded at the study site. Various methods were adopted to maximise efficiency of boat time and equipment available. The methods also varied according to the depths targeted and the equipment available. Figure 2 shows the spatial distribution of records produced in the survey area, including additional data from other sources. Table 2 details the number of information records by method. Specific location names used throughout this report are shown on a map appearing in Figure 7, (Pickmere 1974).

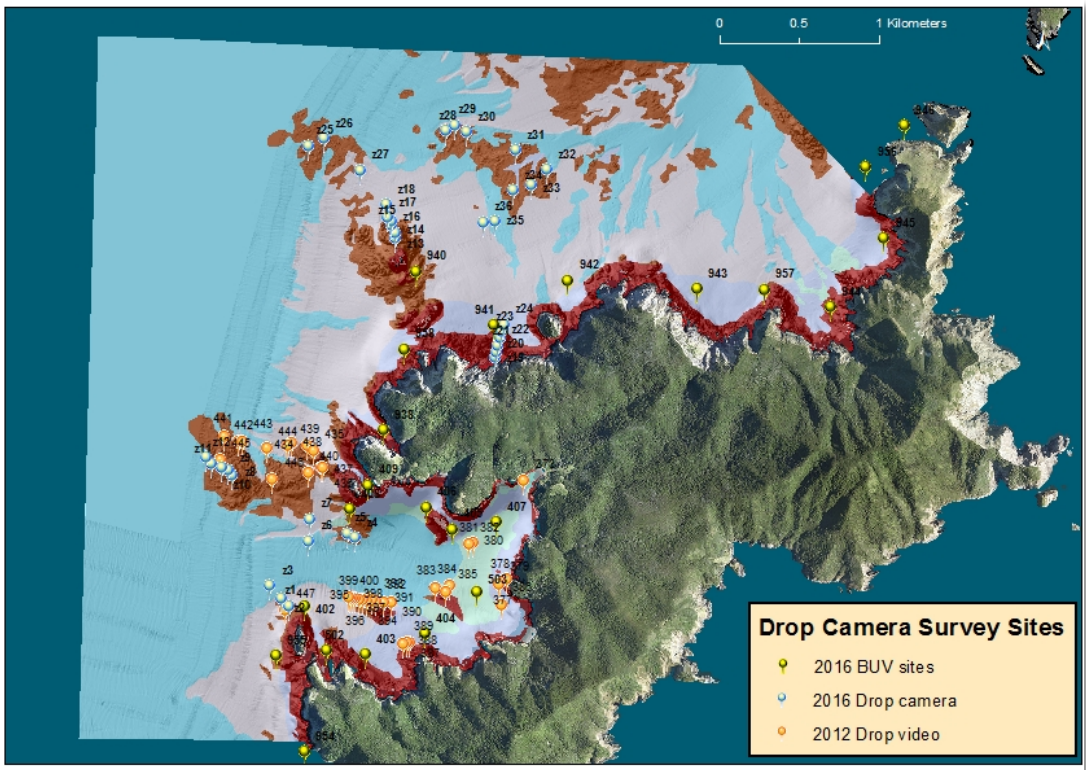

Figure 2 Drop camera survey waypoints shown over the completed habitat (see Map Book map 1 for key to habitats).

2.1.2 Drop camera surveys

Three camera systems were used. In total, 105 locations were investigated with remote cameras dropped to the seabed. One system used a live video camera connected to a small surface monitor screen by cable. The system could be deployed quickly allowing types of seabed and biota to be observed, recorded and interpreted in real time. The second system used a video camera mounted in a simple, robust housing built from a recycled scuba cylinder and plexiglass. The housing had a weight attached to a one-metre line attached to the bottom of the housing. Another line led from the top of the housing to a series of floats starting one metre above the housing. When deployed the unit hangs vertically approximately one metre above the seabed. The arrangement allows for rotation of the camera, effectively panning the camera and increasing the viewing area. A third system used for the deep reef part of the survey carried out in 2016 utilised a GoPro Hero Silver camera mounted on a drop apparatus with lighting supplied by two Sola video flood lights. The GoPro drop camera was set to take high-resolution still photos at 10 second intervals. The design of the drop camera apparatus allowed for some rotation of the system when it was positioned on the bottom to allow for photos to be taken at different angles. Also photos were automatically taken as the apparatus was approaching and leaving the seabed. See Figure 3 below.

At each drop site, time, GPS position, and depth were recorded and photographs or video footage archived for later interpretation. GPS coordinates for all drop camera locations are listed in Appendix 2.

Figure 3 GoPro drop camera system.

2.1.3 Sonar survey data sets and aerial photography

Available sonar data and aerial photography was collected for the study area. The area has had one previous habitat mapping project. The Northland Marine Habitat Map (Kerr, 2010) was digitised from aerial photography of shallow waters and sonar for deeper waters as a broad scale mapping effort for all of Northland's east and north coast. This map layer was used to begin the design of the survey and serve as a base layer in the setting up of a GIS (geographical information system) project. Fine scale data sets for this area and the entire Bay of Islands were produced by NIWA in the 2009 Oceans Survey 20/20 (OS 20/20) Bay of Islands project including high resolution aerial photography and multi-beam sonar surveys (Mitchell et al., 2010).

The OS 20/20 data sets used in this project were:

- 5m resolution multi-beam backscatter data (seabed physical substrate), fine scale,
- 2m resolution bathymetry grid data and 'hillshade' contour GIS layers,
- and high resolution aerial photography (see further section on mapping process).

2.1.4 Sonar survey ground truthing

A 4.2 m Mac boat, equipped with a Humminbird 947 single beam sounder and chart plotter was used for navigation, recording sample locations and surveying bathymetry and seabed structure. Target points for the drop camera survey were determined by locating specific locations of interest in the GIS map layers where interpretation of the sonar data could be tested. Specifically the areas targeted were:

- major physical habitat types
- inconsistent interpretations of sonar data
- areas where substrate boundaries were expected
- reef areas and depth profiles where major biological boundaries might occur
- representative sites chosen to ground-truth interpretation of aerial photography

2.1.5 Snorkel and scuba dives

Habitat interpretations were supported by notes on depth and algal communities from a series of snorkel and scuba dives completed in the area by the author. In addition, the operators of Northland Dive were interviewed as a further exercise in habitat interpretation ground-truthing. Shane Housham and Julia Riddle of Northland Dive have extensive dive records and photographic archives of many sites in the survey area.

2.1.6 Determination of exposure

Exposure to wind, wave energy and currents is known to influence the development of biological communities. The MPA Guidelines identify exposure as important in defining marine habitats for the purpose of its classification system. The guidelines define three exposure categories: low, medium, and high.

- High – areas of high wind/wave energy along open coasts facing prevailing winds and oceanic swell (fetch > 500 km e.g. ocean swell environments or currents > 3 knots).
- Medium – areas of medium wind/wave energy along open coasts facing away from prevailing winds and without a long fetch (fetch 50-500 km e.g. open bays and straits).
- Low – areas where local wind/wave energy is low (fetch <50 km e.g. sheltered areas; small bays and estuaries; current <3 knots).

This definition was applied by drawing a series of lines on a map outward from the coastlines within the survey area to approximately indicate the degree of exposure and fetch.

2.1.7 Habitat mapping process

To support the habitat mapping process, a GIS project was created containing all the data acquired for the study. The GIS environment allows for a range of display and spatial analysis approaches to be used to support interpretation.

Base maps were prepared of the OS 20/20 aerial photos and multi-beam backscatter imagery and terrain model (hillshade) layer. These two layers could be switched on and off and examined with field data overlays. Polygons of the habitat classification were then hand digitised at scales ranging from 1:2,000 in the deeper areas to 1:1,000 and 1:500 for the shallow areas.

Using the OS20/20 aerial photography layer a visual estimate was mapped of the Mean High Water Level and the Mean Low Water Level and classified by habitat. In the shallow waters where visibility of the aerial photo extended down to the seabed, habitat zones were digitised over the photo layer. Where the aerial photo could not be resolved because of light angles or steep slopes, habitat zones were estimated by depth and the use of the OS 20/20 sonar data layers, which showed reflectivity in the form of the backscatter layer (depicting hard or soft substrates) and sea bottom contour in the form of a three-dimensional hillshade layer. After completion of the initial interpretation, the mapped habitat layers were tested against the overlay of the field ground-truthing information.

Figure 4 shows an example of the multi-beam backscatter layer (at 40% transparency) overlaid on a 2 m resolution bathymetry hillshade layer (OS 20/20). This treatment of the sonar data layers was used to identify rocky reef edges.

