SURVEY NAME	DATE OF SURVEY	MULTIBEAM PROCESSED GRID SIZE	MULTIBEAM BACK SCATTER IMAGE	MULTIBEAM DIGITAL TERRAIN MODEL (DTM)	SIDESCAN IMAGERY
Shipping Lane 1 Cape Reinga Section NZ Navy	1999 2000	5 m	Yes but not currently available	Yes	No
Spirits Bay Biodiversity survey NIWA	1999	N/A	No	No	Yes
Spirits Bay Biodiversity survey NIWA (unpublished data)	2006	25 m	No	Tes	No

The Ocean 20/20 project (Mitchell *et al.*, 2009) provided extensive multibeam sonar coverage for much of the zone along Northland's east coast from 50 m depth outwards.

The Shipping Lane 1 and Shipping Lane 1 Cape Reinga Section data sets consisted of only a multibeam digital terrain model as backscatter and sidescan sonar data were not available. Semi-transparent gridded bathymetry from the digital terrain model was draped over hillshading for interpretation. However, fine sediments and coarse sediments were not easily differentiated and may require seabed video or grab sampling to ground truth categories. As a result non-reef substrata in these survey areas are only described as undefined sediments. In the Spirits Bay area, all available data layers from the two studies and the draft maps produced to date were interpreted together to make up the final mapping interpretation (Cryer *et al.*, 2000; NIWA, 2005 unpublished data). Where the NIWA teams had made interpretations of their data layers in the form of draft habitat maps, these interpretations were accepted as the best interpretation of the available data. For all the offshore areas (i.e. >50 m), mapping was carried out at scales ranging from 1:20–50,000.

BAY OF ISLANDS SECTION

Preliminary multibeam sonar was also made available for the Bay of Islands from Ocean 20/20. This survey provided digital terrain models and backscatter images derived from 5 m grid data for areas deeper than 10 m. Sidescan sonar data was produced for areas too shallow to use multibeam efficiently. Where applicable hillshading, bathymetry, sidescan and backscatter layers were used to interpret substratum categories at scales of approximately 1:10–20,000. This finer mapping scale was used because of the quality of the data available and the complexity of the habitats in this area. For the shallow areas covered by the sidescan layer, the method adopted was to switch between the available aerial photographs and the sidescan image layer. Essentially, mapping interpretation was based on the best images that were available in each area. The sidescan was particularly useful in identifying reef located just beyond the underwater viewing range of the aerial photographs. Consistently differentiating between fine and coarse sediments was however difficult. These areas were simply classed as undefined sediments.

