4.3 Subtidal sampling

Side-scan data was collected using a C-Max CM800 Sidescan Sonar system comprising a graphic recorder, a dual frequency tow fish operating in 100 kHz mode, with a SCX tow-cable running through a digital pulley block for displaying layback. A new acquisition file was started at the end of each swath or whenever the layback was changed. Swath width was 200m either side of the fish which was towed at between 2 and 4m from the bottom at about 4 knots boat speed. Sound velocity profiles were obtained at the start of each day using an AML SmartProbe. Adjacent swathes were mosaiced using the CODA DA50 mosaicing software and the data was formatted as a georeferenced TIFF file suitable for input into a GIS.

QTC data was collected using the data acquisition system QTC View Series 4 (manufactured by Quester Tangent Corporation, Canada) interfaced with a single-beam Echotrac DF3200 echosounder and a Trimble DSM212H GPS. The basegain setting for QTC View was 21 dB. The echosounder was operated at a transmit frequency of 200 kHz, a pulse length of 0.32 ms, and a ping rate of 10 per second, resulting in an average between sample distance of 1.25 m and a resolution of 38 – 135 m. The transducer was mounted on a pole on the starboard side of the vessel.

A visual system was used to ground truth the acoustic images, provide information on how communities changed across depth and acoustic transition zones, and to survey areas shallower than 6 m. The visual system used was a colour zoom camera mounted in a depressor frame with integrated lights and laser scaling system. The camera used was a high resolution Tritech Typhoon, with 470 lines of horizontal resolution. A total of 85 video transect samples were collected with each transect covering a minimum of 10 metres. For areas of the Southern Kaipara where water clarity compromised the use of video, samples were collected by an Ockelmann type epibenthic sledge with a 2mm mesh size. A total of 44 dredge samples were collected from tows of approximately 10 metres duration. The video and dredges were analysed to give equivalent data, i.e., large or unusually dense epifauna and information on amount of bioturbation.

Rocky subtidal habitats were sampled by a Benthos Mini-Rover Remote Operated Vehicle (ROV) with colour video camera and integrated lights and depth recording. Video footage began on the soft sediment floor of the channel (~20 m deep). The ROV was then 'flown' up the slope recording video and depth continuously, stopping for close-up views approximately every 4-5 metres. The transects were analysed to characterise the fauna, flora and substrate, as well as ripples and bioturbation (where present).

117 sites were selected for soft-sediment subtidal sampling. Similar to the intertidal sampling, a two-Tiered sampling design was used. A grab ($0.1m^2$) was taken and the appearance of the sieved material and the sediment going through the sieve was noted. If these characteristics were the same as those noted at the next closest site the site was not sampled further. If they were different, two more grabs were taken. The 3 replicate grabs were generally taken from within 15m of each other. All samples were preserved in 50% Isopropyl alcohol and stained with 5% Rose Bengal.

Invertebrates were sorted, identified to the lowest practical taxonomic resolution and counted.

4.4 Analyses

A system of ecological community description decision rules was developed for both the intertidal and subtidal areas of the Southern Kaipara. The basis of the rules was threefold: key species, key functions and factors affecting vulnerability to threats.

Sediment characteristics were analysed in 2 ways. Firstly, the relationship (if any) between sediment variables (coarse > 0.5 mm, medium and fine sediment and muds <63 um) and other environmental factors (i.e., depth, vegetation (type and %cover) and side-scan information) was assessed using generalised linear models (GLM) with data transformations where necessary. The likely distribution of sediment variables were then determined by interpolation between sampled locations using spatial kriging including appropriate covariables identified by the GLM. Secondly, a sediment habitat type was determined for each sampling location, based on the overall sediment characteristics (Table 2). This data was used to determine whether communities had specific affiliations with certain sediment types.

Table 2:

A description of the sediment types found in the Southern Kaipara.

Sediment type	Description
Coarse sands	Sediment sized > 0.5 mm comprises more than 20% of the sediment
Muds	Sediment sized < 63um comprises more than 20% of the sediment
Fine sands	Sediment sized 63 – 250 um comprises more than 90% of the sediment
Medium sands	Sediment sized 250 -500 um comprises more than 30% of the sediment
Sandy	Sediment sized 63 – 250 um comprises more than 70% of the sediment, sediment sized < 63um comprises less than 5% of the sediment and sediment sized > 0.5 mm comprises less than 20% of the sediment.
Sandy muds	Sediment sized 63 – 250 um comprises more than 70% of the sediment, sediment sized < 63um comprises more than 5% of the sediment and sediment sized > 0.5 mm comprises less than 20% of the sediment.
Coarse sandy muds	Sediment sized 63 – 250 um comprises more than 70% of the sediment, sediment sized < 63um comprises more than 5% of the sediment and sediment sized > 0.5 mm comprises greater than 20% of the sediment.

Species that were widely distributed throughout the Southern Kaipara, either intertidally or subtidally or both, were analysed to determine whether they exhibited a spatial distribution associated with sediment characteristics, vegetation, or area within the Southern Kaipara (see below).

A variety of statistical techniques were used to analyse the data:

- Analyses of differences in community structure were done using ANOSIM (Clarke 1993) on Bray Curtis similarities of untransformed data. Average dissimiliarites between communities were derived using SIMPER (Clarke 1993).
- Analyses of differences in number of taxa, number of orders and total numbers of individuals were assessed using Generalised linear modelling, using an appropriate error structure and link function, followed by a multiple contrast (McCullagh and Nelder 1989). Similar analyses were carried out for widespread taxa.
- Analyses of factors affecting species occurrences were done using logistic regression on presence/absence data for widespread species (Ysebaert et al. 2002). Factors used were depth, sediment particle size characteristics, size of ripples recorded in the side-scan data, and side-scan- and QTC-derived classes. Backwards selection was used to select the most appropriate model based on changes to the AIC (Akaike's Information Criteria, Burnham and Anderson 1998). Squared terms were included for sediment particle sizes in case the inclusion of the different catergories (e.g., mud, fine, medium and coarse sand) were not sufficient to explain unimodal responses of the taxa to sediment.
- Analyses of factors affecting numbers of taxa and orders were done using generalised linear models (as above). Factors used were depth, sediment particle size characteristics, size of ripples recorded in the side-scan data, and side-scan- and QTC-derived classes. Backwards selection was used to select the most appropriate model based on changes to the AIC.
- Discriminant analyses (mahalanobis distances) were used to determine which epibenthic characteristics explained the side-scan and QTC classes, based on video/dredge data and sediment particle size characteristics. Video/dredge data was converted into rank abundance (0- absent, 1- sparse, 2- moderate density, 3 – high density) of fauna (aggregated at order level) and degree of bioturbation. Stepwise analysis was used to select the important factors and the degree of concordance was used to demonstrate the usefulness of the factors to explain the classes.
- Interpolations were performed with a thin plate smoothing spline and environmental factors demonstrated by regression to be important as covariables using ANUspline.

4.5 Other data used

Some previous macrofaunal information was available from Britta Hietz (Spatial variability and diversity of macrobenthic communities associated with streams catchments in the intertidal flats of the South Kaipara Harbour, MPhil thesis Massey University). To determine whether this information could be incorporated in this work, and to give some guidance to the degree of change exhibited by intertidal macrofaunal communities in the Southern Kaipara, some resampling of areas from this thesis was undertaken. Core samples taken for the Hietz study were roughly the same size as the core samples in this study (15cm diam cf 13 cm) and over a similar scale (approx. 10 m). Thus one site from the Hietz study on the Omokoiti flat was resampled at low, mid and high tide zones. However, differences in taxonomic resolution between the studies in the amphipoda, isopoda and polychaeta orders and lack of data on the age sturcture of the bivalves found in the Hietz study confounded allocation of the Hietz samples to ecological communities. Also, while the lower site exhibited concordance on the two sampling dates, the mid-tide zone had patches of the Asian mussel (*Musculista senhousi*) not observed in the 2001/02 sampling. The high tide zone sampled in 2004 had fewer *Macomona*, isopoda and amphipoda than in 2001/02, but, at least, for isopoda and amphipoda, these may have been recently settled juveniles and thus likely to be temporally variable. For these reasons, the earlier data has not been incorporated in this study.

Information on subtidal *Zostera* cover in and around AMA D and E was kindly provided by Jim Dollimore. This dataset consisted of a number of transects along which measurements were made of depth and *Zostera* cover.

5 Results

5.1 Intertidal large-scale features of the Southern Kaipara

Most of the intertidal area of the Southern Kaipara is mid to low intertidal; with few areas exposed for more than 7hrs on a tidal cycle. Extensive mangroves (often densely packed) fringe much of the area, with the exception of the South Head area and the sand dunes opposite the mouth. Extensive *Zostera* beds stretch over the intertidal flats in the middle of the main harbour and near the mouth. The vegetation shape file, received from ARC, of these was limited and this survey describes much more extensive coverage (Figure 4). Much of the intertidal area between Helensville and just south of Sandy Beach is predominantly muddy sediment (Figure 5). Seaward of this point, mud is still found near the mangrove edges and small drainage channels, but much of the intertidal flats are sandy. In more exposed areas, firm packed rippled sand is common and in a few areas rocky outcrops occur.

Figure 4: (Click for high resolution map)

Sample positions where *Zostera* was observed and suggested extensions to the *Zostera* shape file.