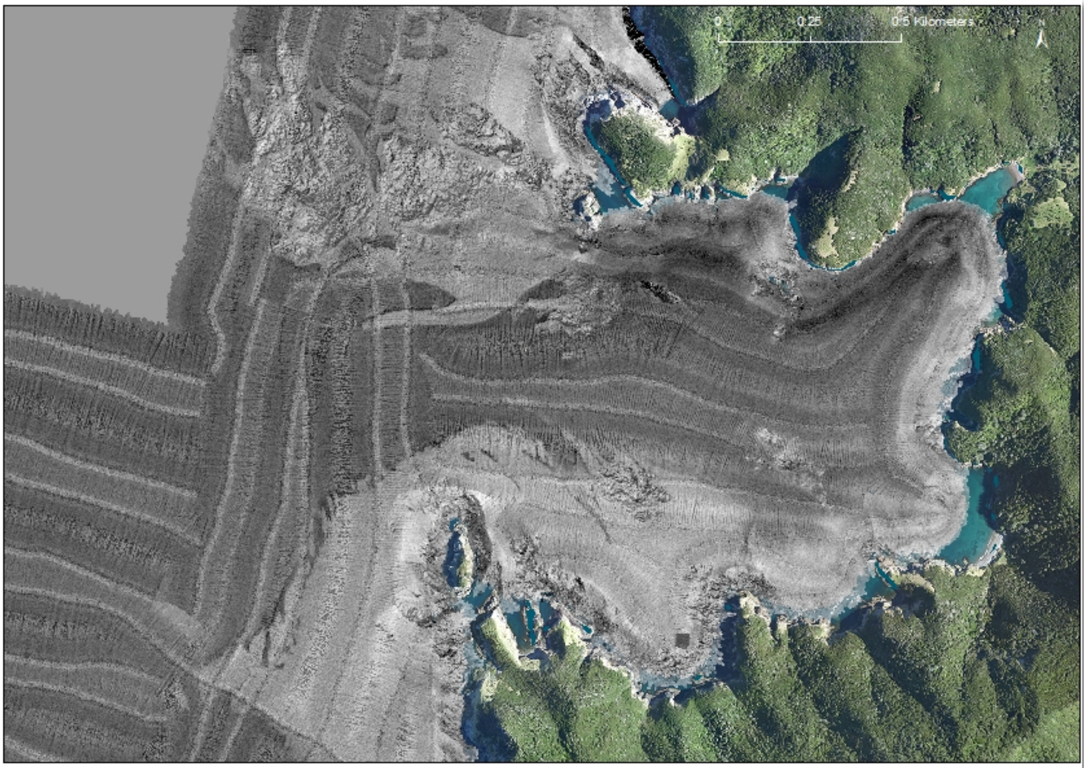

Figure 4 OS 20/20 sonar multibeam backscatter layer displayed over a contour hillshade bathymetry layer. The grayscale in this imagery displays the hardness or softness of the sea bottom substrate. Dark areas are sandier and lighter areas are shell, gravel or reef.

Figure 5 below shows an example of the quality and resolution of the aerial photography available from the OS 20/20 project. In this example you can clearly see substrata boundaries, a gravel beach, rocky reefs and various biological communities. Algal species appear as dark brown and kina barrens appear as light blue, bare-looking rocky areas. While there was full aerial coverage of the study area, wave conditions, sun angle, and shore topography meant that not all images were as easily interpreted as this example. Figure 6 below is a section of the habitat map drawn from the aerial image in Figure 5 showing the habitat interpretation of the colour differences seen in the imagery. The aerial photos for Maunganui Bay generally provided fair to good visual penetration of the shallow habitats. In these areas generally the aerial coverage extended seaward to where the OS 20/20 multibeam data began. On the exposed coast the value of the OS 20/20 aerial photography for the mapping purpose of subtidal habitats is limited because the sun angles at the time the photos were taken created surface glare, in addition to the typically steep slopes of this coast. The OS 20/20 multibeam data however comes very close to shore in this area providing accurate depth data and backscatter imagery. Where conditions for aerial photography interpretation were suitable this allowed fine scale mapping to extend seaward, typically, to a depth of 10 – 15 m.

Figure 5 OS 20/20 aerial photo of the White Reef area in Maunganui Bay, White Reef is the pale area in the lower left corner of the image where a large kina barren depicting bare rock is clearly seen. The dark patch around the kina barren is Ecklonia kelp forest habitat. The scale bar is 100m long.

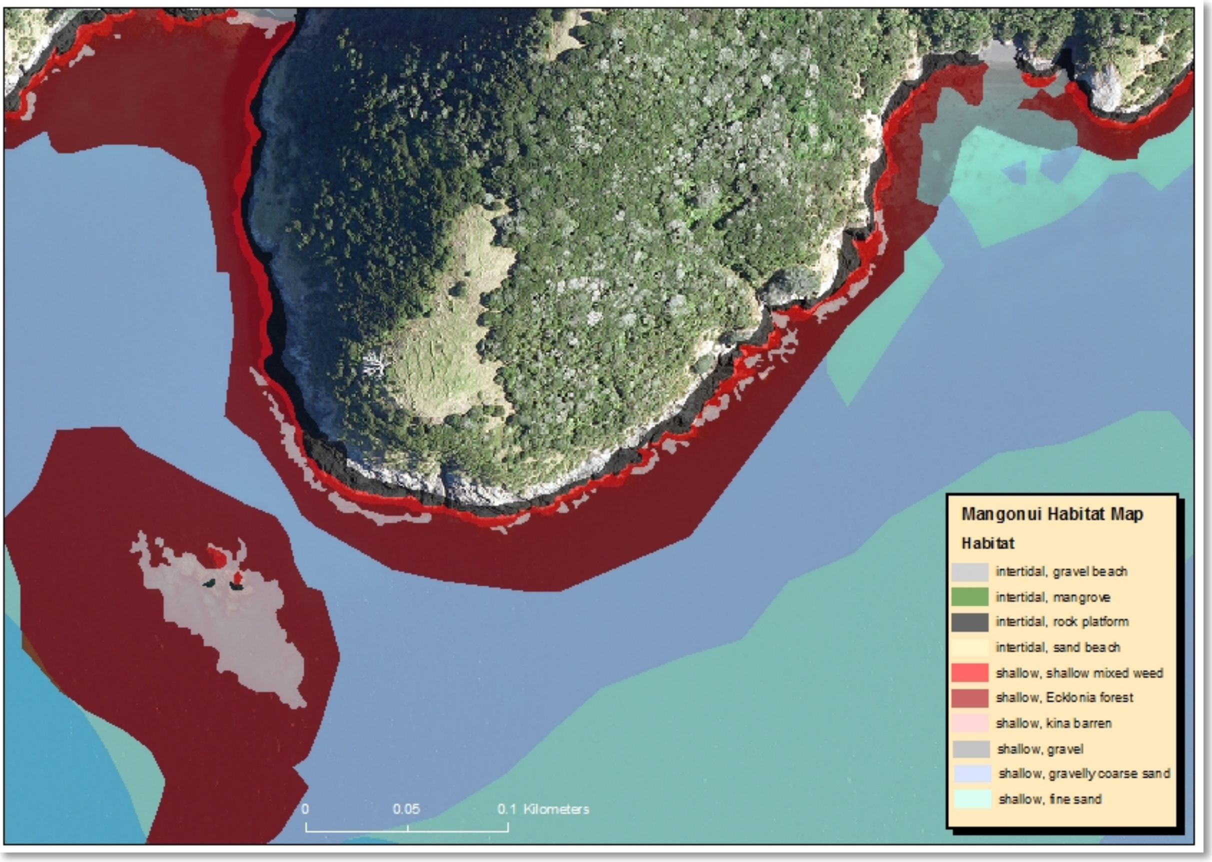

Figure 6 A section of the completed habitat map prepared with same spatial extent and scale of the aerial photo in Figure 5. Note the kina barrens depicted in a pale pink colour. The scale bar is 100m long.

3 Results

3.1.1 Interpretation of drop camera survey imagery

All camera drops were evaluated for substrate type and notes were made of significant biological communities and species. These results were plotted as coloured symbols to aid the habitat mapping process. Figure 7 below shows the camera drop locations with symbols representing the interpretation of habitats observed.

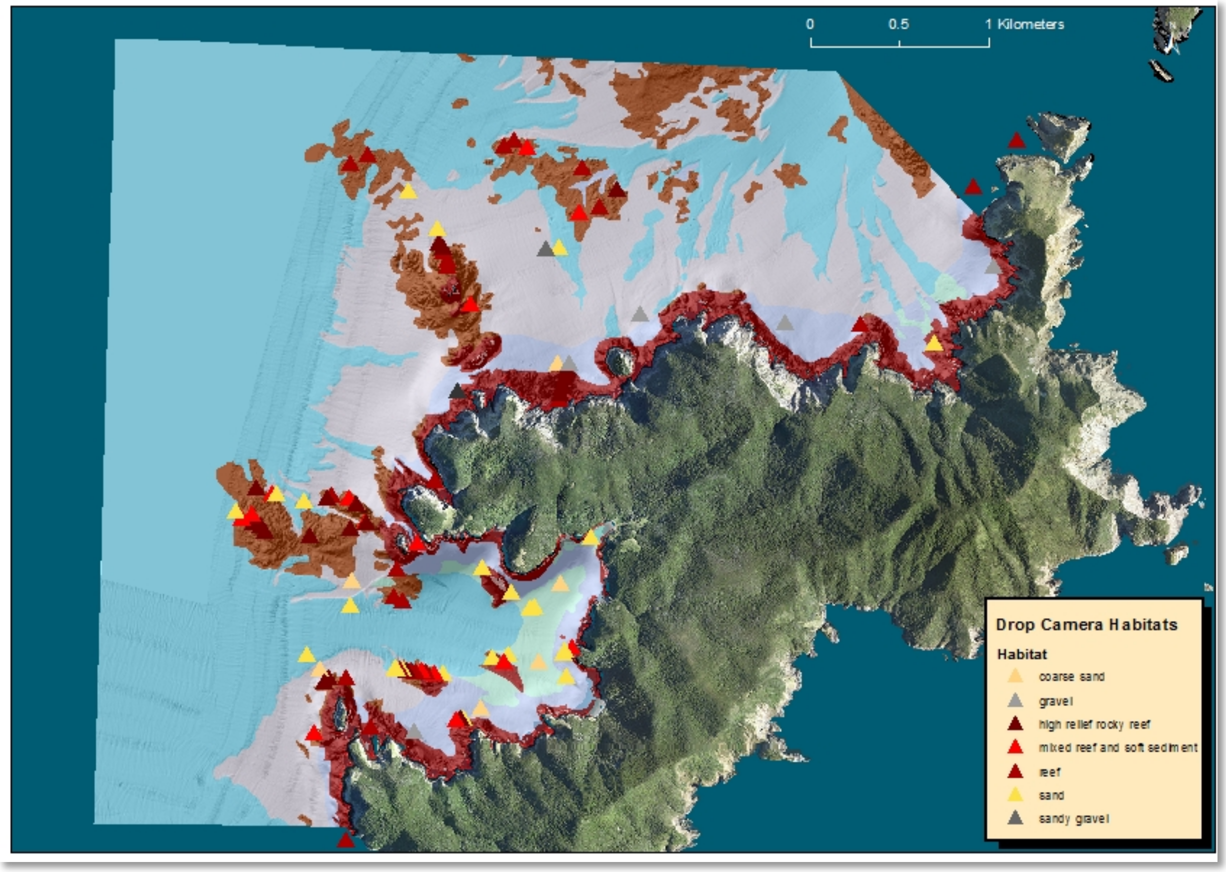

Figure 7 Drop camera survey waypoints shown over the completed habitat (see Map Book map 1 for key to habitats underlying habitat map).