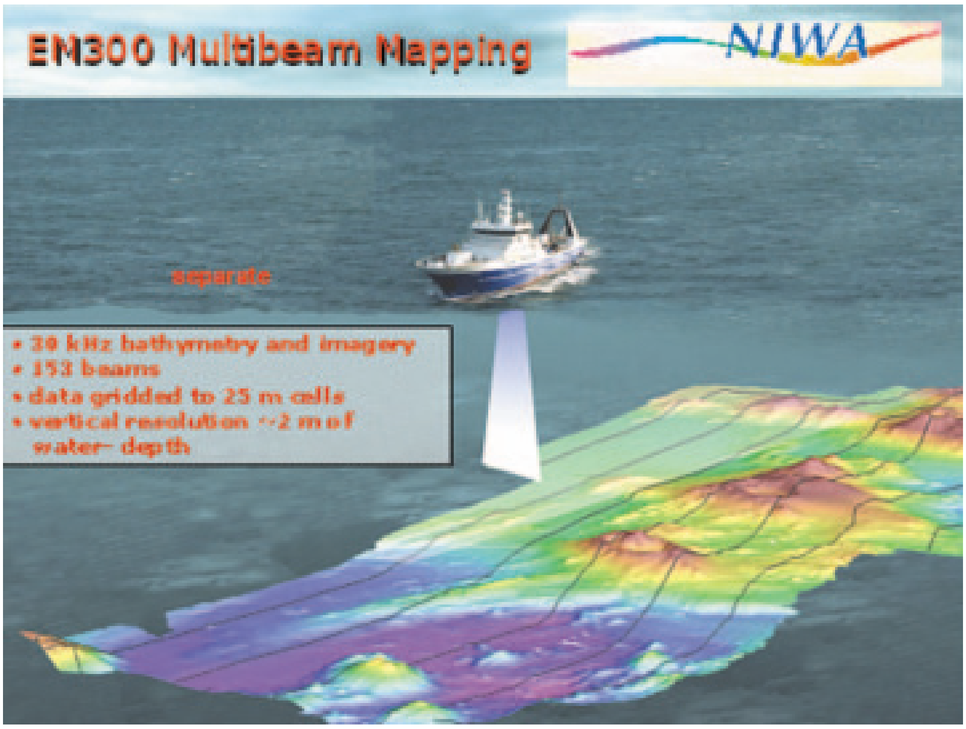

Figure 4. NIWA research vessel Tangaroa and graphic representation of multibeam sonar survey (courtesy of NIWA)

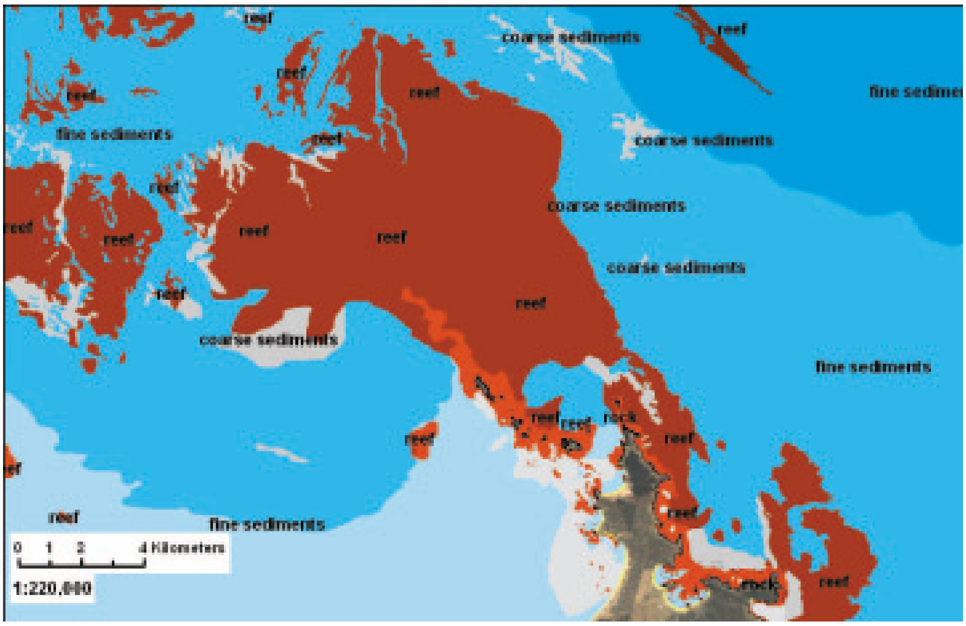

Figure 5a. Example of Ocean 20/20 multibeam sonar derived habitat data layer (Mitchell *et al*, 2009). The area pictured is extending offshore to the northeast from Cape Karikari.