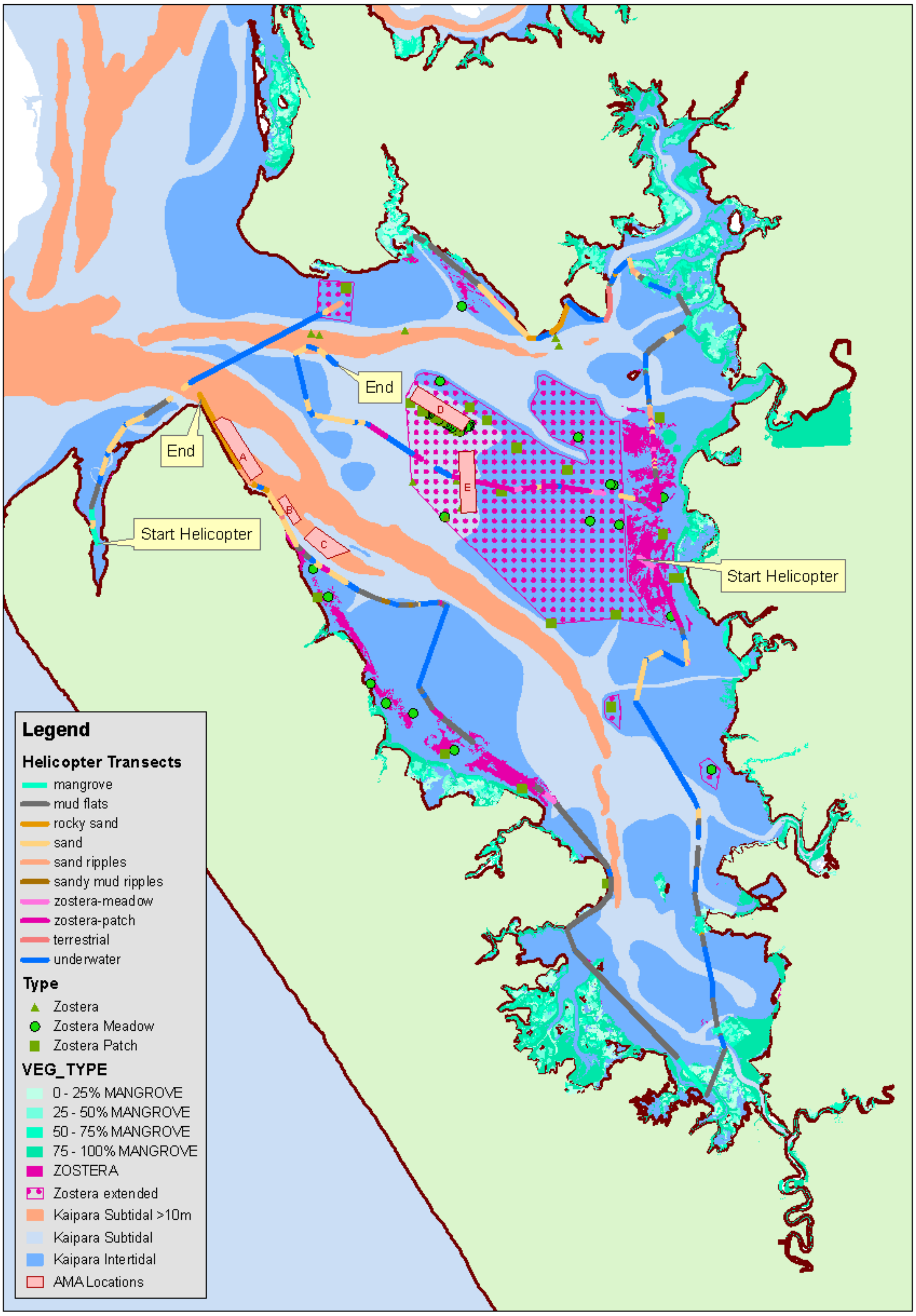
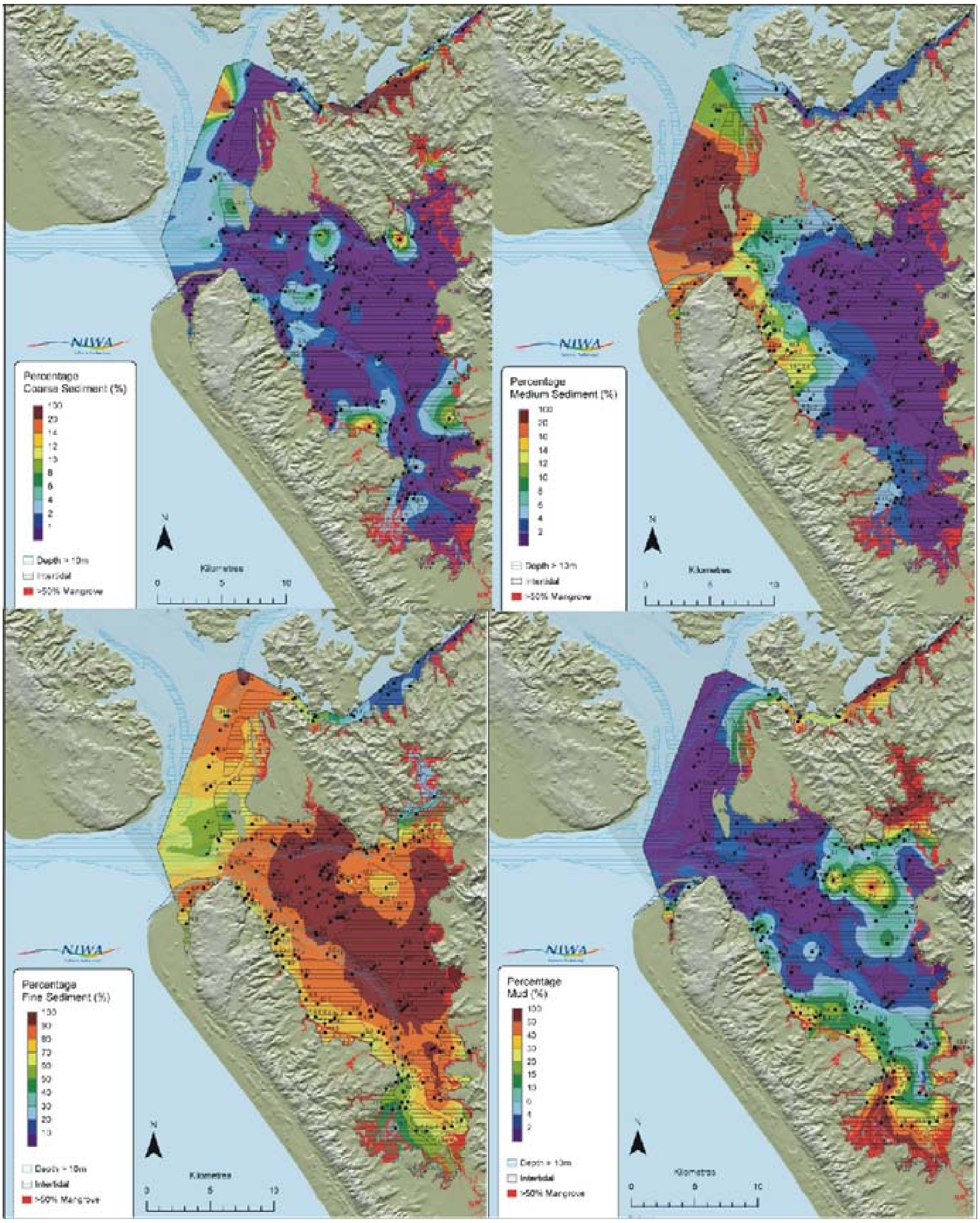


Figure 5: (Click for high resolution maps)
Interpolated plots of sediment particle size.



5.2 Intertidal communities of the Southern Kaipara

Three different community types were observed in the rocky intertidal. Small rocky reefs had few oysters and were dominated mainly by mussels, although on two of the reefs, small barnacles were overgrowing the mussels. Only one dense area of oysters was found on the small rocky reefs sampled. Conversely the steep bedrock area at the base of the cliffs was predominantly oysters. There was no obvious depth pattern, except that near high tide nothing grew and at the extreme low tide mark some serpulid polychaete tube mats were observed.

Fifteen different community types were defined for the soft substrata intertidal area of the Southern Kaipara (Table 3, Figure 6). The hierarchical community rules identified six communities based on bivalves: three of these were based on biomass of adult bivalves: a *Macomona* community; an *Austrovenus* community; and a *Macomona/Austrovenus* community. Some areas of dead cockle shells were also observed, e.g., on the intertidal flats out by Tauhoa Channel. No high densities of large adult pipis (*Paphies australis*) were found, although some areas of high densities of an intermediate size class were observed (20 – 40 mm). Other types of bivalve-dominated communities were those dominated by suspension feeders[1], or deposit feeders and one dominated by large numbers of the invasive Asian date mussel (*Musculista senhousia*).

High taxonomic level (order) diversity was found at a number of sites with communities within these areas dominated either by tube dwellers, large animals, suspension feeders or deposit feeders. Outside of these high diversity areas, similar to many of New Zealand's estuaries and harbours, polychaete dominated communities were widespread, displaying a mix of ecosystem functions (e.g., tube-dwellers, large predatory/scavenging polychaetes and deposit feeders). These communities occurred in all types of sediment and tidal heights and were spread throughout the harbour. Finally two communities of low diversity were observed; one dominated by surface bioturbators and the other dominated by burrowing organisms and confined to muddy sediment.

All communities identifed by the heirachical community rules were more than 80% dissimilar; most were greater than 93% dissimilar. More similarities were found between the communities dominated by either *Austrovenus* or *Macomona* and the other communities, as the similarity analysis was based on numeric data and these communities were selected by biomass. The different types of polychaete communities were also less distinct from each other than from other community types.