3.1.2 The habitat maps

Detailed maps for this project can be viewed in a map book in Appendix 1. Map 1 shows the habitats of the entire survey area viewed at 1:23,000 scale. The entire survey area is 1,389 hectares. Within this area, the proposed marine reserve is 912 hectares and the mapped area of Maunganui Bay is 163 hectares.

The habitat maps of this report were prepared in a GIS project as a combination of two layers of data. The top layer is made up of hand-drawn polygons, representing the habitats areas. The habitat polygons are assigned a colour which is shown in the key. This top habitat layer is set at 30% transparency. Below this top layer is the OS 20/20 hillshade layer which essentially is a 3D image based on the very detailed bathymetry captured in the multibeam sonar survey. The hillshade layer is effectively a contour map which shows the 3D nature of the bottom contours through the semi-transparent habitat layer.

Table 2 lists the spatial areas and percentage coverage of each of the 10 habitats mapped in the proposed marine reserve area. In reference to the Marine Protected Area Plan habitat classification all of this area was evaluated as having high exposure.

The proposed marine reserve area has a significant area of shallow rocky reef habitat made up of shallow mixed weed and kina barrens and *Ecklonia radiata* kelp forest. The shallow mixed weed makes up 5.6 ha of this total and the *Ecklonia* forest is the major habitat at 49 ha. The kina barrens make up just under 1 ha of this total; this result must be taken only as an indication of presence as we were unable to source aerial photographs suitable for mapping most of this area. The offshore reefs beyond 30m depth are significant in this area, totalling 100 ha in size. Amongst these areas there are some very high quality deep reef habitats.

Soft sediments are mixed between the coarse gravelly sands, which also have a shell component in places, and the fine sands. Generally on this coast the soft sediment areas are more gravelly and shelly towards the shoreline and transition to sandier substrates, with silt becoming more evident beyond about 60m deep.

Table 2 Areas (hectares) of habitats in the proposed marine reserve area.

Depth, Habitat	Hectares
intertidal, rock platform	5.2
shallow, shallow mixed weed	5.6
shallow, Ecklonia forest	49.4
shallow, kina barren	0.9
shallow, gravelly coarse sand	39.8
shallow, fine sand	1.7
deep, gravelly coarse sand	258.5
deep, rocky reef	100.3
deep, fine sand	448.6
islands, land	2.0
Total	**912**

The habitat areas of Maunganui Bay are listed in Table 3 below. Maunganui Bay has 12 habitats listed; the additional habitats in the proposed marine reserve that are not found on the open coast are gravel beach and shallow gravel. Maunganui Bay has a similar arrangement of habitats to that described for the open coast, with one important difference. In Maunganui Bay kina barrens make up 1.7 ha in area which is 4.86 % of the shallow reef habitats in total.

Table 3 Areas (hectares) of habitats for Maunganui Bay.

Depth, Habitat	Hectares
intertidal, gravel beach	0.4
intertidal, rock platform	6.1
shallow, shallow mixed reef	4.3
shallow, Ecklonia forest	30.4
shallow, kina barren	1.7
shallow, gravel	0.6
shallow, gravelly coarse sand	39.0
shallow, fine sand	23.9
deep, gravelly coarse sand	12.0
deep, rocky reef	6.1
deep, fine sand	36.8
islands, land	1.2
Total	**163**

Map 2 shows the underlying substrata and sediments of the habitat survey area. This version of the map is based on the physical substrates, omitting the finer resolution and depth-based zonation of the biological habitats.

In Map 3, the exposure classification is added to the analysis. Each habitat appears within the exposure classification, further defining habitats by the degree of wave energy to which it is exposed. In this classification the number of habitats classified expands to 28. Table 3 shows the calculated areas of each habitat when exposure is added to the classification.

The open coast of the Cape Brett area is all subject to large swells from several directions. Wave energy is commonly high as a result of local wind waves or large swells from the north or northeast.

Maunganui Bay however, because of its indented coastline, is afforded some protection from wave energy. In Maunganui Bay there is virtually no exposure to east swells and wind and much of the Bay is also well sheltered from the northerly direction, however some lower energy local wind waves do penetrate right into Maunganui Bay in a northwest wind condition. As result of the varying degrees of shelter afforded to the different parts of Maunganui Bay, it actually has a full range of exposure conditions from 'high' at the entrances to the Bay, to 'low' at the popular anchorage area in the far eastern corner. Table 4 below lists the habitats and their calculated areas when the exposure classification displayed in Map 3 is applied.

Table 2 Areas (hectares) of habitats for different exposures in Maunganui Bay.

Exposure	Depth, Habitat	Hectares
med	intertidal, gravel beach	0.3
low	intertidal, gravel beach	0.1
high	intertidal, rock platform	3.4
med	intertidal, rock platform	2.2
low	intertidal, rock platform	0.5
high	shallow, shallow mixed reef	2.3
med	shallow, shallow mixed reef	1.7
low	shallow, shallow mixed reef	0.3
high	shallow, Ecklonia forest	18.1
med	shallow, Ecklonia forest	11.4
low	shallow, Ecklonia forest	0.9
high	shallow, kina barren	0.6
med	shallow, kina barren	1.0
low	shallow, kina barren	0.1
med	shallow, gravel	0.2
low	shallow, gravel	0.4
high	shallow, gravelly coarse sand	13.2
med	shallow, gravelly coarse sand	23.0
low	shallow, gravelly coarse sand	2.7
high	shallow, fine sand	0.6
med	shallow, fine sand	22.1
low	shallow, fine sand	1.2
high	deep, gravelly coarse sand	12.0
high	deep, rocky reef	5.8
med	deep, rocky reef	0.3
high	deep, fine sand	21.9
med	deep, fine sand	14.9
	islands, land	1.2
	Total	**163**

Maps 4-6 show a fine scale of the habitat maps prepared at a 1:7,000 scale. These four maps divide the survey area in to four sections so that at the fine scale, details of shoreline and reefs and habitat boundaries can be seen more clearly.

Map 7 shows a finer scale (1:2,000) view of Maunganui Bay, illustrating the quality of the OS 20/20 aerial photography used and visibility of underwater terrain and features. This is the mapping scale that was used to draw boundaries for large features and at this scale small features like individual kina barrens can be seen but not easily mapped in detail. Mapping of these fine scale features was typically done at scales 1:1,000 and 1:500.

3.1.3 Biological zonation

Boundaries of marine communities on shorelines have traditionally been defined in relation to height above and below tide levels. When combined with exposure these two physical factors have a great influence on how communities are composed. In this study, we did not attempt to characterise the intertidal habitats beyond their most basic physical drivers; however, within this band where the tide comes in and out and wave energy is often high, there is great variation in community structure and significant zonation by depth up the shore from the low tide mark.

Below low tide the main factors are depth which affects light penetration and the wave energy or exposure. The first zone descending from low tide may be referred to as the shallow mixed weed zone. This zone varies in its depth range from less than 2 m in the very sheltered locations of Maunganui Bay to a depth of 8 m in the most exposed areas of the Cape Brett coast. In this zone there are groups of algae dominating the community, which are specially adapted to the physical demands of wave energy and the degree of wave energy affecting each location.

The next zone, descending downwards, is typically a kelp forest dominated by the brown algae *Ecklonia radiata* which forms a dense canopy up to 2 m in height. There is a great diversity of algae and encrusting invertebrates associated with this habitat.

Within the *Ecklonia radiata* zone there is an important sub-type to which we will refer as kina barren, sometimes called kina grazed zone. In the kina grazed zone kina abundance is typically greater than 4 individuals/m^2 and the *Ecklonia radiata* forest is grazed out, leaving largely bare rock with a much impoverished encrusting invertebrate community compared to the kelp forest community.

Boundaries between shallow rocky reefs dominated by *Ecklonia radiata* forest and encrusting invertebrate communities on deeper reefs were consistently observed between 25 m and 35 m depths. Typically the *Ecklonia radiata* thins out considerably approaching a depth of 25 m. At depths of 30 to 35 metres, it is very thin or absent completely. Conversely, the diversity and dominance of sponge species increases from a few understorey species in the 10-25 m zone to dominance beyond 30 m depth. We used 30 m as the mapping boundary for consistency. Adopting this uniform depth boundary is consistent with the MPA classification scheme and helps consolidate boundaries. In reality, this transition zone is only approximate and varies under different conditions (see below). Light levels (especially red light) decrease markedly beyond 20 m depth. As a result the density of the *Ecklonia radiata* forest decreases and various groups of invertebrates like sponges, hydroids, gorgonians, and bryozoans increase in abundance and diversity. These organisms are filter feeders and benefit from the ample currents and water column movements common at these depths. The deepest we saw *Ecklonia radiata* kelp was at 35 m, but this was uncommon.