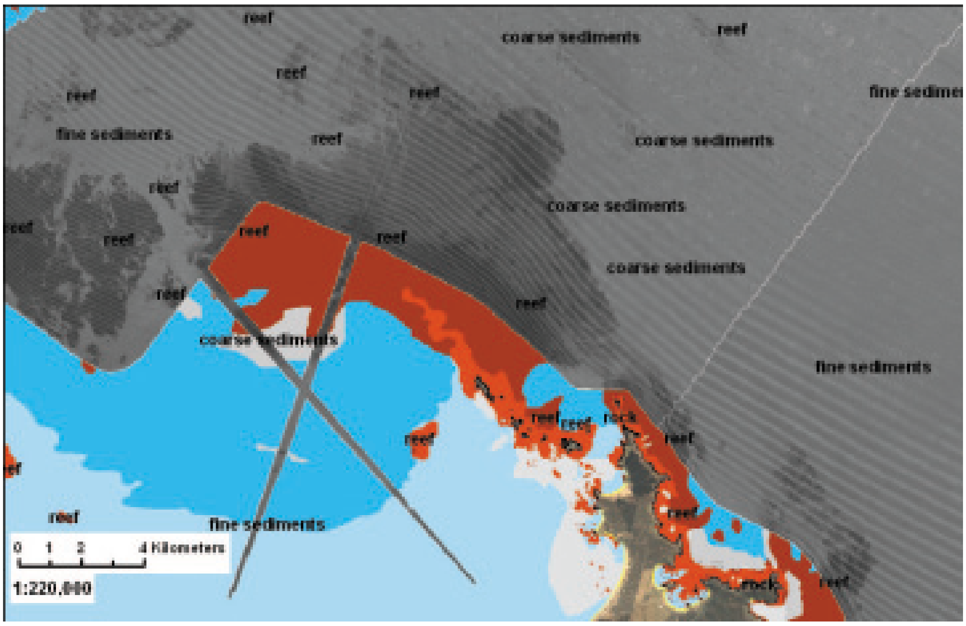

Figure 5b. Example of Ocean 20/20 multibeam sonar backscatter image (Mitchell *et al*, 2009): b). The area pictured is extending offshore to the northeast from Cape Karikari.

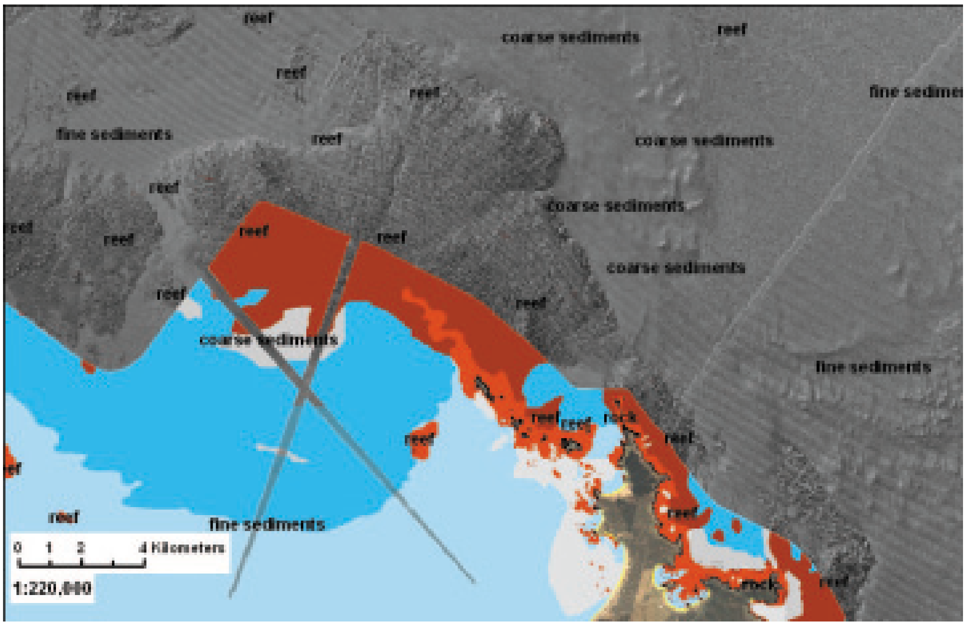

Figure 5c. Example of Ocean 20/20 multibeam sonar derived data layers—backscatter image draped over digital terrain model (Mitchell *et al*, 2009). The area pictured is extending offshore to the northeast from Cape Karikari.