[1] Note that not all bivalves could be placed into these categories. For some species the information is not available, and some small individuals could not be identified.

Figure 6: (Click for high resolution map)

Distribution of ecologically significant intertidal communities found in the Southern Kaipara.

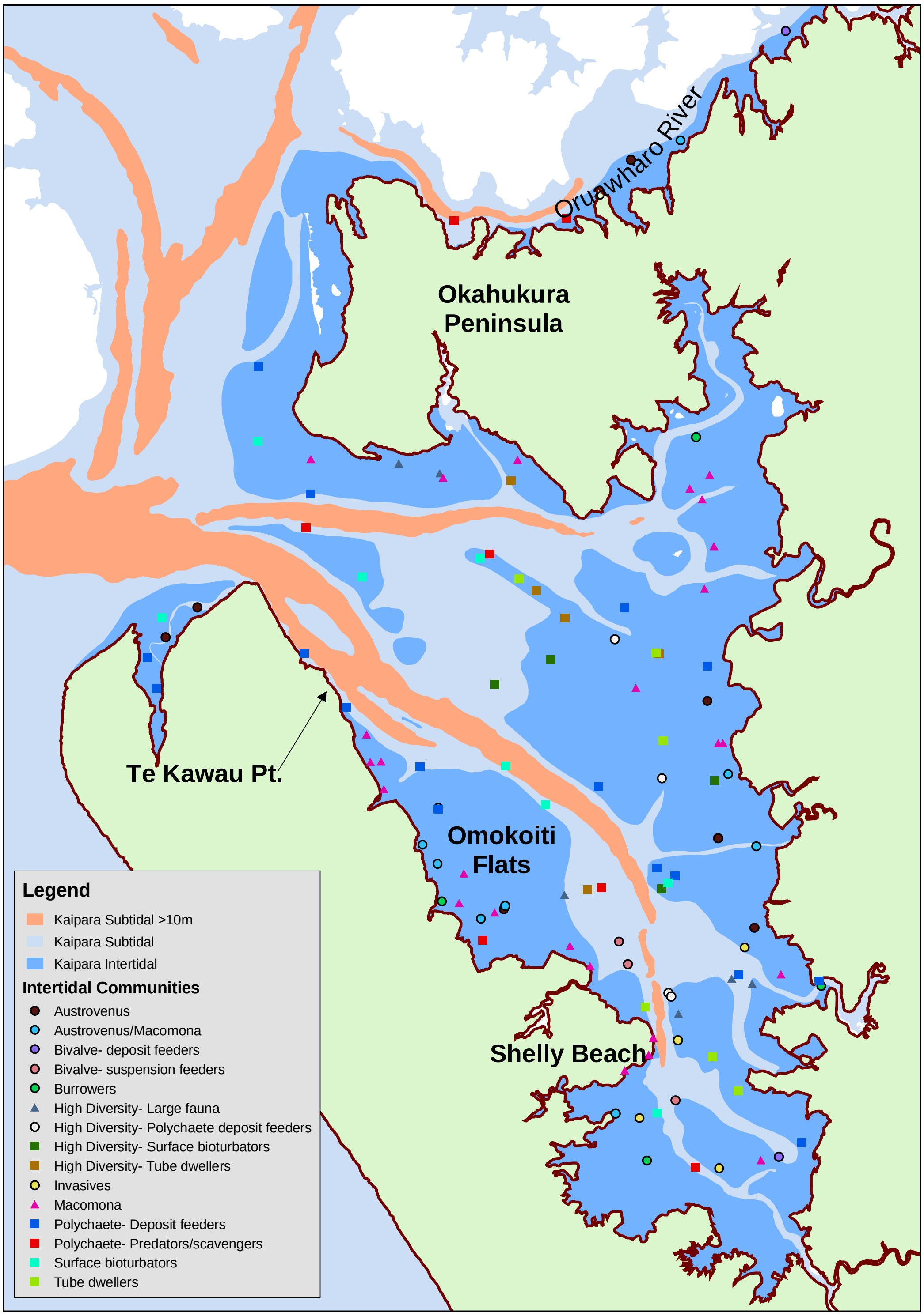


Table 3:

Ecologically important intertidal communities found in the Southern Kaipara using the hierarchical rules given in Box 2.

	Community type	Description
1	Austrovenus	Dominated by large *Austrovenus*, found in high to low intertidal in a mix of sediment types. High diversity, usually found in conjunction with anemones, limpets and small *Nucula hartvigiana*.
2	Bivalves- deposit feeders dominated	Moderate diversity, dominated by bivalve deposit feeders, often occurring with Nereid polychaetes, amphipods and decapods. Found in muddy sediments
3	Bivalves- suspension feeders dominated	Moderate diversity, dominated by suspension feeding bivalves, often co-occurring with low numbers of polychaete deposit feeders, amphipods and gastropods. Found in a range of sediment types.
4	Burrowers	Low diversity, mainly the mud crab *Helice crassa*. Found in mud and mangroves.
5	Austrovenus-Macomona	Adults of both *Austrovenus* and *Macomona* found, though the size of the *Austrovenus* were generally smaller than those found in *Austrovenus* only communities. Mid to low intertidal in mud to sand.
6	High diversity- large fauna dominated	Large gastropods, crabs, limpets and predatory/scavenging polychaetes. Found in sandy-mud to sandy sediments.
7	High diversity- polychaete deposit feeders	Dominated by deposit feeding polychaetes, but a range of other animals are found in low numbers. Often includes juvenile *Macomona*. Not found in coarser sediments.
8	High diversity- surface bioturbators	Dominated by small gastropods, amphipods and isopods, although polychaetes, amphipods and barnacles occur. Found in fine sand.
9	High diversity- tube dweller dominated	Dominated by tube dwellers, although high numbers of other large organisms including shrimps and predatory/scavenging polychaetes occur. Found in mud to sandy sediments.
10	Invasive	Dominated by the invasive bivalves *Musculista* or *Crassostera*, in densities up to 136 per core, moderate to low diversity of other organisms. Found in a range of sediment types.
11	Macomona	Dominated by large *Macomona*, found in mid to low intertidal mainly in fine sand. Moderate to high diversity, large numbers of deposit feeding polychaetes.
12	Polychaete- deposit feeders dominated	Moderate diversity, variable species but often including *Magelona*. Frequently found with burrowing organisms (crabs and/or shrimps). Found in a range of sediment types.
13	Polychaete- large predator dominated	Moderate to low diversity, variable species. Found in a range of sediment types (mud to sand).
14	Surface bioturbators	Low diversity, high to low intertidal, mainly small gastropods and amphipods. Found in a range of sediment types.
15	Tube dweller dominated	Moderate diversity, lower numbers of tube dwellers than in the high diversity group, co-occurring with low numbers of large organisms such as nemerteans and holothurians. Found in finer sediments (mud to fine sand).
	Oysters (Rocky)	Low diversity, variable cover of oysters with few chitons, limpets and gastropods. Found on rocky substrate
	Mussels (Rocky)	Low diversity, variable cover of mussels with few chitons, limpets and gastropods, some times overgrown by barnacles. Rocky substrate

5.2.1 Comparisons between habitat types.

Species data were analysed to determine whether the major intertidal habitat types (mud, sand, *Zostera*, mangroves) supported significantly different assemblages. As expected from the ecological communities, communities found in dense mangroves were different to those found in all but sparse mangrove areas. Mangrove communities were dominated by the mud crab (*Helice crassa*), with low numbers of Nereid polychaetes and, in the Oruawharo arm, the small bivalve *Arthritica bifurca*. However, although these mangrove communities were significantly different from those found in other habitat types (ANOSIM $p < 0.05$) they did not have a high within-habitat similarity (only 13%). Communities found in mud differed from those found in some of the other habitats (*Zostera*, rippled sand and all sediment types coarser than sandy mud) but were not significantly different from those living in the sparse mangrove habitat. The mud community was highly variable (low self similarity 5%); with the most similarity being driven by the presence of Nereidae and *Theora lubrica* (another invasive bivalve species) and reasonable abundances of the polychaete *Cossura consimilis*. As expected lower numbers of taxa were observed in the mangroves and muddy areas, than the sandier sediments with the lowest diversity found in the dense mangroves, similar to Ellis et al. (2004). No difference was observed between the communities observed in fine sand and those in coarser sediments, probably due to high variability of these communities. *Zostera* meadows did not support communities different to the bare sand habitats. This result is similar to that from studies in Manukau, Whangapoua and Wharekawa which found that *Zostera* beds in different locations of the same harbour are usually more different in community structure than they are to the bare sediment directly adjacent (Turner et al. 1999, Hewitt et al. 2003, van Houte-Howes et al. 2004).

5.2.2 Widespread taxa.

Fourteen taxa were found at more than 20% of sites and represented bivalves, polychaetes, Nemerteans and Cnidaria. The bivalves were those common elsewhere in the Auckland region (*Nucula hartvigiana* , *Macomona liliana* , *Hiatula siliqua* , *Austrovenus stutchburyi* , *Arthritica bifurca*) and are species monitored in the Tier 1 programme in the Manukau, Mahurangi and Waitemata harbours. They represent both deposit feeders and suspension feeders. The polychaetes represent large predators/scavengers (Nereidae, *Glycera* spp. and *Aglaophamus macroura*), tube builders (*Macroclymenella stewartensis*, *Boccardia* spp.) and deposit feeders (*Magelona* sp, *Heteromastus filiformis*, *Aquilaspio aucklandica* and *Aonides oxycephala*). All of these polychaetes, except Nereids, are monitored in at least one of the Tier 1 monitoring programmes.