3.1.4 Habitat descriptions and examples

The habitat descriptions presented in this section are a compilation from all the surveys and notes taken in this study, namely the study of the OS 20/20 sonar data, drop camera imagery and notes from snorkel and scuba dives undertaken by the author and Northland Dive. The location names shown in the Figure 8 map below are sites where diver notes and imagery were used.

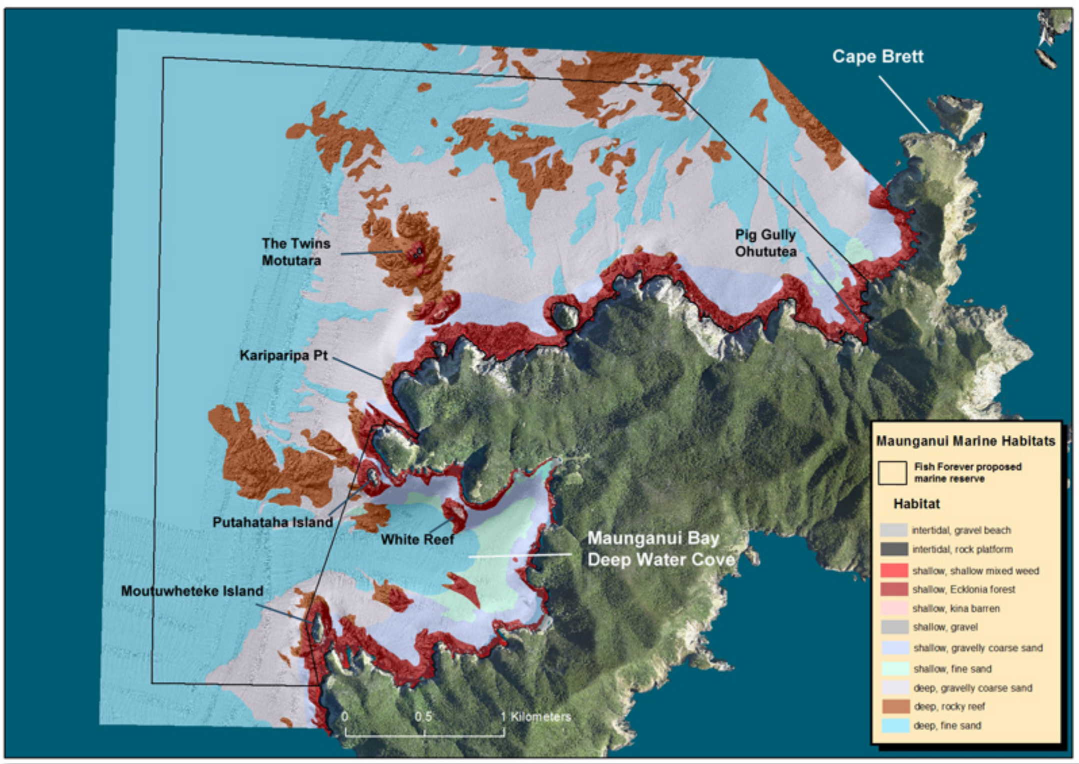

Figure 8 *Prominent locations and dive locations used in the survey to develop the habitat descriptions.*

3.1.4.1 Exposed shore shallow mixed weed habitat

On the exposed shores, there is a distinct top band of the subtidal habitat referred to as the shallow mixed weed zone. This algal community group is especially resilient to the high wave energy. The upper levels of this sublittoral zone are dominated by the brown algae species *Xiphophora chondrophylla, Carpophyllum maschalocarpum* and *Carpophyllum augustifolium.* The latter is the species that dominates in the most exposed of the shorelines. Another indicator of surge and high wave energy is the brown kelp *Lessonia variegata*. This species thrives in the most extreme exposure areas, for example: pinnacles rising to the surface; or the extreme outer seaward shores of headlands; or guts which magnify wave energy. Towards the bottom of the shallow mixed weed zone at 4-8 m there is often a mixture of the common red algae *Pterocladia lucida* and the deep red coloured *Osmundaria colensoi.* Occasionally *Carpophyllum maschalocarpum* and *Carpophyllum plumosum* feature in the lower reaches of the shallow mixed weed. In addition to this list of common species, there is also a diversity of small red algae species falling into the main groups of encrusting calcareous species, such as *Corallina officinalis* and foliose species. At the bottom of the shallow mixed weed zone *Ecklonia radiata* starts to appear, signalling a decrease in the impact of wave energy and transition to the next zone dominated by this large brown algae species.

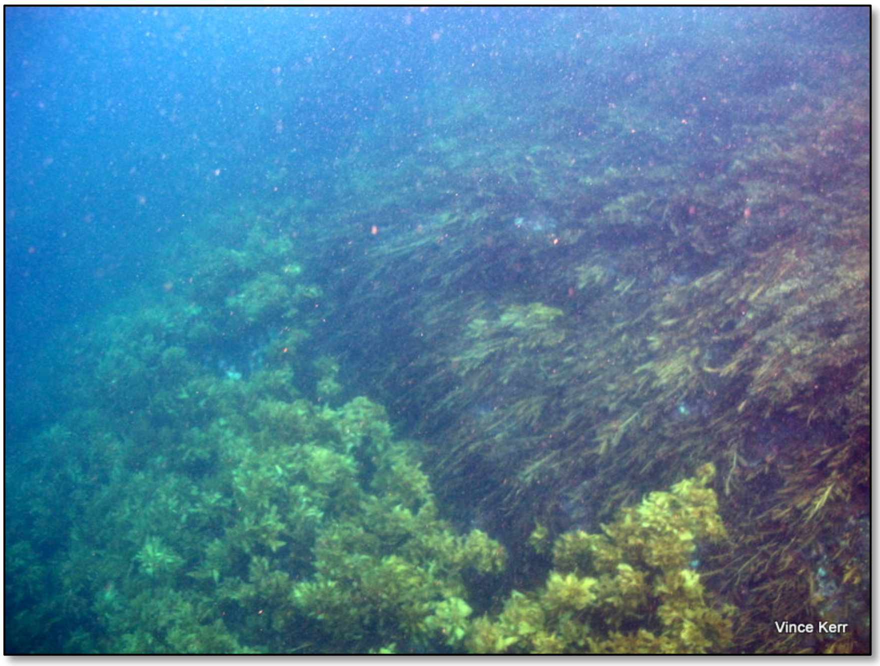

Figure 9 *The shallow mixed weed community at Putahataha Island at the northeast entrance to Maunganui Bay. Carpophyllum maschalocarpum is the main species seen here as the darker brown seaweed on the right side of the image. Ecklonia radiata is the yellow-green coloured seaweed to the left and bottom of the image which marks the deep boundary of shallow mixed weed zone.*

3.1.4.2 Exposed shore kina barrens

Aerial photos obtained for this survey and mapping exercise only had good visibility below the water surface in some locations; probably less than 50% of the exposed coastline. As the area mapped only has value as an indicator of the presence of kina barrens, there is not a reliable quantitative measure of how much kina barren habitat is there. Much of this coastline is also very steep making it difficult to map the detail of these habitats in a two-dimensional plane. From our observations there are kina barrens scattered along this coast but they are intermittent and generally small in area, similar to what is seen in Figure 10 below. Table 5 below lists the areas of the shallow reef habitats and the relatively limited area of kina barren that we were able to identify.

Table 5 *Areas (hectares) of shallow reef habitat and percentage area of kina barren.*

Depth, Habitat	Hectares
shallow, shallow mixed reef	5.59
shallow, Ecklonia forest	49.42
shallow, kina barren	0.89
total shallow rocky reef area	55.91
Percentage of kina barren area in shallow rocky reef habitat	**1.60%**

Figure 10 *Examples of kina barrens on the exposed coast, Pig Gully. In the right side photo you can see the high density of the kina in the grazed bare area of rock, this is typical of a young expanding kina barren.*

3.1.4.3 Sheltered shore shallow mixed weed

In the more sheltered areas, the shallow mixed weed has a slightly different group of seaweed species that dominate the community. The main species at the shallowest part of the zone is *Carpophyllum maschalocarpum,* there is also *Xiphora chondrophylla* and at times the common red algae *Pterocladia lucida*. Towards the bottom of the zone, *Ecklonia radiata* becomes common and then at the deep boundary of the zone *Ecklonia radiata* dominates forming a dense canopy. In this transition zone, there is often a number of encrusting and foliose red algae species and the other large brown algae species *Carpophyllum plumosum* and *Sargassum sinclairii* may be seen.

One of the most important differences between the shallow mixed weed communities in the sheltered areas of the exposed shore is the depth range. In the sheltered areas the depth range varies between approximately 1.5-3m as compared to 4-8m depth observed on the exposed coast. This difference is a result of the effect of the variation in wave energy experienced by these algal communities.

Figure 11 *Examples of SMW algal communities, taken at high tide near White Reef in Maunganui Bay; three common species are easily visible in this photo. The light brown algae on the right side of the photo is Xiphora chondrophylla, the dark brown algae in the middle of the image is Carpophyllum maschalocarpum and the more yellow brown large leaf algae to the left is the Ecklonia radiata.*

3.1.4.4 Sheltered shore kina barrens

The quality of the aerial photos for Maunganui Bay was very good in nearly all areas. This made it possible to map the kina barrens accurately for most of the shoreline. Kina barrens were most visible in the more sheltered parts of the bay. Overall, kina barren made up just under 5% of the shallow reef habitat, which is significant in terms of the loss of productivity by *Ecklonia* forest from these areas. The total shallow rocky reef area in Maunganui Bay is 34.71 ha, Kina barrens make up 1.69 ha of that total, shallow mixed weed 4.28 ha and the Ecklonia radiata forest 30.43 ha.