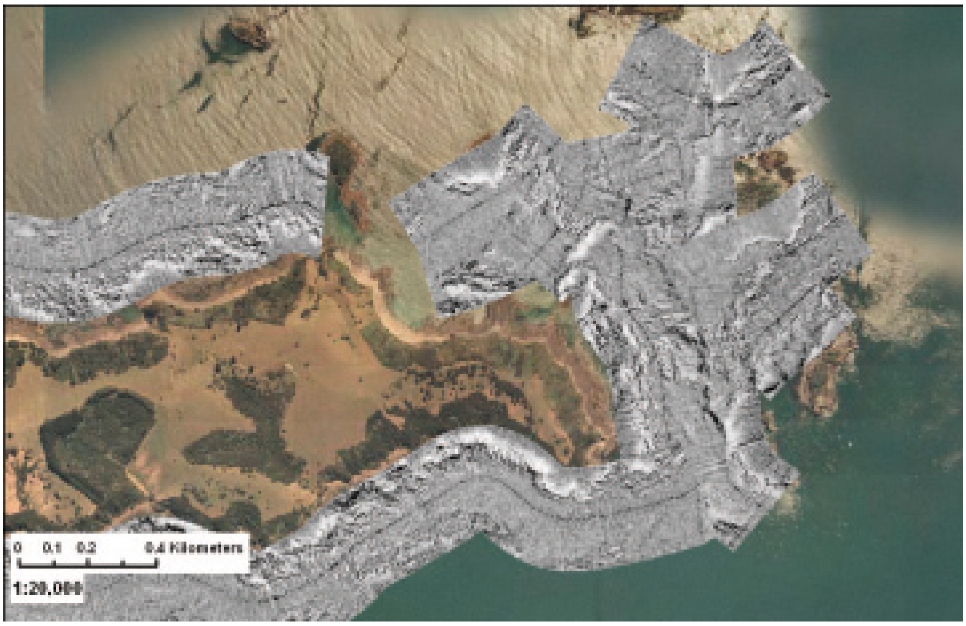

Figure 6a. Example of sidescan image from Ocean 20/20 (Mitchell *et al*, 2009). Area shown here is Black Rocks, Bay of Islands.

Figure 6b. Example of habitat polygons derived from Ocean 20/20 (Mitchell et al, 2009) side scan imagery (6a). Area shown here is Black Rocks, Bay of Islands.

ADDITIONAL DATA

For areas that were not covered by the previously described data there was a need to evaluate all other data sources that could be used to help cover the target mapping area. The area not covered by specialised survey is very large and extends over areas of outer shelf habitats in depths beyond 200 m. Off North Cape, part of the continental slope and canyon areas come within the 12 nm limit of the territorial sea. Available bathymetry data and marine charts were used to identify potential reefs associated with large changes in elevation. However, flat reefs and flat patch reefs and areas of coarse sediments and mixed sediments could not be reliably identified by this method. To refine this approach, we acquired the original paper naval fair sheets (depth soundings for marine charting) for the region from LINZ. We then applied the following method of preparation and analysis to these charts. All charts were scanned and georeferenced in our GIS project. They were printed off at a consistent scale (20,000:1 in most cases). We then visually assessed the data using a ruler with 200 m (scaled map unit) intervals. All depth measures were checked with adjacent measures. To indicate when a change in elevation exceeded 4 m across a horizontal distance of 200 m a symbol was drawn on the chart. A double symbol was drawn wherever the vertical change exceeded 8 m in a 200 m horizontal distance. Another symbol indicated when the elevation change was a hole versus a rise. Once the entire chart was marked in this way, polygons were drawn around the marks to indicate potential reef areas. The chart was then scanned again, the images georeferenced and indicative habitat areas hand digitised in ArcGIS 9.3.1.