5.2.3 Taxa preferences.

These fourteen taxa were analysed to determine species preferences (i.e., factors affecting their occurrence). Table 4 summarises this information. There were interesting differences between some areas of the harbour. In particular there were a number of otherwise widespread taxa not found in the Oruawharo arm or in Waionui Inlet. The majority of taxa demonstrated some relationship between occurrence and sediment particle size. For those taxa for which differences were observed between the Gibbs et al. (2004) report on preferences/aversion to sediment mud content (*Glycera*, *Boccardia*, *Heteromastus*, *Nucula* and *Arthritica*) any relationship with sediment particle size may be confounded by differences occuring between locations in the harbour (e.g., differences in recruitment potential), as all of these taxa exhibit strong spatial distributional patterns. A negative relationship between mud and number of species is frequently observed (Thrush et al. 2003b).

Figure 7: (Click for high resolution maps)

Interpolated plots of the distribution of total numbers of individuals, number of taxa and number of orders found in the cores taken from the intertidal sites.

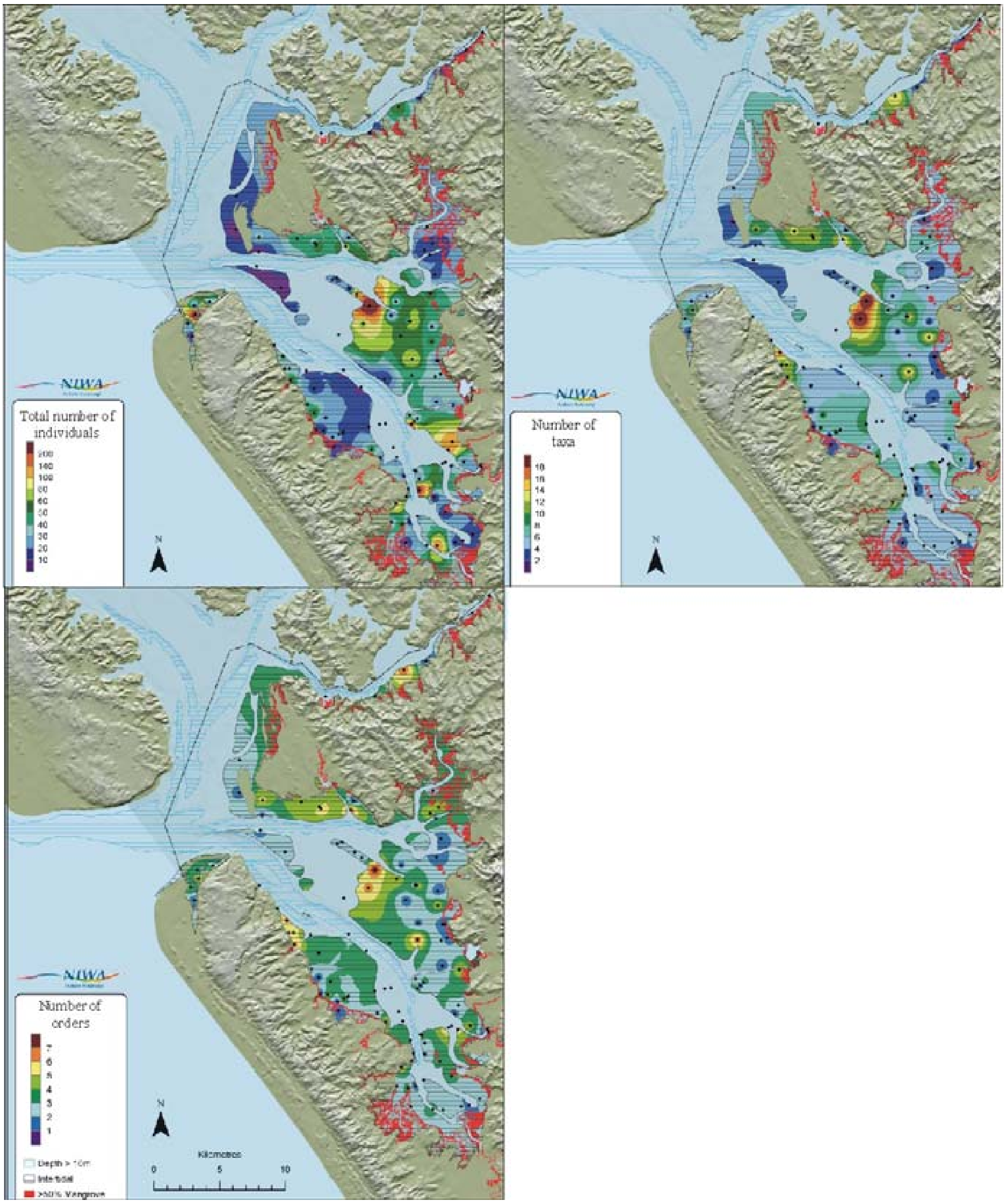


Table 4:

Locational and sediment preferences of widespread taxa found in the intertidal area of the Southern Kaipara. Sensitivity to mud reported by Gibbs et al, 2004 is given after the taxon name. SS, S = prefers sand, I = intermediate, MM,M = prefers mud.

Taxa		Location	Sediment
Arthritica	I	High in Oruawharo arm, none in Waionui Inlet	+ve relationship with mud
Austrovenus	S	No relationship	+ve relationship with medium sand
Hiatula		Primarily on west coast of the main harbour, not found in Oruawharo arm	No relationship
Macomona	S	None found in Waionui Inlet	+ve relationship with fine sand
Nucula	S	Avoids exposed areas, mainly found on eastern side of the Kaipara River arm	+ve relationship with mud and fine sand
Aglaophamus		Primarily in Kaipara River arm	-ve relationship with mud
Aonides	SS	Primarily in Kaipara River arm	+ve relationship with medium sand
Aquilaspio	I	Generally low, none in Waionui Inlet	+ve relationship with mud and medium sand
Boccardia	S	Primarily up Tauhoa arm and the Eastern side of the Kaipara River arm	No relationship
Glycera	I	Rarely found in Oruawharo arm	No relationship
Heteromastus	I	Primarily in Eastern side of Kaipara River arm	+ve relationship with fine sand
Macroclymenella	S,I	Primarily in centre of main harbour and Tauhoa arm, not found in Oruawharo arm	+ve relationship with fine sand
Magelona		Primarily on eastern side of the Kaipara River arm	-ve relationship with mud
Nereid	M	Frequent in Oruawharo arm and edge of the main channel	+ve relationship with mud
Total abundance		High in Waionui Inlet, low in Oruawharo arm	No relationship
Number of Taxa		Highest diversity never occurs in the upper arms	-ve relationship with mud
Number of Orders		No relationship	No relationship

5.2.4 Mesh size.

Some samples from each habitat type were analysed to determine the effect of sampling with a mesh size of 1mm, rather than 0.5 mm, as is done in the Tier 1 monitoring. At no sites was the overall number of taxa found affected by more than

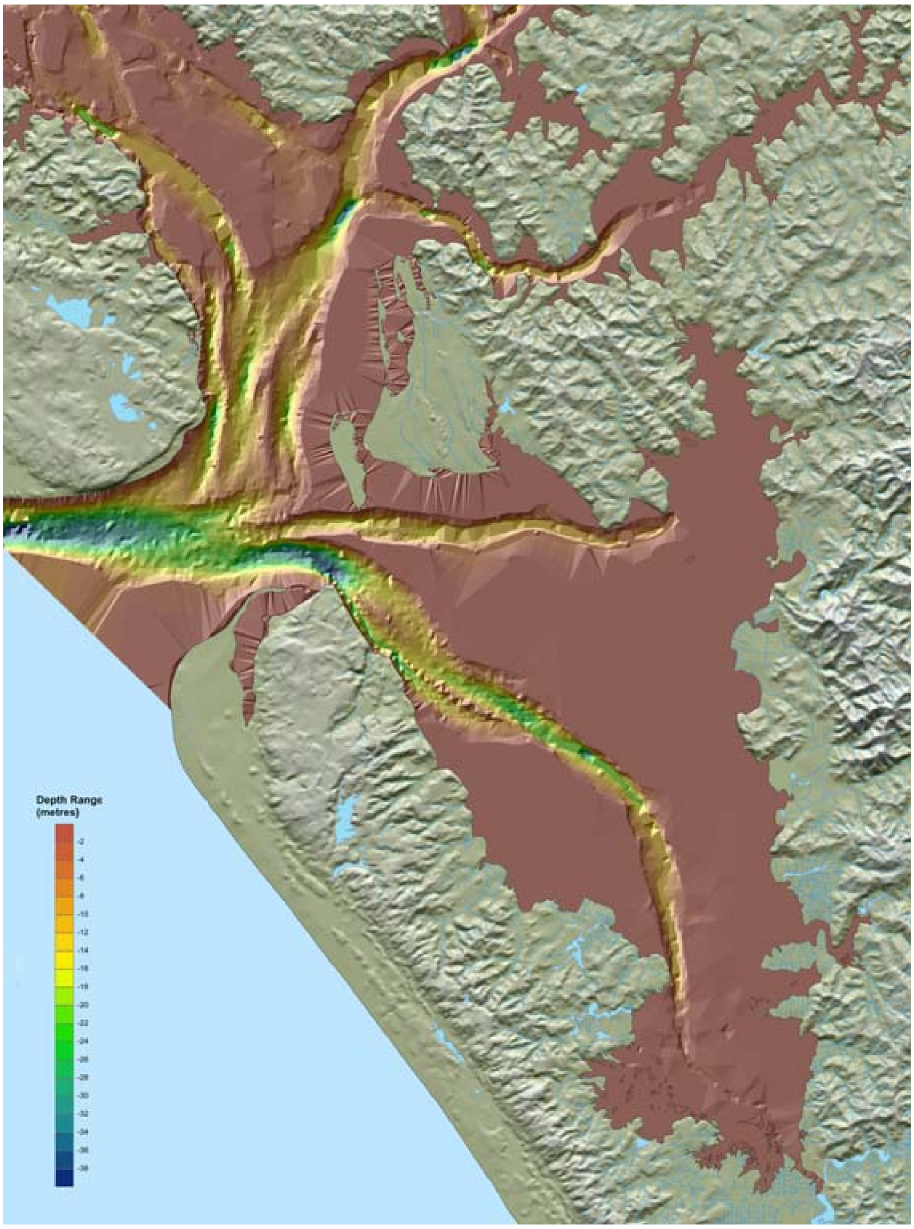
10%, i.e., the effect was within the 90% quality assurance standard. At some sites a large number of individuals were found in the 0.5 to 1mm fraction; mainly juvenile amphipods, bivalves, Nereids and *Heteromastus filiformis*. Thus, as hoped, using the 1mm mesh sieve removed the effect of recent settlements of juveniles, resulting in a data set that would be more robust for comparisons between one-off samples taken a long time apart. However, while the dataset gains in robustness to small-scale temporal variations (particularly for numbers of taxa), some smaller but numerically important taxa are missed. Taxa that were missed by the 1mm mesh sampling were, as expected, the family of small polychaetes, Exogoninae, and Oligochaetes. This should make us wary of making direct comparisons between this study of the southern Kaipara and other areas sampled by a 0.5 mm mesh, especially for mudflat and mangroves habitats because these generally have higher densities of smaller taxa. It does not preclude indirect comparisons as long as the effect of not sampling to the same degree is considered.