Table 6. *Areas (hectares) see above*

Depth, Habitat	Hectares
shallow, shallow mixed reef	4.28
shallow, Ecklonia forest	30.43
shallow, kina barren	1.69
total shallow rocky reef area	34.71
Percentage of kina barren area in shallow rocky reef habitat	4.86%

Figure 12 *Examples of kina barrens along the sheltered shore, (left) taken along the coast to the northeast from White Reef in Maunganui Bay, (right) divers hover over the large area of kina barren at White Reef in Maunganui Bay. Photo: Northland Dive*

3.1.4.5 Ecklonia radiata kelp forest

On the exposed shores, the *Ecklonia* forest extends from about 8 m depth to around 30 m depth, or to the edge of the reef if that occurs at less than 30 m. In the more sheltered areas, this transition takes place at 1.5 to 3 m. In most cases the stands of algae appear to be monotypic. In places, the *Ecklonia* can form quite dense canopies; effectively competing against other algal species for light. As you travel down in depth, the canopy becomes scattered or sparse and encrusting invertebrates start to feature. Common species associated with *Ecklonia radiata* forest are kina *Evechinus chloroticus* and the brown algae *Carpophyllum plumosum.* Typically there are areas where turfing and foliose red algae form patches or understorey to the *Ecklonia radiata* forest. As you travel down the reef slope, some of the common sponges begin to appear. First is the grey sponge *Ancorina alata*. Towards the deeper zones the grey cup sponge *Geodia regina* and the *Raspalia sp.* finger sponges are present.

The understorey of the kelp forest is an especially valuable ecosystem in its own right. It is a low-light environment in which the canopy provides enough shelter from wave energy to favour a wide range of encrusting invertebrates like sponges, sea squirts, anemones and hydroids, which make their living as filter feeders in high current areas.

The base of the kelp plants, called the holdfast, is another special feature of this habitat. It is highly complex in terms of cracks and crevices formed and this provides safety and shelter for an extensive list of invertebrates and small fish (Smith 1990, Anderson 2005).

The kelp forest also plays an important role in our coastal fishery for many pelagic fish species as a temporary nursery. These fish species make the transition from planktonic larvae to large schooling fish in this nursery environment. Snapper *Pagrus auratus* and trevally *Caranx lutescens* can be seen in the summer and autumn months as tiny 10-20 mm fish hiding in the kelp. Later on in their lifecycle, as adult fish, these pelagic fish return to the reef either on temporary feeding visits or as long-staying reef residents. As adults, these species take on the role of primary predators on the reef and fulfil a fundamentally important ecological role.

Figures 13 and 14 show typical views of healthy *Ecklonia radiata* kelp forest. This is a very productive habitat and should be seen as one of our most valuable coastal habitats. There are many fish species that live specifically in this habitat, either browsing on kelp or feeding off the many invertebrates that live there.

Figure 13 *Ecklonia radiata forest examples, (left) a typical view taken at approximately 10 m depth at Pig Gully illustrating how dense the canopy is at this optimum depth for the species. (right) This photo was taken at approximately 20 m depth at Pig Gully; an eagle ray Myliobatus tenuicaudatus rests in the understorey of the Ecklonia forest. In the foreground on the rock in front of the ray are examples of coralline paint, encrusting calcareous red algae (seen as smooth pink coloured) and a second species of encrusting red algae that looks more purple red and rougher in texture (directly below the ray), photo: Northland Dive.*

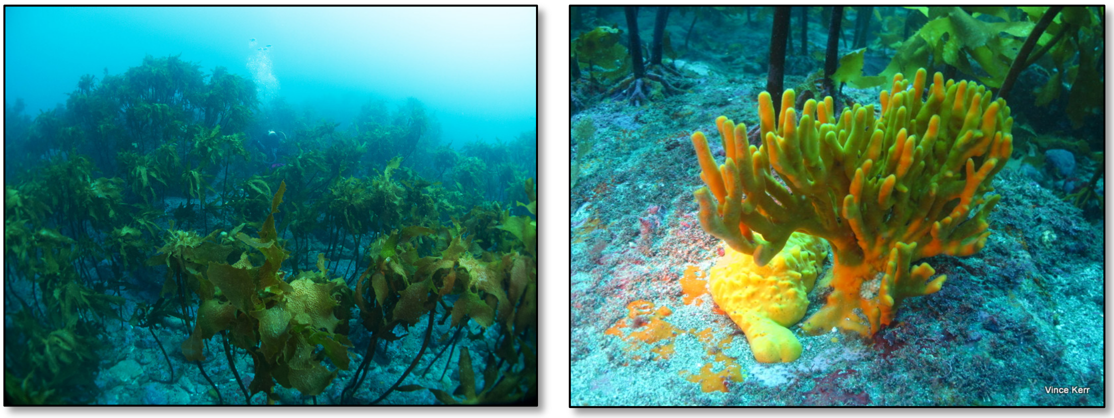

Figure 14 *Ecklonia radiata forest, (left) taken at approximately 25 m depth at Pig Gully; note how the Ecklonia forest is thinning out at this depth, photo: Northland Dive, (right) examples of the invertebrate encrusting community growing as an understory under the Ecklonia forest, yellow more prostrate sponge is Polymastia aurantium and the upright finger sponge is Raspailia topsenti, several unidentified species of encrusting sponges and calcareous encrusting red algae species are also present in the photo.*

3.1.4.6 Deep reefs

Beyond 30 m, on the reefs outside Maunganui Bay the kelp forests thin out and disappear as light levels become too dim to support them. Replacing the seaweeds as the dominant species is a wide array of encrusting invertebrates that form the basis of the deep reef community. Primarily these species make their living as filter feeders, but there are many other organisms that feed on these encrusting invertebrates or the species attracted to the reef for shelter. The interaction of currents with these reefs plays a major role; the more vertical the reef, the more it creates eddies or upwellings in the currents. Eddies and upwellings are very important and productive for filter feeding invertebrates and planktivorous fish species. Along with the great diversity of sponge species, pink gorgonian fans *Primnoides sp.* are commonly seen at these depths. Alongside the elegant gorgonian fans and sponges in all shapes and colours, is typically a diverse community of filter feeding encrusting invertebrates made up of bryozoans, hydrozoans, ascidians, and many other groups. These encrusting communities form a complex three-dimensional structure on the surface of the reef.

The terrain of the deep reefs in the Maunganui Bay area varies greatly from flat patch reef surrounded by soft sediments, to bouldery areas, to large expanses of flat reefs and some impressive pinnacles and large rock formations rising up from the sea bottom. As observed in our camera drops, the pinnacles and high-relief terrain were typically the hotspots for encrusting invertebrate life and fish life. It was noticeable that these areas had no sign of silt whereas some of the flatter terrain, especially beyond 60m in depth, was silty.

The image in Figure 15 below illustrates the contrasting environments of the 40 m depth range high-relief deep reef with the deeper flat 70 m deep reef. The drop camera image in Figure 14 is at location Z1 which was just north of the tip of Motuwheteke Island at the southern entrance to Maunganui Bay. There the terrain is rugged with steep slopes dropping off to just beyond 40 m depth. As can be seen in the image the encrusting life is vigorous, diverse and the environment looks free of silt. The lush growth of the Gorgonian fans is an indication of the high quality and productivity of this environment.

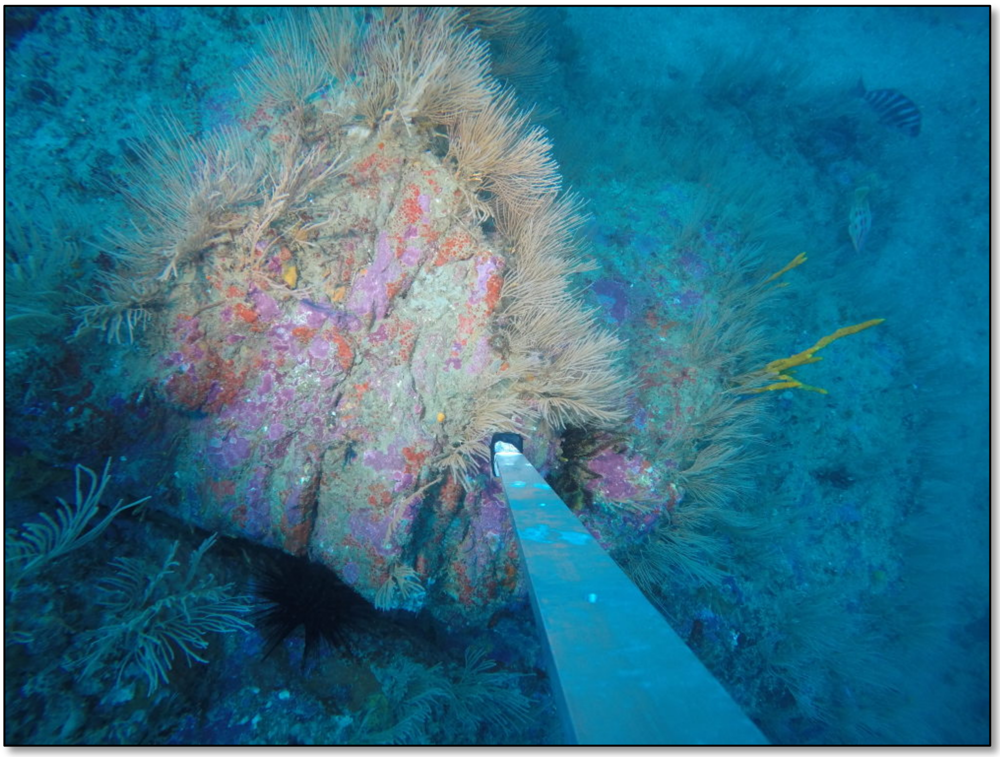

Figure 15 *Drop camera image from location z1, depth 42 m; visible in this shot is a wide diversity of encrusting sponge and coralline paint algae covering all available surfaces of the rock. The pink Gorgonian fan Primnoides sp. is a dominant filter feeder in this area. A large yellow finger sponge Iophon major can be seen centre right. Just under the rock ledge bottom centre left is the sea urchin species Centrostephanus rodgersii. An echinoderm feather star can be seen to the immediate right of the point of the drop camera shaft. The two fish seen in the top right corner are a pigfish Bodianus unimaculatus and a red moki Cheilodactylus spectabilis.*

Figure 16 is a drop camera image taken at location z25 which is a deep reef area lying approximately 1 km to the northwest of the Twins at 70 m depth. In this location the reef is relatively flat and low-lying with patch reef nearby. From the image you can see there is considerable silt and fine sand covering the reef and a very different sort of encrusting community than what is seen on the high relief 40-50 m depth reefs. This image reveals a good diversity of sponge species but they are spread further apart; an indication that the productivity of the filter-feeding community is less at this depth than at 40 m.