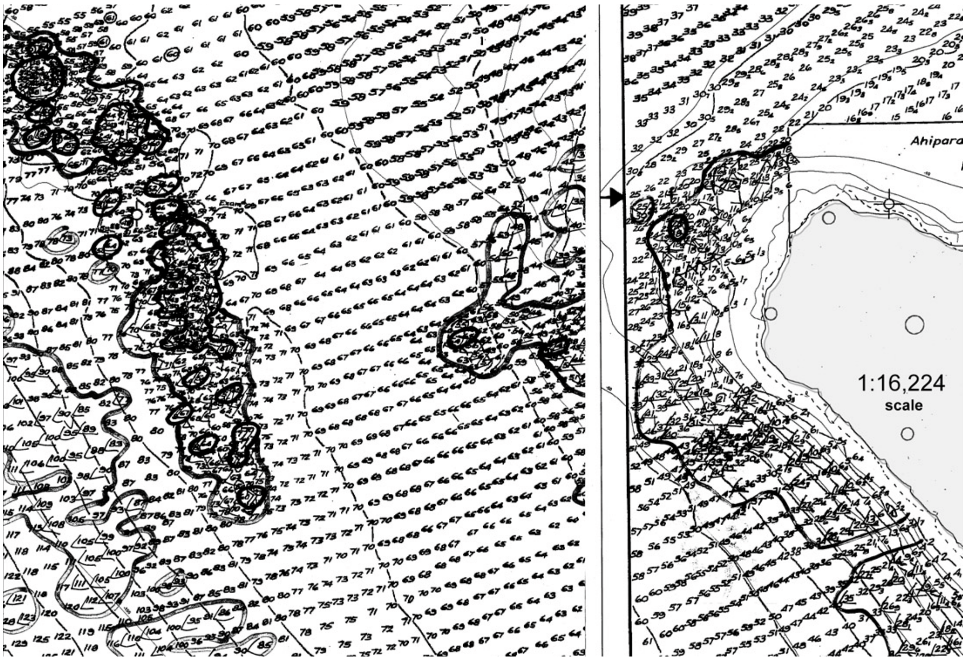

Figure 7a. Example of marked fair sheet analysis for reef indication. Area shown here is the area offshore to the west of Tauroa Pt. Data points are depth soundings in meters.

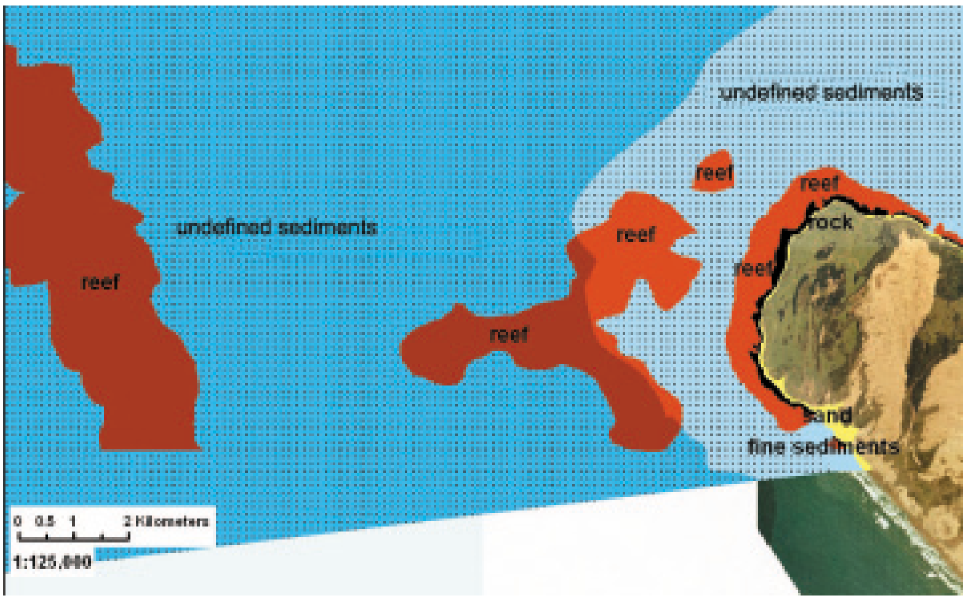

Figure 7b. Example of habitat polygons derived from fair sheet analysis (7a) Area shown here is the area offshore and to the west of Tauroa Pt.