5.3 Subtidal large-scale features of the Southern Kaipara

The subtidal area of the Southern Kaipara comprises a number of different regions based on depth (Figure 8) and exposure to waves and currents. The harbour mouth has a deep wide channel (maximially 50 m depth), from which the seabed rises steeply to form shallow subtidal areas. The channels, banks and shoreline are very mobile as demonstrated by the beach erosion and accretion at Tapora Island. Two channels lead in to the main harbour, Tauhoa Channel and the Kaipara River channel. One channel leads north to the Oruawharo Arm. The Kaipara River channel is the deepest of the channels found in the harbour, being > 20 m in places. AMAs A,B and C are located in the deep area near the cliffs of South Head where current flow is fast. The Oruawharo and Tauhoa arm are shallower, although a couple of holes nearly 20 m deep are located in the Oruawharo Arm. The main shallow subtidal area is found at the confluence of the Tauhoa and Kaipara River channels, and is somewhat sheltered at low tide by a shoal to the northwest. Smaller shallow subtidal areas are found further up both the Tauhoa and Kaipara River channels. Shallow subtidal areas are smallest in the Oruawharo Arm.

Figure 8: (Click for high resolution map)

Depth distribution in the Southern Kaipara (uniform brown indicates intertidal or lack of depth information).



5.3.1 Side-scan images of seafloor types

A number of seafloor types were apparent from the side-scan data, based mainly on sediment characteristics. Many of the seafloor types were described in Hume et al. (2001), others are based on technical expertise (Hume pers obs). Sediment particle size characteristics were confirmed by the sediment sampling previously described.

1. In the exposed, deep channel area in front of the mouth, large sand waves (average 120 m wave length) were observed (Figure 9A). Megaripples of 1 –

5 m wavelength often were seen across the backs of the larger waves. Sediment type ranged from medium to fine sands.

2. Mega ripples (5 – 20 m wave length) were found in both the mouth and the three channel areas (Figure 9B). These ripples are generated by strong tidal currents and run transverse to the current direction. Sediment type ranged from medium to fine sands.

3. Smaller ripples, probably generated by waves were found in many places (Figure 9C). These may not be so long lasting as the previous two sand structures, being event driven. Sediment ranged from fine to coarse sands.

4. Areas of patchy sand ripples (Figure 9D) where tidally driven structures are broken down as the tide changes direction were also common. They were comprised of a range of sediment types from coarse to fine sands.

5. Shaded dark then light areas, indicating steep channel banks (Figure 9E).

6. Areas armoured in shell lag were found (Figure 9F), particularly in high flow areas around channels banks. Sediments ranged from mud to fine sands.

7. Rubble and rock blocks in a sand matrix were found around South Head (Figure 9G).

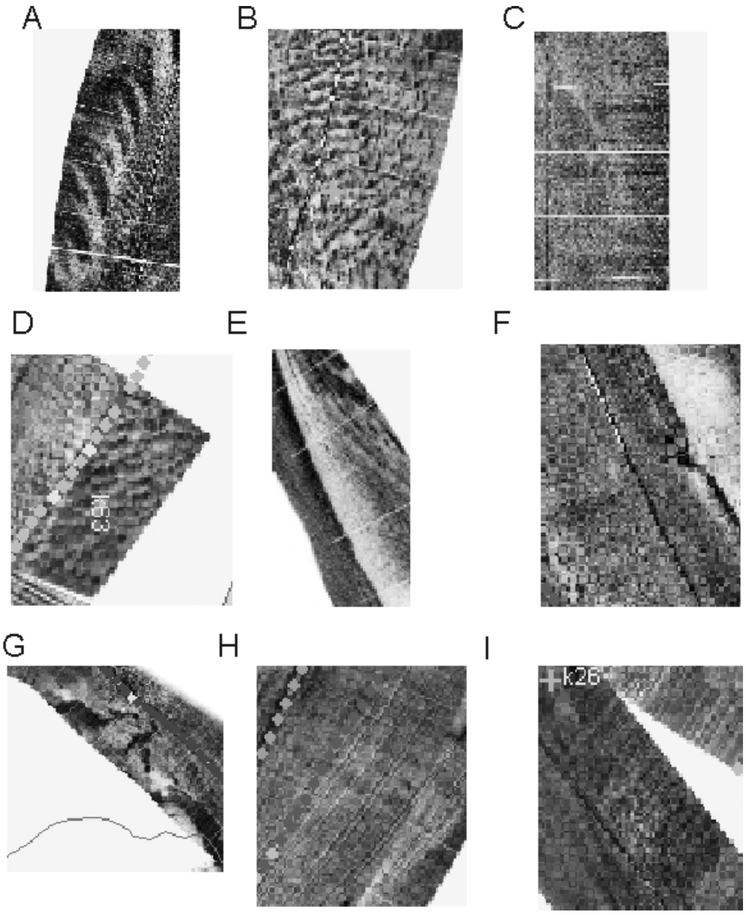
8. Relatively flat areas of mud or muddy sand (Figure 9H) were found in the upper arms, stretching further towards the mouth of the Oruawharo and Tauhoa arms, than the main harbour. Sediment ranged from muds to coarse sandy muds.

9. An area of smooth sand/mud with small sparse dark spots was found in the central harbour (see section 5.5).

10. Some areas of obvious artefacts (Figure 9I), and some that were possibly artefacts were found in some places (see section 5.5).

Figure 9:

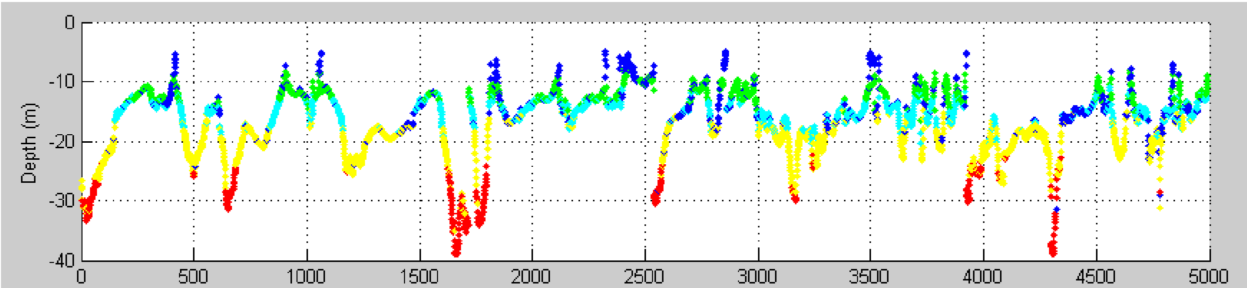
Examples of seafloor types revealed by side-scan data. (A) sand waves, (B) mega ripples, (C) smaller ripples, (D) broken ripples, (E) channel banks, (F) shell lag, (G) rubble, (H) flat mud or sand and (I) potential artefacts.



5.3.2 QTC seafloor types

From the seabed data logged by QTC View during this survey, 5 clusters of acoustic data were identified as the optimal number of classes, based on changes to the Total Score. The change in total score from 4 to 5 classes was < 5%. These clusters were strongly depth orientated (Figure 10).

Figure 10:
A strong relationship was observed between different QTC classes (represented by different colours) and depth.