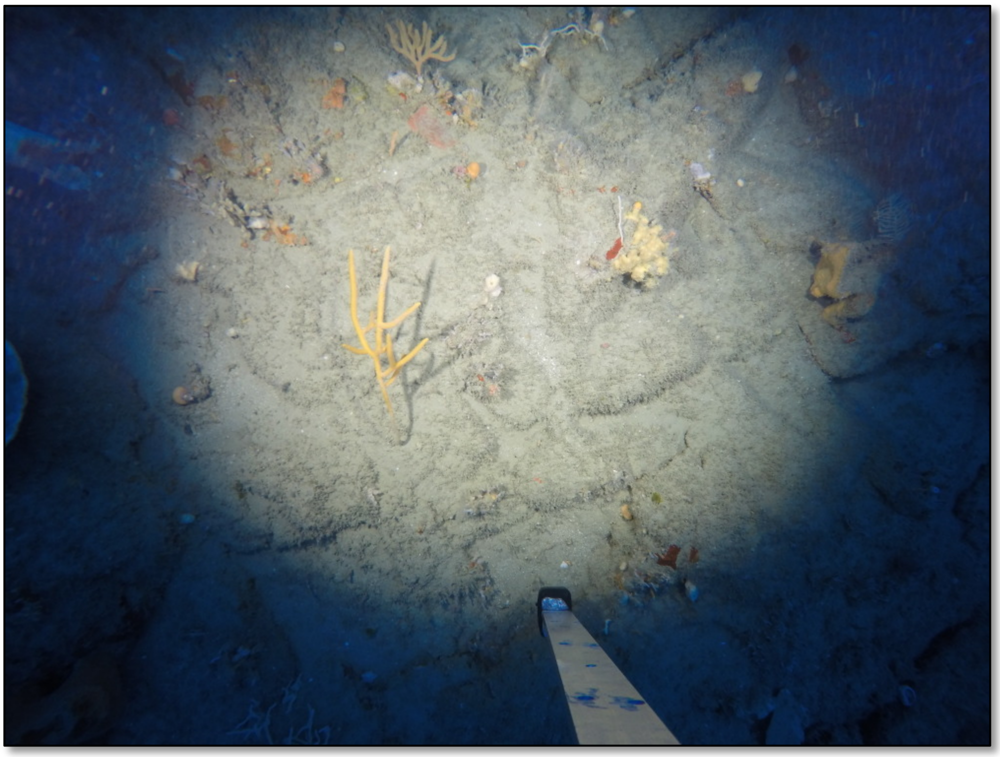

Figure 16 *Drop camera image from location z25, depth 70 m, a diversity of sponge species, the furriness of the bottom substrate is made up of silt sand and a number of different encrusting groups including many species of tube worms, bryozoans and hydroids.*

Figures 17 and 18 are images taken by Northland Dive. The locations are both near the northeast entrance to Maunganui Bay but are from the outer or seaward parts of these reefs. Figure 16 is from the outer edge of the reef at Putahataha Island and Figure 17 is from further along the open coast to the east at Kariparipa Point. These locations are both dramatic examples of the shallow part of the deep reef zone at around 35-38 m depth. In these areas, the inshore reef runs on to sand or gravel soft sediment areas. In both images a few very weak individual *Ecklonia radiata* plants can be seen. This depth marks the very limit of where this species grows. In both images the encrusting community is very diverse and vigorous and there is little evidence of silt.

Figure 17 *Diver photo taken at approx. 35 m depth where the reef meets a coarse sand bottom, Putahataha Island, a wide range of finger sponges presents and diverse encrusting community on the rock surface including Bryozoans and soft coral species. The two fish species in left centre of photo are bigeye Pempheris adspersus and butterfly perch Caesioperca Lepidoptera. Weak and widely-spaced Ecklonia radiata kelp can be seen in the distance. Photo: Northland Dive.*

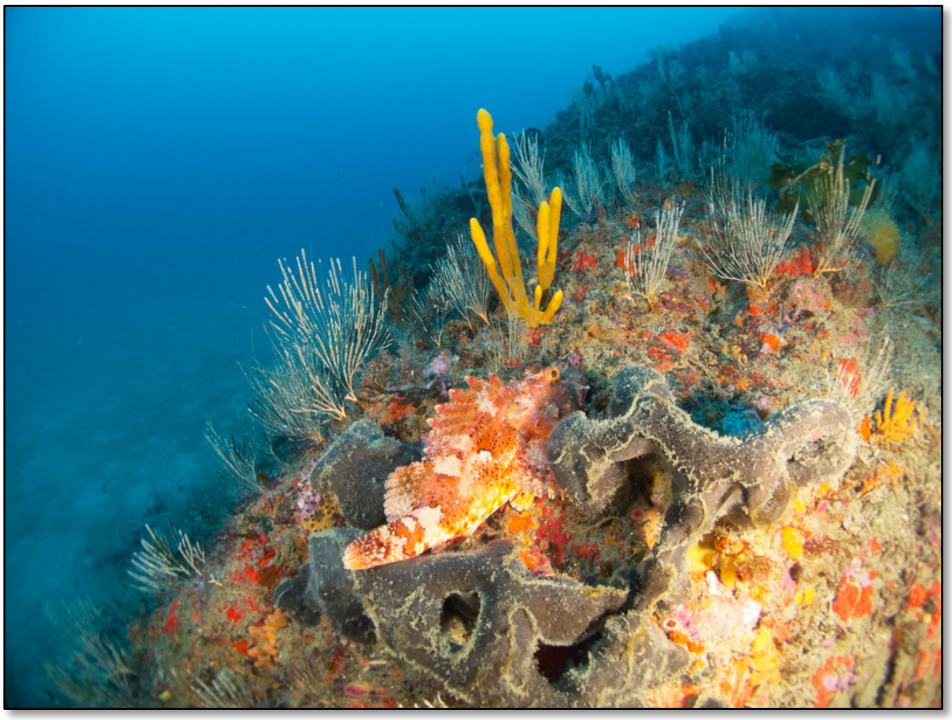

Figure 18 *Diver photo taken at Kariparipa Pt at 35-38m depth. A grandaddy hapuka, Scorpaena cardinalis sits surrounded by the grey sponge Anchorina alata; here the reef is completely covered in a diverse and healthy encrusting community including many sponges species, the Gorgonian fans Primnoides sp., the large upright yellow finger sponge is Iophon major.*

3.1.4.7 Soft sediments

Interpretation of the OS 20/20 sonar data suggests that the soft sediments extending off the coast of the Cape Brett and Maunganui Bay are largely gravels and coarse sands with potentially significant shell content. Pockets of finer sands also exist in places near the reef edges, notably in Maunganui Bay. The data also shows gullies of fine sediments streaking through these coarse sediments running out to sea. One of the difficulties of interpretation of the sonar data is that it is hard to determine a difference between very fine sands and mud and silt, and also a difference between gravels and shell material. In order to ground-truth these interpretations, two locations were chosen for video drops located to traverse the change from finer to coarse sediment signals. The locations of camera drops were at z35 and z35 (700 m off the east-northeast of the twins at 52 m depth) and z6 and z7 (45 m depth, Figure 2). Figure 19 shows the difference between these two sediments. While the sites are only 150 m apart, they are made up of quite different sediment materials. When examined at full resolution, it was clear that the z6 sediment was made up of primarily fine sands, with a component of silt and very little shell material present. By contrast, z7 was primarily coarse sand with some gravel and shell hash material and very little silt. The other pair of sediment sites videoed (z35 and z36) showed a similar make up and contrast across the sediment boundary.

For the purpose of mapping, the sediment description 'coarse gravelly sand' was used in this report as a catch-all group for sediment types that, in reality, vary greatly in terms of the amount of gravel versus shell composition. In practice, this range cannot effectively be differentiated with sonar data alone, and at fine scales would require a great deal of ground truthing to resolve. Our ground-truthing imagery supports the statement that in this area the coarse sediments are made up of highly variable components of gravels and/or sand that vary across quite fine spatial scales.

The great deal of variation of soft sediments and relative clean nature (free of silt) in this area could be expected to support a great diversity of benthic communities.