GROUND TRUTHING

Ground truthing by scuba diving surveys, underwater video, sediment grabs or dredges would ideally compliment all of the methods described in this project. However a significant body of information of this type from previous studies and the experience of the author in Northland waters also provided support for habitat interpretation. In addition, the completed Ocean 20/20 project will also provide ground truthing for this work and additional information on substrata, habitats and species on Northland's eastern shelf.

GIS DATABASE

The database behind the mapped habitat polygons contains information fields documenting substrata, habitats and various zones for each habitat polygon according to the classification outlined in Table 1. Fields also document data sources, methods and data editors so that polygons can be queried and readily updated when new and more detailed information becomes available.

Results

The completed maps of this project can be viewed in the Map Section at the end of this report. Map 1 is drawn at 1:1,850,000 scale and shows the extent of the complete project which covers the coastal area from Mangawhai to Ahipara and out to the 12 nm limit to the New Zealand territorial sea. Maps 2a–d show this same map drawn at 1:310,000 scale with the entire area broken into four sections. Map 3 shows the Bay of Islands drawn at 1:110,000 scale. Altogether the mapped area covers 1,354,545 ha and represents the Northland Conservancy portion of the Bioregion as defined in the New Zealand MPA Implementation Plan (MinFish & DOC, 2008). The capabilities of the GIS system mean that this map can be drawn at any scale which is useful for specific site-based work. The accuracy of the mapping method allows this map to be useful at scales as large as 1:2,000 for estuaries and shallow areas. This would translate to dozens of maps (A3 size) to cover the whole area. The GIS system also allows us to calculate the areas of any attribute that is represented by a polygon on the map. Table 3 below contains the result of the analysis of areas represented by each habitat for the entire mapping area.

TABLE 3 HABITAT AREA CALCULATIONS FOR MAPPING AREA

DEPTH	HABITAT	HECTARES	PERCENTAGE
Total		1,354,545	100%
30–200 m	undefined sediments	405,513	29.94%
30–200 m	fine sediments	259,882	19.19%
> 200 m	undefined sediments	199,538	14.73%
30–200 m	reef	156,162	11.53%
0–30 m	fine sediments	77,423	5.72%
> 200 m	fine sediments	56,607	4.18%
30–200 m	coarse sediments	46,802	3.46%
0–30 m	undefined sediments	42,122	3.11%
0–30 m	reef	31,811	2.35%
0–30 m	coarse sediments	10,770	0.80%
> 200 m	shelf canyon	9,758	0.72%
intertidal	mangroves	9,393	0.69%
intertidal	mud	8,891	0.66%
intertidal	sand	8,266	0.61%
0–30 m	channel	7,096	0.52%
> 200 m	reef	5,702	0.42%
intertidal	seagrass	5,192	0.38%
> 200 m	coarse sediments	4,467	0.33%
0–30 m	island	2,906	0.21%
> 200 m	steep shelf	2,477	0.18%

intertidal	rock	2,459	0.18%
intertidal	salt marsh	749	0.06%
30–200 m	ridge feature	262	0.02%
intertidal	gravel	239	0.02%
0–30 m	rhodolith bed	51	0.00%
30–200 m	shelf canyon	3	0.00%

Intertidal, shallow, deep and very deep depth zones accounted respectively for 2.6%, 12.7%, 64.1% and 20.6% of the mapping area. Estuarine environments made up 3.3% of the mapped area and there were 487 islands mapped representing just over 0.2% of the mapping area. Perhaps the most interesting result is the very large area of shallow and deep rocky reef that exists off the eastern and northern coasts of Northland. In total the reef areas mapped represent 193,675 ha or 14.3% of the total mapped area. Approximately 2.4% of the region's total area is estimated to be shallow (<30 m) rocky reef, 11.5 % is deep (30–200 m) rocky reef and 0.4% is reef deeper than 200 m.

Seagrass and mangrove areas in estuaries comprise some significant areas. Seagrass covers 5,192 ha and mangroves 9,393 ha. Salt marsh is a habitat that has been greatly decreased due to reclamation and drainage programs and currently covers only 749 ha. It is quite possible that subtidal seagrass beds have been underestimated due to the limitations of the survey. Likewise the known rhodolith beds in the mapping area are most likely only a small percentage of what actually exists. Specialist surveys are required to map these habitats comprehensively. Rhodolith beds are considered to be important for biodiversity and are a protected habitat in the European Union.