5.3.3 Subtidal epibenthic habitats (based on dredge and video data).

The subtidal habitats of the Southern Kaipara fall into 5 main categories: the rocky cliff faces on the east side of South Head; areas of exposed rubble and rock in a sand matrix primarily again near South Head; areas with subtidal vegetation; areas dominated by sedentary epifauna; and primarily bare areas (Figure 11). Except for the rocky cliff and rubble areas, these main categories are dividable into a number of biogenic-habitats, dependent on the epifauna and flora (see Table 5).

The rocky cliff faces together with the rubble/rock/sand matrix found around the foot of the cliffs contained the most diverse epibenthic communities observed in the Southern Kaipara. The slopes of the cliff walls along South head vary from gently sloping to near vertical. In some areas, overhangs and small platforms are apparent. Near the bottom, substrate varied between rubble, shell in a sand matrix to hard packed shell lag. Fauna and flora changed in type, density, size and distribution with depth, substrate and slope, but was dominated by encrusting epifauna. No large algae were observed; small algae and *Zostera* were infrequently observed. Low to medium sloping areas of sand or shell generally had small sponges, starfish and gastropods. Larger sponges, mussels, barnacles and other encrusting species increased in density and size with larger, more complex relief. Vertical walls and overhangs displayed complex communities with high densities and diversity of sponges, ascidians, turfing bryozoans and other encrusting species. Shallow sandy areas observed near the tops of some slopes were generally bare except for occasional starfish or gastropods.

Figure 11: (Click for high resolution map)

Distribution of subtidal epibenthic habitats found in the Southern Kaipara.

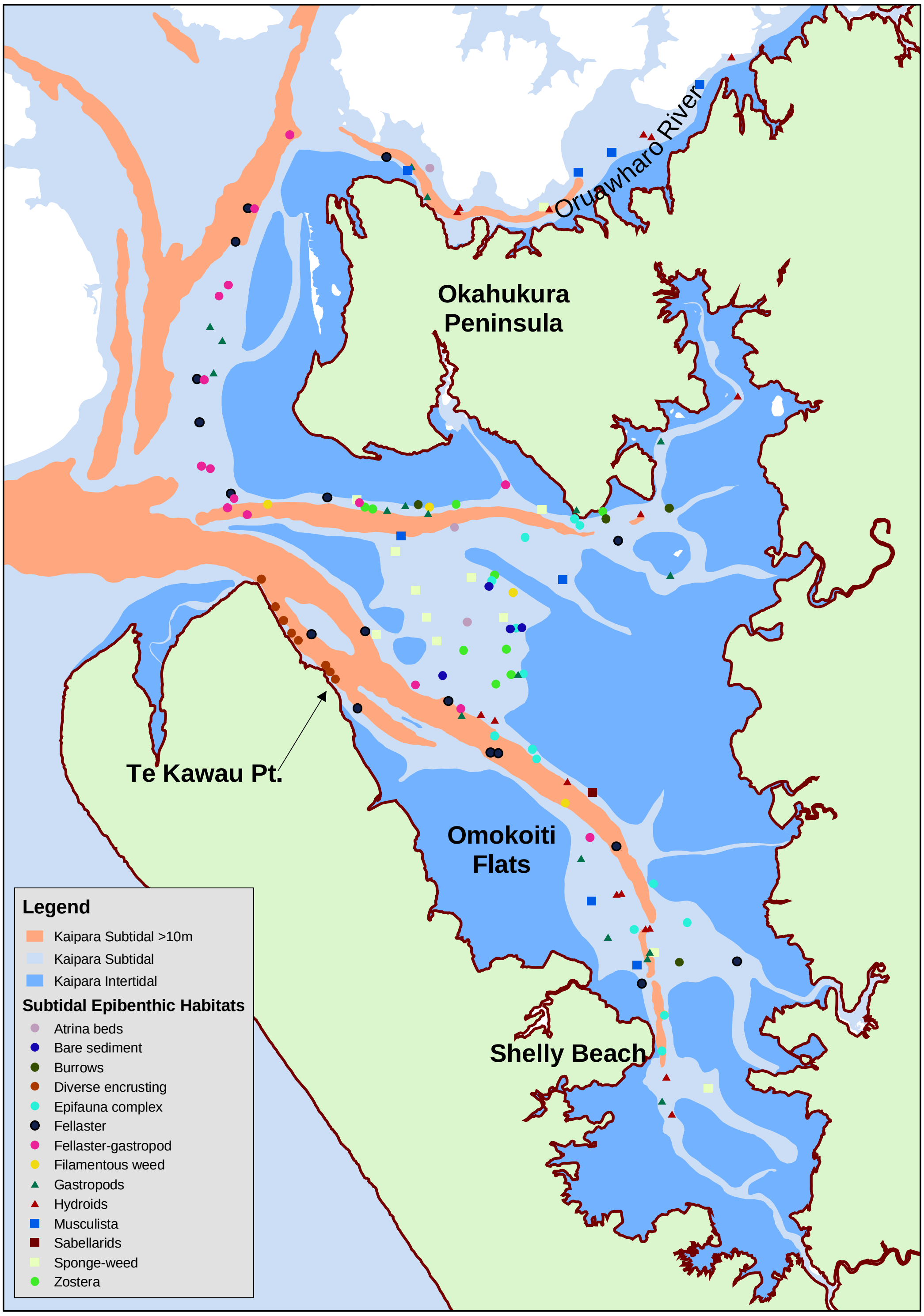
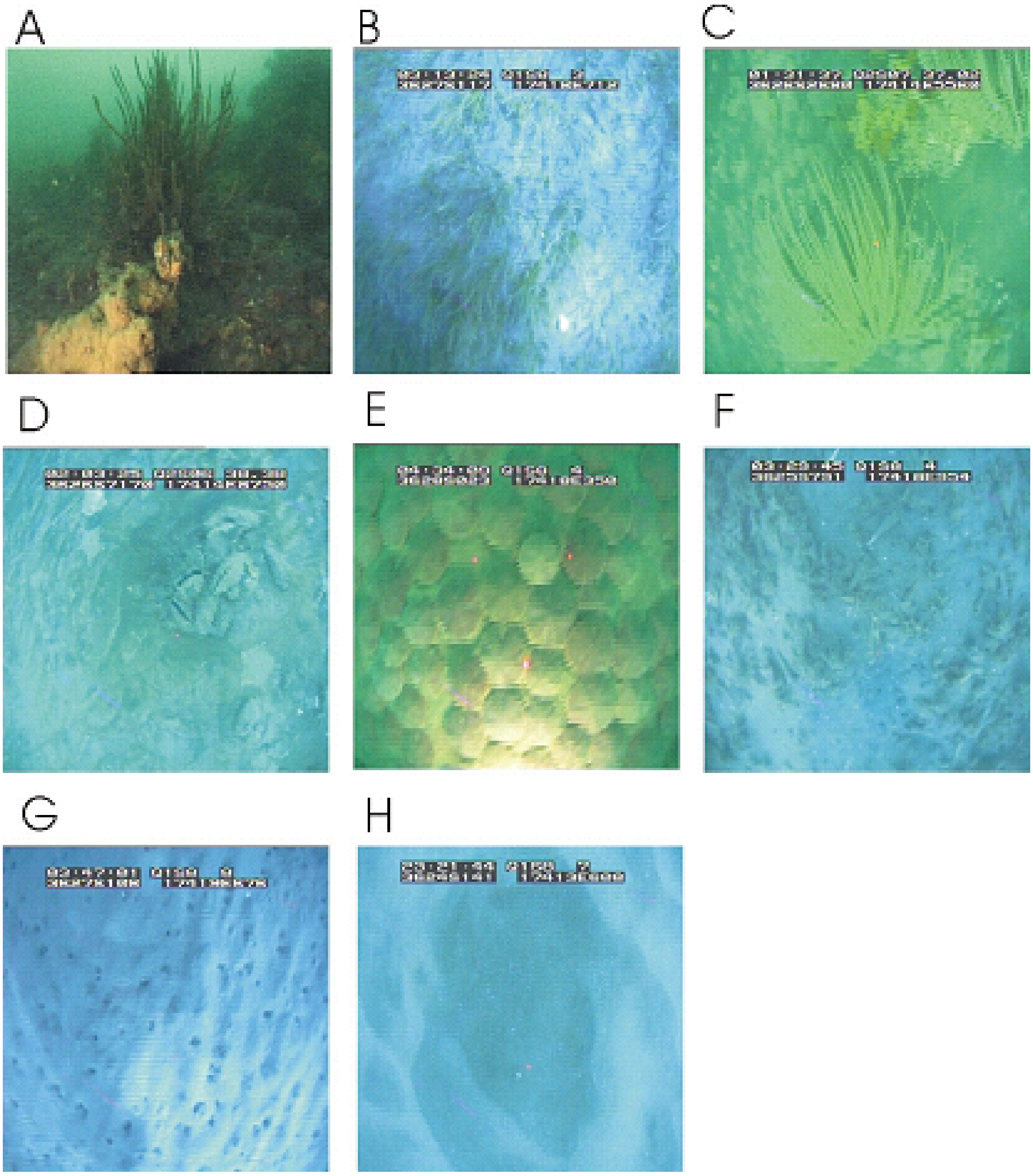


Table 5:

Subtidal epibenthic habitats of the Southern Kaipara obtained from video and dredge sampling. Figure 12 shows examples of some of these.