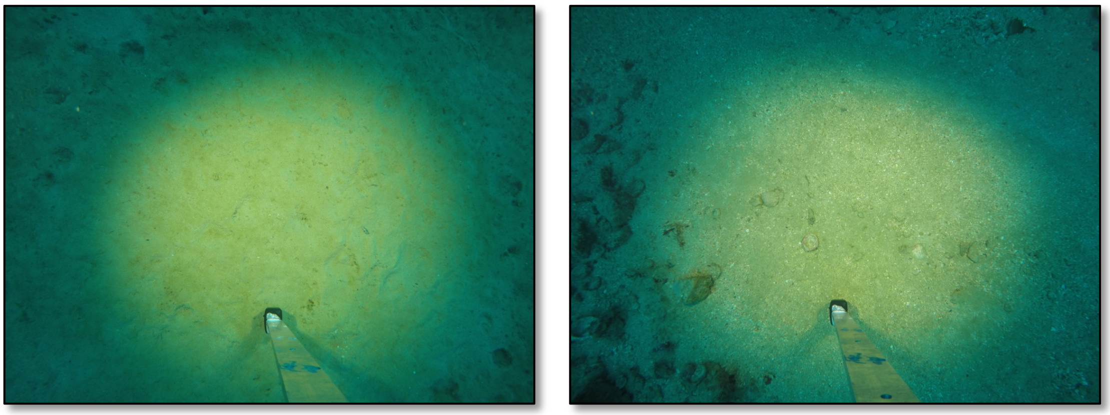

Figure 19 *Soft sediment ground-truthing camera drops 900 m to the southwest of Putahatahaa Island, (left) camera drop z6, depth 45 m, sediment is a fine sand, (right) camera drop z7, depth 45 m, sediment is a mix of coarse sands gravel and shell hash.*

4 Discussion

4.1.1 Potential uses of this mapping resource

This mapping resource should be viewed and used as a work in progress. The data layers and the interpretation can be improved upon in the future. The classification could be extended further to resolve soft-bottom substrates and achieve greater definition of significant biological communities. The GIS-based approach allows updates to be made readily as new information becomes available. This project was specifically designed to fulfil the basic information requirements to evaluate a proposal for marine protection using criteria suggested in the New Zealand MPA Guidelines (DOC and MFish, 2008). Specifically, the map of habitat types enables depiction and calculation of the extent to which the proposed marine protected areas in question might be representative of the full range of habitat types in this locality. The map can also be useful to many forms of marine planning, including resource management, fisheries investigations, the design of future scientific research and marine education generally.

4.1.2 Habitat diversity and quality

The Cape Brett area deserves protection status under the Marine Reserves Act 1971, which will also contribute to the Government's initiatives under the Marine Protected Area Policy, the Resource Management Act 1991 and other national legislation and policies. The diversity and quality of the habitats within this relatively small area is remarkable. The values found here should be considered equal to the most unique and outstanding sites in Northland and throughout New Zealand. The exposed coastline of Cape Brett could also be considered representative of this habitat in Northland, and a very high quality example.

There are many contributing and interacting factors which combine to create the ecological significance of this area: oceanographic influences, presence of rare subtropical species, geological influences, diverse substrates, complex topography are just a few.

4.1.3 Limitations of the study

In the shallow areas, mapping precision was determined by the resolution and geo-referencing accuracy of the OS 20/20 aerial photography, estimated at 3-5 m or better. We attempted to draw significant biological boundaries at scales down to 1:500. At this scale, drawing errors typically would be within 5 m.

For the offshore areas, information layers had spatial accuracy in the range of 2-15 m. The precision of the OS 20/20 sonar data layers was high at 2 m resolution and this data set has nearly full coverage of the mapping area. Accuracy of our ground-truthing camera drop data points contributed small potential errors (up to approximately 15 m).

A more significant potential for error results from our qualitative interpretation of the sonar data. In the case of determining the edge of rocky reefs where there is elevation variation of several metres, the sonar data depicts this edge clearly. However, where the reef becomes flat and broken - as with patch reefs - interpretations can become difficult. The 'backscatter' sonar return image layer assists in this interpretation, but some substrata interpretations can be confounded due to the mixing of gravels, cobble, and heavy shell in areas which give similar backscatter returns to rock reef. Our ground-truthing data assisted this interpretation greatly, although this was point data spread over wide areas. This limitation may have caused the underestimation of the area of flat and patch reef occurring on the edges of some of the reefs.

4.1.4 The kina barren threat

An attempt was made in this project to map the shallow reef habitat referred to as kina barrens at fine scale 1:500. In Maunganui Bay a significant area of kina barren exists; nearly 5% of the shallow rocky reef in total area. A number of areas were dived, allowing for an on-the-ground check that these areas were kina barrens; however no actual mapping of kina barren itself was done by divers. Having said this we feel our mapping result in Maunganui Bay gives a good representation of what was there in 2010 when the photos were taken. On the open coast in the proposed marine reserve area, we found just over 1 % of the shallow rocky reef in kina barrens. It was clear that a large amount of this coast could not be mapped from the available photos. As such, our mapping effort can only be seen as an indication that kina barrens are present, but not a quantitative or precise picture of what is truly there. Notwithstanding the limitations of our kina barren mapping, we suggest the existence of this habitat is significant ecologically and represents a substantial impact on the shallow reef environment as a result of long-term fishing pressure on the predators of kina. For a fuller discussion of the issues and background information around the development of kina barrens and the threat they represent to reef ecology please refer to two previous Fish Forever reports on this subject, which review the available information and make recommendations on what needs to happen to reverse this concerning trend (Kerr and Grace, 2015) and (Booth, 2015).

A current research project being done for Fish Forever by Chris Richmond and Vicky Froude is investigating a method and survey that accurately estimates the state of algal forest health and presence or absence of kina barrens, utilising a GPS-tracked snorkel diver approach. There is potential that this new approach may complement and, to some degree, overcome the limitations of the mapping process used in this project. The author is also involved in further field studies in this area.

5 Recommendations

We recommend supporting future efforts in monitoring and research. In this special area there are ideal opportunities to gain more knowledge that can guide management and marine protection planning for this coast. We suggest further work should:

1) Maintain the commitment to, and continue to work towards the establishment of the highest level of marine protection available for this area. Marine reserves provide us with an alternative to long-term ecological decline and a place to learn about what is natural in our marine environment.

2) Support further investigations into the special nature of habitats and biodiversity in the Cape Brett and Maunganui Bay survey area. Fish diversity, algal communities, benthic invertebrate communities, and deep reef encrusting invertebrate communities are all good candidates for future investigations.

3) Pursue research and monitoring opportunities to build on our knowledge of the ecology of the relationship between kina *Evechinus chloroticus,* their predators snapper *Pagrus auratus* and crayfish *Jasus edwardii* and the shallow kelp forest. This work needs to bring together the related fields of spatial distribution of recreational fishing effort and its impact on shallow rocky reefs, the predator prey ecology and the impacts of protection on reversal of the kelp forest decline.

6 Acknowledgements

The authors would like to acknowledge the positive work being carried out by the Te Rawhiti hapu, Ngati Kuta and Patukeha, who have worked to set up the Rahui (Sec 186 of the Fisheries Act) temporary closure to fishing at Maunganui Bay. Also we would like to acknowledge the hapu and DOC in the restoration of the terrestrial ecosystems of the Brett Peninsula which have taken place for many years now. This pioneering work should be seen as encouragement to treat adjacent marine habitats as high priority areas for study and consideration for protection.

Shane Housham and Julia Riddle of Northland Dive gave their time and photographs freely in support of the habitat mapping work. Their experience of the underwater environments of Cape Brett is extensive and their input much appreciated.

Special thanks go to Catherine Langford who assisted with editing and proof reading. We thank Chris Moretti and Diane Kerr who ably assisted the field work. Dr Dan Breen provided peer review comments for this report that was greatly appreciated.

7 References

Anderson, M. J., Diebel, C. E., Blom W. M. & Landers T. J. (2005). *Consistency and variation in kelp holdfast assemblages: spatial patterns of biodiversity for the major phyla at different taxonomic resolutions*. Journal of Experimental Marine Biology and Ecology 320: 35–56.

Ayling, A.M., Cumming, A., Ballantine, W.J. (1981). *Map of shore and subtidal habitats of the Cape Rodney to Okakari Point Marine Reserve*, North Island, New Zealand in 3 sheets, scale 1:2,000. Department of Lands and Survey, Wellington.

Booth, J. D. (2015). *Flagging kelp : potent symbol of loss of mauri in the Bay of Islands.* An essay prepared for the Bay of Islands group Fish Forever. http://www.fishforever.org.nz/images/ff/latest-news/john-booth-articles/Flagging%20kelp_Feb-15.pdf

Bowden et al. (2010). Bay of Islands OS20/20 survey report. Chapter 9: *Seafloor assemblage and habitat assessment using DTIS*. http://www.os20/20.org.nz/bay-of-islands-coastal-survey-project/3

Cook, S. de C., 2010. New Zealand Coastal Marine Invertebrates, Vol 1. Canterbury University Press, Private Bag 4800, Christchurch, New Zealand.

Department of Conservation & Ministry of Fisheries (2008) *Marine Protected Areas: Classification, Protection Standard and Implementation Guidelines*.

Fish Forever, 2014. *Proposal for two marine reserves and a scientific reserve in the Bay of Islands: results of community consultation.* Compiled by Vince Kerr, Catherine Langford, and Dean Wright for Fish Forever, Bay of Islands Maritime Park Inc. Download

Francis, M.F., (1996). *Coastal fishes of New Zealand; an identification guide.* Reed Publishing (NZ) Limited, 39 Rawene Road, Birkenhead, Auckland 10.

Grace, R.V. (1981). *Paparahi Marine Survey*. Report to Mimiwhangata Farm Park Charitable Trust. Hauraki Gulf Maritime Park Board.