Discussion

This is the first attempt to derive a consistent regional map of marine habitats for the Northland section of the Bioregion. The range of methods and data sources mean that there are significant variations in precision and accuracy, particularly at fine scales. However, the work provides an extremely useful first map of the distribution and occurrence of marine habitats in this region that can be used for initial planning for marine protection, prioritising additional research and applications in many other areas.

However it is important to qualify fitness for use of the data by recognising limitations that may be due to a number of factors:

1. the subjective interpretation of data layers assembled;
2. the scale at which the map drawing is undertaken;
3. the accuracy and resolution of the data layers used; and
4. the limited amount of ground truthing.

In previous Northland projects carried out at Mimiwhangata and Doubtless Bay (Grace & Kerr, 2005, 2005a), a similar interpretation method was employed. Ground truthing demonstrated that within the stated precision range the interpretation method proved reliable. Some of the multibeam sonar data produced by the Ocean 20/20 survey also overlapped the previously surveyed Doubtless Bay and Mimiwhangata habitat maps, helping to ground truth these areas and indicating that previous maps had a very high level of consistency with the new multibeam data.

The drawing scale is a limiting factor on mapping precision. Drawing scales ranged from 1:10,000 to 1:50,000 depending on habitat. For rocky reef, in most cases the error was low as they were relatively easy to detect, although flat reefs and flat patch reefs were often difficult to differentiate from coarse sediments. Where substrata were mixed in composition or arranged in streaks, bands and mosaics, interpretation was also difficult. Where there was doubt due to data type or quality, the habitat was classified as 'undefined' sediments. The differentiation between silts, muds and sand within the fine sediments group was also not practicable without additional aids to interpretation. Ground truth data would improve the accuracy of the classification of sediments indicated on this map.

With the exception of the area covered by the Shipping Lane 1 Cape Reinga data, the West Coast section of this map has poor data coverage. Marine charts and the results of the fair sheet analysis method were used for this section. During the course of this project we had opportunities to compare the results of the fair sheet analysis method to data from the multibeam surveys and previous surveys at Mimiwhangata and Doubtless Bay. We found that this method was sometimes a useful method to identify boundaries between reefs and sediments. However, predictions were also frequently very poor depending on the type of substrata. The cases where the method failed were:

1. areas of flat reef and flat patch reef (falsely identified as soft sediment);
2. consistent sloping terrain of sediments (falsely identified as rocky reef); and
3. areas of sediments with large wave and ridge features (falsely identified as rocky reef).

However, areas that had rocky reefs with high relief could be consistently indicated using the fair sheet method.

In the West Coast section of the survey area, where fair sheet analysis was used, a conservative approach was therefore adopted and only 'indicated reefs' were mapped for obvious high relief features. The remaining area was coded as 'undefined sediment'. The significant area of reef off Tauroa Pt was mapped with the fair sheet method. As a result, the areas of reef that are mapped are high relief reef only, and it is possible that we have significantly underestimated the extent of the reef that is flat or near flat in contour.

In the area south of Cape Maria Van Diemen there is an area of locally known banks and ridges. Our fair sheet analysis indicated large areas of reef, but with the data available many of these indicated reefs could in fact be sand and gravel wave, ridge features and banks, so we again took a conservative approach and classified the areas as undefined soft substrate where any doubt existed.