1. Highly diverse encrusting community	Patches of rock and rubble in a sand matrix to vertical cliff faces. Dominated by encrusting fauna, (e.g., green lipped mussels, barnacles, anemones, sponges) and coralline algae.
2. Filamentous weed	A mixture of small filamentous seaweed, gastropods and, sometimes, sand dollars (*Fellaster zelandiae*). Figure 12A.
3. *Zostera*	Subtidal *Zostera*, often patchy, with burrows, gastropods and sometimes anemones. Found in a relatively small area in the central main harbour near AMA D and E and in small patches in AMA B. Figure 12B.
4. Sponge-weed	Sponges (four genera) with filamentous seaweed or turfing algae, sometimes with gastropods and occasionally dead *Atrina*. Found in sandy areas. Figure 12C.
5. Hydroids	Dominated by hydroids, sometimes with clumps of large gastropods. Widespread, except in exposed sites near entrance.
6. Epifauna complex	Sponges with either hydroids, bryozoans or anemones. Found in sandy areas.
7. *Atrina* beds	Some medium density *Atrina zelandica* (horse mussel) beds, with or without sponges. Infrequently occurring. Figure 12D.
8. Fellaster	Areas of adult *Fellaster*, frequently forming a dense carpet. Often found in more exposed sandy areas. Figure 12E.
9. *Fellaster*- gastropod	A mix of patchy *Fellaster* and gastropods (often *Maoriocolpus roseus* or *Amalda australis*). Widespread.
10. Gastropods	Gastropods, sometimes with hermit crabs, and burrowing crabs, or starfish. Widespread. Figure 12F.
11. Burrows	Areas of relatively flat soft sediment, dominated by burrows, found up the arms of the harbour. Figure 12G.
12. Musculista	Dominated by mounds of *Musculista* , sometimes with gastropods, *Fellaster* or burrowing crabs. This habitat is mainly found in the Oruawharo arm, though there are a few scattered areas in the other two arms of the harbour.
13. Bare sediment	Areas of bare sediment with little bioturbation or epifauna. Figure 12H.
14. Sabellarids	An area of Sabellaridae tube mat was found in one location.

Figure 12:
Underwater photographs taken of the different epibenthic habitats. Some habitats were unable to be photographed due to poor visibility. A, filamentous weed. B, *Zostera*. C. sponge. D, *Atrina*. E, *Fellaster*. F, gastropods. G, burrows. H, mostly bare sediment.



5.4 Subtidal communities of the Southern Kaipara

A number of diverse ecological communities were defined from the grab sampling of the subtidal areas of the Southern Kaipara (Table 6, Figure 13). Frequently these reflect the habitats derived from the video/dredge samples, being dominated by sedentary epifauna (*Atrina*, Sponges, Nudibranchs, Hydroids and Bryozoans), filamentous weed, tube dwellers and large surface disturbing animals (*Fellaster*, Gastropods). All communities were more than 80% dissimilar; most were greater than 93% dissimilar. The different types of polychaete communities tended to be the ones that were less distinct. Interestingly, although deposit-feeding polychaetes were frequently common, there were few areas with communities dominated by them.

Figure 13: (Click for high resolution map)

Distribution of ecologically significant subtidal communities found in the Southern Kaipara.

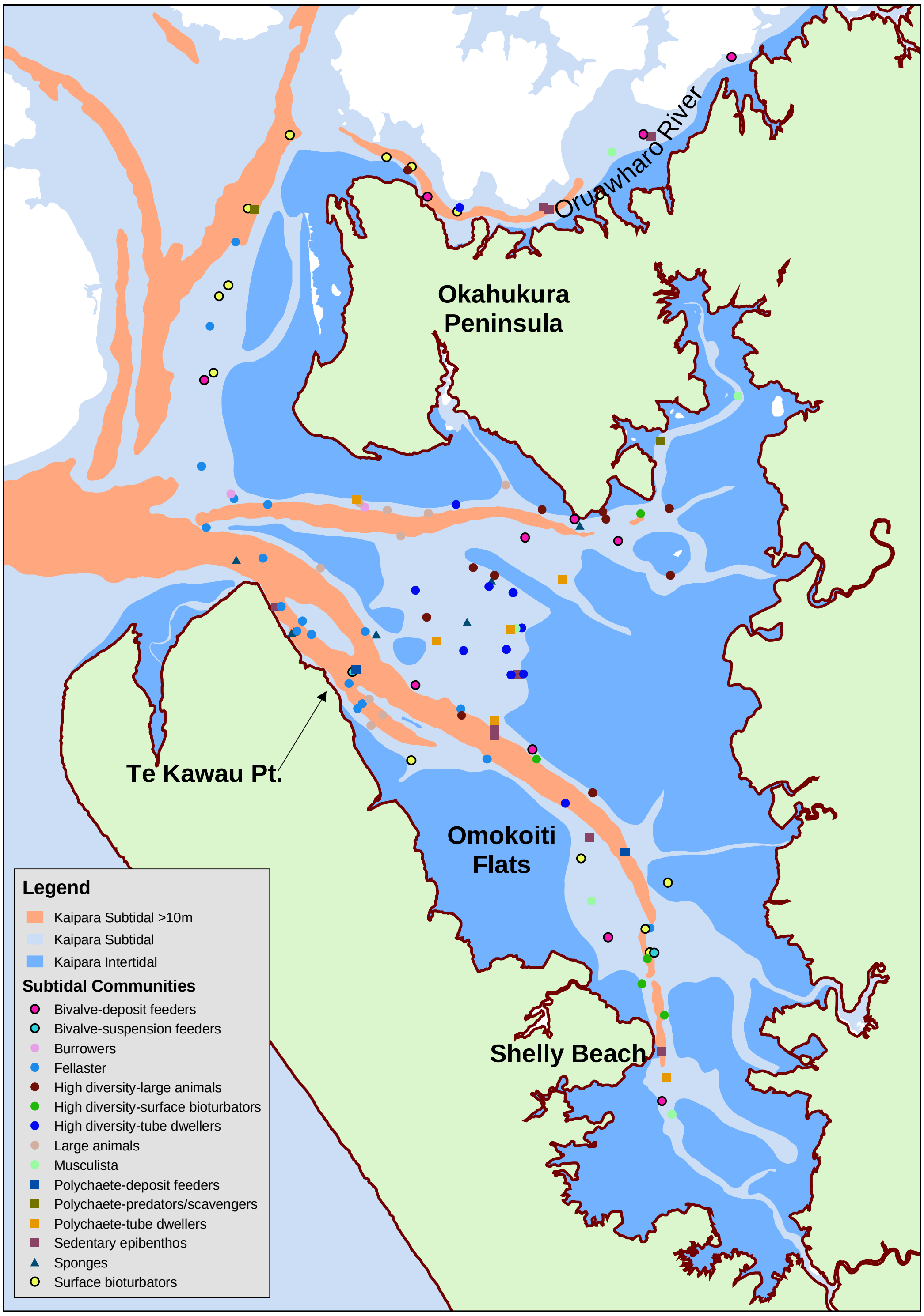


Table 6:

Ecologically important subtidal communities found in the Southern Kaipara using the hierarchical rules given in Box 2.

1. Sedentary epibenthos	Generally high taxon richness, though some lower diversity areas observed, found in fine to medium sands.
2. Sponges	Sponge communities were found mainly in the central area of the main harbour in medium to fine sands. Small filamentous seaweed clumps were often present and encrusting bryozoans were found on shell debris.
3. Fellaster	Dominated by *Fellaster*, generally of low diversity. This community was found in a range of sediments but not at the extremes of muds or coarse sediments. Higher densities were found at deeper sites.
4. Surface bioturbators	A highly variable community, representing a mix of small gastropods, hermit crabs and ophuroids and amphipods
5. High diversity- tube dwellers	A high diversity community of tube dwellers (*Macroclymenella*, *Owenia*, Phoronids and *Euchone*) with Nemerteans, a bivalve (*Myadora*) and an anemone. Found in predominantly fine sands at < 3m depth
6. High diversity- large animals	Dominated by the gastropod *Maoriocolpus* with moderate densities of the gastropod *Zegalerus tenuis* and low densities of *Paguristes* (hermit crab) and *Nucula*. Found predominantly in fine sands
7. High diversity- surface bioturbators	Low densities of *Zegalerus*, and *Maoriocolpus* found in conjunction with Corophid amphipods, found in sandy mud to coarse sediments in all but > 15 m depth
8. Bivalve- suspension feeders	Dominated by *Myadora*, found in sandy mud to fine sediments.
9. Bivalve- deposit feeders	Bivalve dominated with large numbers of *Nucula* and smaller numbers of other deposit feeding bivalves. Found in finer sediments from muds to sandy muds.
10. Burrowers	Primarily dominated by the shrimp (*Pontophilus australis*) and occurring in sandy to medium sand.
11. Large animals	A community of low density *Fellaster*, with Holothurians, and large swimming crabs (*Ovalipes carthaus*, *Nectocarcinus benetti*). Found in sandy muds to medium sands.
12. Musculista	Dominated by *Musculista* , found in mud to fine sand.
13. Polychaete- predators/scavengers	Dominated by the predatory/scavenging polychaetes *Glycera*, Siglionidae and *Lumbrineris*, found in mud to fine sands
14. Polychaete- tube dwellers	A lower diversity community of tube dwellers (*Macroclymenella*, *Owenia*, Phoronids and *Euchone*) found over a wide range of sediment types at shallow depths.
15. Polychaete- deposit feeders	An infrequently found community, very variable in species composition.

5.4.1 Comparisons between habitat types

Species data were analysed to determine whether the major habitat types (as defined by the video/dredge sampling) supported significantly different assemblages. Not surprisingly results varied. Epibenthic habitats comprised of *Fellaster* were most distinctly different to the other habitats; they were of low diversity, frequently comprising nothing but *Fellaster*. The Epifauna complex, Sponge and Hydroid habitats also supported communities that were different from other habitats, though not from each other. Similar to the intertidal results, the *Zostera* habitat did not support a distinct community.