Grace, R. V. (1983). *Zonation of sublittoral rocky bottom marine life and its changes from the outer to the inner Hauraki Gulf, north-eastern New Zealand*. Tane 29: 97–108.

Grace, R.V., Kerr, V.C. (2005). *Intertidal and subtidal habitats of Doubtless Bay, Northland, N.Z.* Contract report for the Department of Conservation, Northland Conservancy, Whangarei.

Kelly, M., 2015. Splendid Sponges a guide to the sponges of New Zealand, Version 1. NIWA marine identification guides and fact sheets series. http://www.niwa.co.nz/coasts-and-oceans/marine-identification-guides-and-fact-sheets/Splendid Sponges

Kerr, V.C., Grace, R.V., 2015. *Marine habitats of the proposed Waewaetorea Marine Reserve*. A report prepared for Fish Forever, Bay of Islands Maritime Park Inc. Download

Kerr, V.C., (2014). *Analysis of Boundary Design for Two Proposed Marine Reserves in the Eastern Bay of Islands: a report to Fish Forever*. Client report prepared for Fish Forever, Bay of Islands. Kerr & Associates. Download

Kerr, V.C., Langford, C., Wright, D. (2014). *Proposal for two marine reserves and a scientific reserve in the Bay of Islands: results of community consultation*. Prepared for and published by Fish Forever, Bay of Islands Maritime Park Inc. Download

Kerr, V.C., (2010). *Marine Habitat Map of Northland: Mangawhai to Ahipara Vers. 1.* Technical Report, Department of Conservation, Northland Conservancy, Whangarei, New Zealand.
http://www.doc.govt.nz/Documents/science-and-technical/drds201.pdf

Kerr, V.C., Grace, R.V., (2005). *Intertidal and subtidal habitats of Mimiwhangata Marine Park and adjacent shelf.* Department of Conservation Research and Development Series 201, 55 p.
http://www.doc.govt.nz/Documents/science-and-technical/drds201.pdf

Leleu, K., Remy-Zephir, B. (2012). *Mapping habitats in a marine reserve showed how a 30-year trophic cascade altered ecosystem structure.* Biological Conservation, 155, 193–201.
http://archimer.ifremer.fr/doc/00107/21842/20067.pdf

Mitchell, J. et al. (2010). Bay of Islands OS 20/20 survey report. Chapter 2: *Seafloor Mapping*.
http://www.os20/20.org.nz/bay-of-islands-coastal-survey-project/

Morton, J.E., Miller, M.C. (1973). *The New Zealand Seashore*. Collins, London–Auckland (2nd ad).

Parsons, et al. (2010). Bay of Islands OS 20/20 survey report. Chapter 10: *Shallow rocky reefs*.
http://www.os20/20.org.nz/bay-of-islands-coastal-survey-project/

Pickmere, A. H. 1974. Pickmere atlas of Northland's East Coast: compiled from the completed charts, field notes, and survey records of A.H. Pickmere. Published and compiled by Janet M. Watkins.

Pritchard et al. (1984) Marine Sponges: Forty-six sponges of northern New Zealand. Leigh Laboratory Bulletin, 14: 49 p.

Shears, N.T., Babcock, R.C. (2002). *Marine reserves demonstrate top-down control of community structure on temperate reefs*. *Oecologia 132*: 131,142.

Shears, N.T.; Babcock, R.C.; Duffy, C.A.J.; Walker, J.W. (2004). *Validation of qualitative habitat descriptions commonly used to classify subtidal reef assemblages in north-eastern New Zealand*. New Zealand Journal of Marine and Freshwater Research, 38: 743-742.

Shears, N.T.; Babcock, R.C. (2007). *Quantitative description of mainland New Zealand's shallow subtidal reef communities*. Science for Conservation, Department of Conservation, Wellington, New Zealand.

Smith, S. D. A., Simpson, R. D. and Cairns, S. C. (1996). *The macrofaunal community of Ecklonia radiata holdfasts: Description of the faunal assemblage and variation associated with differences in holdfast volume*. Australian Journal of Ecology, 21: 81–95.

8 Appendix 1 Map Book of Maunganui marine habitats

9 Appendix 2 GPS locations of drop camera survey sites

Waypoint	Longitude	Latitude	Depth	Type	Year
955	174.28723	-35.2016	41	BUV site	2016
938	174.29437	-35.1888	15	BUV site	2016
940	174.29652	-35.1798	30	BUV site	2016
941	174.3019	-35.1828	28	BUV site	2016
942	174.30697	-35.1802	32	BUV site	2016
943	174.31583	-35.1806	26	BUV site	2016
944	174.325	-35.1815	21	BUV site	2016
945	174.32866	-35.1776	21	BUV site	2016
946	174.32992	-35.1712	20	BUV site	2016
402	174.28913	-35.1988	26	BUV site	2016
403	174.29333	-35.20147	21	BUV site	2016
404	174.29744	-35.20025	14	BUV site	2016
405	174.29923	-35.19434	25	BUV site	2016
406	174.2974	-35.1931	23	BUV site	2016
407	174.30223	-35.19392	12	BUV site	2016
408	174.29218	-35.19328	16	BUV site	2016
409	174.2934	-35.1919	9	BUV site	2016
503	174.30096	-35.19787	25	BUV site	2016
502	174.29065	-35.20128	14	BUV site	2016
947	174.273669	-35.225368	18	BUV site	2016
948	174.277429	-35.223138	16	BUV site	2016
949	174.281989	-35.224608	15	BUV site	2016
950	174.281329	-35.221528	22	BUV site	2016
951	174.286069	-35.220638	19	BUV site	2016
952	174.287459	-35.218028	24	BUV site	2016
953	174.289669	-35.212898	25	BUV site	2016
954	174.289249	-35.207008	24	BUV site	2016
956	174.327348	-35.173568	24	BUV site	2016
957	174.320448	-35.180578	27	BUV site	2016
958	174.295749	-35.184198	22	BUV site	2016
z1	174.2880654	-35.19878116	41	camera drop	2016
z2	174.2875452	-35.19834267	46	camera drop	2016
z3	174.2867279	-35.19765954	47	camera drop	2016
z5	174.2920055	-35.19462135	38	camera drop	2016
z4	174.2925617	-35.19487783	41	camera drop	2016
z6	174.2893683	-35.1950908	45	camera drop	2016
z7	174.2894214	-35.19384973	45	camera drop	2016
z8	174.2840654	-35.19144949	46	camera drop	2016
z9	174.2837699	-35.19114249	50	camera drop	2016
z10	174.2833026	-35.19099238	52	camera drop	2016
z11	174.2826168	-35.1908088	57	camera drop	2016
z12	174.2822188	-35.19044325	57	camera drop	2016
z13	174.2950541	-35.17796123	30	camera drop	2016
z14	174.295005	-35.17761584	43	camera drop	2016
z15	174.2947338	-35.17723262	49	camera drop	2016

z16	174.2947922	-35.17702172	57	camera drop	2016
z17	174.2944547	-35.17681062	57	camera drop	2016
z18	174.2943557	-35.17606022	61	camera drop	2016
z19	174.3020476	-35.18458373	13	camera drop	2016
z20	174.3020525	-35.1843204	14	camera drop	2016
z21	174.3021979	-35.18395401	19	camera drop	2016
z22	174.3023331	-35.18353132	22	camera drop	2016
z23	174.3024326	-35.18315791	26	camera drop	2016
z24	174.3025999	-35.18273863	28	camera drop	2016
z25	174.28899	-35.17279023	70	camera drop	2016
z26	174.290041	-35.17237826	71	camera drop	2016
z27	174.29255	-35.17413832	64	camera drop	2016
z28	174.2984318	-35.17183771	64	camera drop	2016
z29	174.2990571	-35.17151373	63	camera drop	2016
z30	174.2998364	-35.17192284	64	camera drop	2016
z31	174.3032685	-35.17288791	60	camera drop	2016
z32	174.3054418	-35.17398335	54	camera drop	2016
z33	174.3043571	-35.17482999	54	camera drop	2016
z34	174.3031016	-35.17517749	54	camera drop	2016
z35	174.3018477	-35.17689428	51	camera drop	2016
z36	174.3010761	-35.17696937	52	camera drop	2016
373	174.30411	-35.19152	8	video drop	2012
374	174.30413	-35.19154	8	video drop	2012
375	174.303	-35.19698	9	video drop	2012
376	174.30302	-35.19708	11	video drop	2012
377	174.30302	-35.1971	12	video drop	2012
378	174.30253	-35.19723	18	video drop	2012
379	174.3025	-35.19738	22	video drop	2012
380	174.30068	-35.1951	36	video drop	2012
381	174.3004	-35.19516	36	video drop	2012
382	174.30038	-35.19515	30	video drop	2012
383	174.29811	-35.19763	31	video drop	2012
384	174.29909	-35.1975	30	video drop	2012
385	174.29886	-35.19785	28	video drop	2012
386	174.3027	-35.19855	17	video drop	2012
387	174.29641	-35.20077	22	video drop	2012
388	174.29618	-35.20079	20	video drop	2012
389	174.29593	-35.20082	21	video drop	2012
390	174.29512	-35.19852	34	video drop	2012
391	174.29455	-35.19853	35	video drop	2012
392	174.29401	-35.19846	31	video drop	2012
393	174.29379	-35.1984	32	video drop	2012
394	174.29338	-35.19841	37	video drop	2012
395	174.29314	-35.19834	39	video drop	2012
396	174.29284	-35.19838	40	video drop	2012
397	174.29256	-35.19831	41	video drop	2012
398	174.29244	-35.19829	41	video drop	2012
399	174.29229	-35.19828	41	video drop	2012
400	174.29212	-35.19825	41	video drop	2012