There are many references in New Zealand marine science literature to the extensive natural values of the Northland region and its importance in biodiversity terms. An overview and bibliography have been brought together in the publication *An information review of the natural marine features and ecology of Northland* (Morrison, 2005a). It is not necessary to attempt to discuss that body of information in the context of this report. However, the special marine values of the Northland inshore region form the backdrop to this project. For the first time, knowledge of marine biodiversity and fisheries can be examined and investigated in the context of comprehensive habitat map of these waters. The information in these maps, seen in one spatial context, immediately points to some significant findings and observations. Although work of this kind has not been completed yet in many other regions of the country, it is apparent that Northland may have a disproportionately high amount of coastal reef habitats from the intertidal zone extending out to waters of 200 m and deeper. When this is considered in light of the geographical position of Northland and the effects of the East Auckland current, the indication is that, in marine biodiversity terms, Northland has a large proportion of the most important coastal habitat areas in New Zealand. The completion of similar mapping projects around New Zealand's coast will in time allow us to examine this claim quantitatively.

This mapping resource allows us to portray the habitats of our unique array of estuaries in the context of the greater coastal area for the first time. Northland's estuaries are indeed rich in biodiversity and marine habitat terms. The large estuaries of Parengarenga and Rangaunu have extensive areas of rich intertidal mud and sand flat habitats, important for many species, including internationally significant migratory shorebirds. These two estuaries arguably have a significant percentage nationally of *Zostera capricorni* seagrass habitats, a key nursery habitat for commercially important fish species and a habitat generally diverse in marine flora and fauna (Morrison, 2005b).

POTENTIAL USES OF THIS MAPPING RESOURCE

This first version of the mapping resource should be viewed and used as a work in progress. The data layers and the interpretation approach adopted will be improved upon in the future. The classification can and should be extended to further define physical substrates and identify significant biological communities. An adaptive approach to the GIS database design has been adopted to allow updates to be readily made as new information becomes available. The map can be useful to many forms of marine planning, including resource, fisheries and aquaculture planning management and the design of future scientific research. However, this project was specifically designed to fulfil information requirements for the National MPA Strategy, and specifically the Northland section of the Bioregion (MinFish & DOC, 2008). With limited exceptions, this task is now advanced. Important tasks in the MPA process are now enabled. An analysis of habitat areas can be made. This information can be used to complete a gap analysis of current protection mechanisms. This process can lead to goal setting and identification and prioritisation of recommended areas, leading to the establishment of an effective network of MPAs with a core of highly protected areas for Northland and the Bioregion. Information on how to obtain the GIS resources, the maps of this report and the electronic copy of this report can be obtained from the DOC website: www.doc.govt.nz/northlandmarinehabitats1

Looking to the future, this habitat map and the GIS resources created can form the basis of a MPA design process which has the potential to effectively engage and inform the community and decision-makers in the considerable challenges that lie ahead. The next steps in this process are:

1. Identify and assemble additional information layers in a spatial context that documents and quantifies social and economic values in relation to the marine environment. The focus will be on marine use and user information, and on more detailed ecological information where available.
2. Develop modelling and decision support GIS-based software systems to generate, test and evaluate design criteria and goals to generate options for protection or special management arrangements.

The above modelling and design process briefly outlined here is essentially a technical and information support process. Overseas experience demonstrates that its use can greatly aid the larger full MPA public participation process (Beck *et al.*, 2009; Wahle *et al.*, 2009; Bernstein *et al.*, 2004). It brings an ability to engage participants in a formative process that is objective, transparent and can be portrayed in a readily understood visual format. Having the ability to assess cost and benefit analyses for alternative design options can help to achieve solutions and compromises among diverse stakeholder interests. Sound information, and tools to access and communicate this information, are not substitutes for well-run community participation processes and governance but they are clearly an important tool in helping to meet these challenges.

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Map book

Map 1 Northland MPA Habitats

Map 2a Northland MPA Habitats (far north)

Map 2b Northland MPA Habitats (upper north)

Map 2c Northland MPA Habitats (mid north)

Map 2d Northland MPA Habitats (lower north)

Map 3 Northland MPA Habitats Bay of Islands

Map 4a Northland MPA Method Map (north section)

Map 4b Northland MPA Method Map (south section)

Map 5a Northland MPA Rapid Sonar Survey (north section)

Map 5b Northland MPA Rapid sonar survey (south section)

These maps may be downloaded as PDF files from the DOC website: www.doc.govt.nz/northlandmarinehabitats1