The ecological communities derived from the grab data correlated well with the epibenthic habitats for dense Fellaster, Fellaster/gastropod, Gastropod areas. Areas with sparse Fellaster or gastropods were more likely to be allocated to other ecological community types. Some differences were observed for epibenthos that were highly clumped (Sponge, Epifaunal complex, Hydroids) as the epibenthic habitats were based on observations of larger-scale data and therefore integrated over highly clumped data, whereas the grab data would often miss these.

Some differences between communities in different sediment type and at different depths were found. Communities found in the mud, sandy mud and fine sand sediment type differed from each other and from those found in all other sediment types ($p < 0.05$). Communities found at < 3 m deep were dissimilar to those at all other depths. However, similar to the intertidal results, the communities found with in these sediment types and depth strata were highly variable (self similarity < 10%).

5.4.2 Widespread taxa

Seventeen taxa were found at more than 20% of subtidal sites and represented a more diverse array of taxonomic orders than were found in the intertidal areas (bivalves, polychaetes, gastropods, echinoderms, holothurians, decapods, phoronids, nemerteans, ophiuroids and cnidaria). There were four widespread bivalves (*Nucula* spp., *Musculista*, *Myadora* spp. and *Felaniella zelandica*) representing both deposit feeders and suspension feeders. Unlike the intertidal area, the widespread polychaetes were mainly tube builders (*Macroclymenella stewartensis*, *Owenia* sp., *Euchone* sp.) with only one large predator (*Aglaophamus* sp.). Two decapods, the common shrimp *Pontophilus australis* and the hermit crab *Paguristes setuous* were wide spread, as were bryozoans (erect and encrusting) and cnidaria (four genera), but each of the other orders were represented by one species.

5.4.3 Taxa preferences

The seventeen widespread taxa were analysed to determine species ranges in a similar way to the intertidal taxa (see Table 7). For taxa occurring in both intertidal and subtidal areas similar responses to location and sediment were observed. Generally more species preferred the shallow subtidal area of the central main harbour (Figure 14). Interestingly, the difference between taxa found in the Oruawharo arm and elsewhere was not as marked with subtidal taxa as it was with the intertidal taxa. Relationships between taxa and sediment particle size were more common than for the intertidal taxa. Only three taxa did not show some relationship with sediment particle size. *Pontophilus* and *Paguristes* generally exhibit a wide tolerance to particle size and the Phoronid exhibited a close association with the presence of other tube dwellers.

Figure 14 : (Click for high resolution map)

Interpolated plots of the distribution of total numbers of individuals, number of taxa and number of orders found in the grabs taken from the subtidal sites.

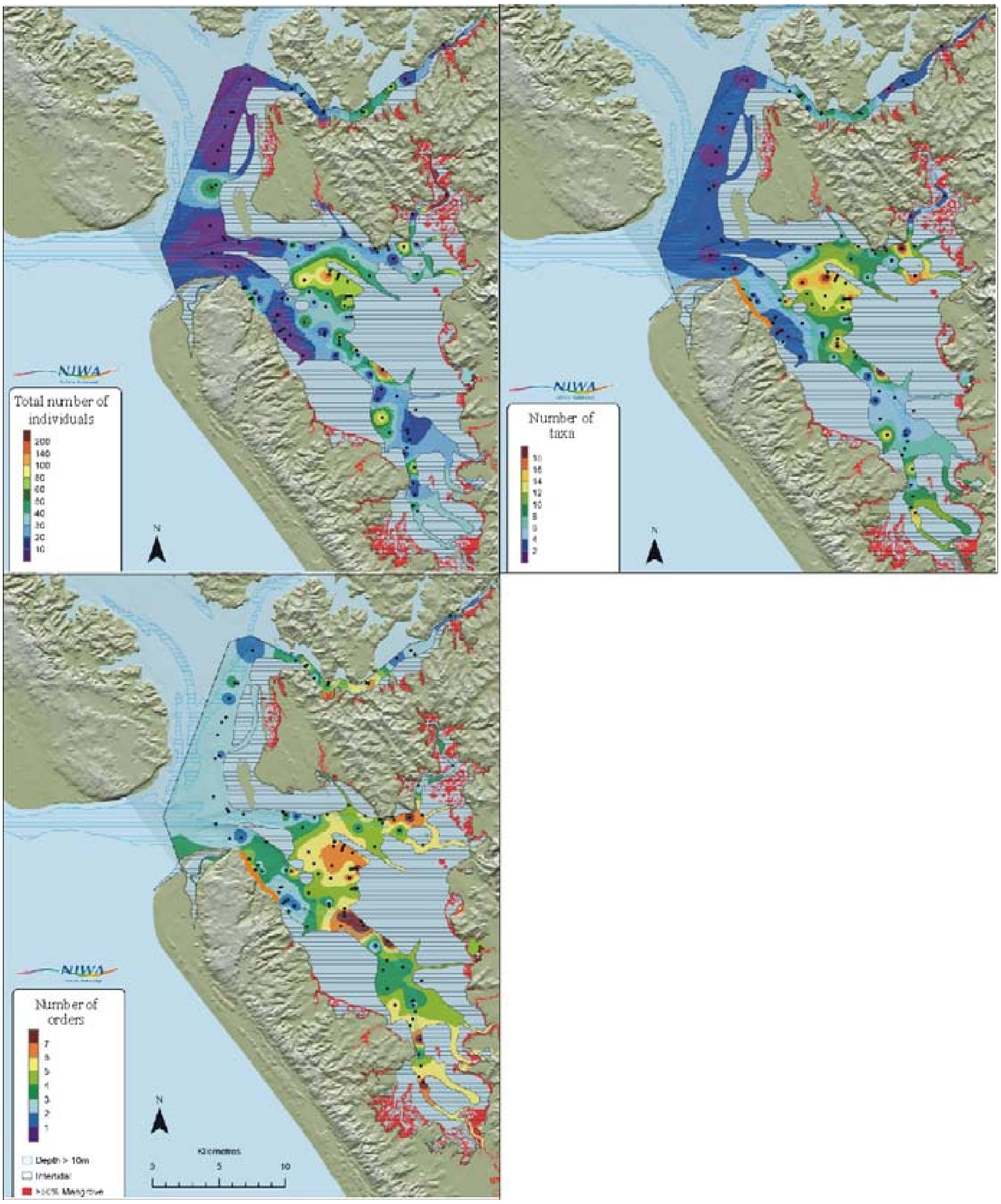


Table 7:

Location and sediment preferences of widespread taxa found in the subtidal area of the Southern Kaipara. Sensitivity to mud reported by Gibbs et al, 2004 is given after the taxon name (wherever possible). SS, S = prefers sand, I = intermediate, MM,M = prefers mud.

Taxa		Location	Sediment	Depth
Felaniella		Mainly in shallow central area of main harbour	+ve relationship with fine sediment	Highest in shallow subtidal
Musculista	S	Higher in shallow, sheltered areas	-ve relationship with medium sediment	No relationship
Myadora		Mainly in shallow central area of main harbour and Tauhoa arm	+ve relationship with fine sand and -ve relationship with medium sand	Highest in shallow subtidal
Nucula	S	Mainly in shallow areas and upper arms	+ve relationship with mud and fine sand	No relationship
Aglaophamus		Primarily in the centre of the main harbour	+ve relationship with mud and fine sand	No relationship
Euchone		Very localised around the shallow central area of main harbour	-ve relationship with medium sediment	Highest in shallow subtidal
Macroclymenella	S	Not in the Oruawharo arm or in exposed areas	+ve relationship with fine sand and -ve relationship with medium sand	Highest in shallow subtidal
Owenia		Mainly in shallow central area of main harbour	-ve relationship with medium sediment	No relationship
Anemones		Mainly in shallow central area of main harbour	No relationship	No relationship
Fellaster	S	Not in the Oruawharo arm	+ve relationship with medium sand	Highest in deeper water, particularly >15 m
Amphiura rosea		Not found in exposed areas or upper arms	+ve relationship with fine sediment and mud	No relationship
Bryozoans		Mainly near AMA B and C	-ve relationship with fine sediment and mud	Highest in deeper water, particularly >15 m
Phoronid		Mainly in shallow central area of main harbour	-ve relationship with medium sand	No relationship

Table 7 continued:

Taxa	Location	Sediment	Depth
Pontophilus	Mainly in upper arms	No relationship	No relationship
Paguristes	Highest in deep exposed areas	No relationship	Highest in > 15 deep water
Total abundance	No relationship	No relationship	No relationship
Number of taxa	Highest in shallow subtidal in main harbour	+ve relationship with mud and fine sand	Highest in shallow subtidal
Number of orders	Highest in shallow subtidal in main harbour	+ve relationship with mud and fine sand	No relationship
Number of large animals	Highest in shallow subtidal in main harbour	No relationship	Highest to 7m
Number of sedentary epifauna	No relationship	No relationship	No relationship

5.5 Integrating communities, sediments and large-scale features

5.5.1 Communities and acoustic sampling

Subtidal sampling by video, dredge and/or grab had been taken in each of the seafloor types identified by side-scan. Comparison between the descriptions derived from the video/dredge samples and the seafloor types revealed that while the physical description matched (e.g., sand waves, rubble, flat mud or ripples), in most cases the epibenthic habitats were variable (Table 8).