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Review of Environmental Information on the Kaipara Harbour Marine Environment

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Prepared for

Auckland Regional Council by ASR Ltd and Coastal and Aquatic Systems Ltd.

This report is one of a series funded by Auckland Regional Council but part of a joint Auckland Regional Council/Northland Regional Council evaluation of the Kaipara Harbour, its environmental values, management issues and options.

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Executive Summary

The Kaipara Harbour is one of the largest estuaries in the world, and is thought to be the largest estuary in the Southern Hemisphere. It is recognised as an area of international importance for coastal birds, has a high diversity of marine organisms, and contains ecologically significant marine communities that provide a wide variety of functions and services. Due to the abundance of natural resources within and around the Kaipara (e.g. timber, seafood, and sand), the harbour has been utilised extensively for more than 150 years.

Regulatory authorities are concerned that the quality of the harbour may be decreasing due to human activities in both the harbour and the surrounding catchments. The impacts of these activities could be exacerbated by a number of new, large-scale developments that have been proposed. Successful mitigation of the subsequent environmental impacts is hampered by the lack of a comprehensive management strategy, which would consider the cumulative effects of all the activities and integrate the functions of the key management agencies.

This report summarises the environmental information that is available for the Kaipara Harbour coastal environment, with a primary focus on the coastal marine area. The aims of the study were: to determine the current environmental state of the harbour, assess threats to the harbour, identify knowledge gaps, and examine synergies and gaps in existing environmental monitoring programmes. The report also reviews the effects of activities managed under different statutes and considers the relative influence of various pressures on the environmental values and sustainability of the harbour. It also identifies resource management issues that potentially affect fisheries, conservation management, and/or biosecurity in the harbour; and discusses environmental issues that cross planning boundaries.

The marine components evaluated were: the physical environment (water quality and physical oceanography), intertidal and subtidal benthic habitats and communities, fish and fisheries, coastal birds, and coastal vegetation. Data were obtained from a range of sources, and varied widely in terms of currency and detail.

Current state of the Kaipara Harbour marine environment: The evaluation confirmed that the Kaipara contains many high value species, communities and habitats and that the environmental values of the Kaipara have been, and are continuing to be, degraded. It also highlighted a lack of core environmental information for the majority of the key marine components that were evaluated. More information is available for the southern Kaipara than for the northern Kaipara; in particular, the Tier II Ecological State of the Environment (SoE) monitoring survey undertaken by the ARC, which provides maps showing the distribution and abundance of intertidal and subtidal benthic habitats and communities throughout much of the southern harbour.

Current studies: Environmental studies presently being carried out within the Kaipara include: assessments of benthic communities and invasive species at discrete locations throughout the harbour, the role of seagrass (*Zostera capricorni*) in primary production and in supporting secondary (animal) production, fish habitat utilisation throughout the harbour, and marine mammal use of the harbour (particularly Maui's dolphin). In addition, the Ministry of Fisheries is investigating options for assessing scallop numbers in the harbour, following a ban on harvesting that was initiated in July 2005. Findings from these studies will add significantly to understanding the harbour.

Monitoring: Time series monitoring is undertaken in the Kaipara Harbour for SoE assessments of general water quality (including bulk water quality, bathing water quality and shellfish monitoring), fisheries assessments, and as a condition of resource consents. Currently, water quality monitoring within the Kaipara Harbour is characterised by a lack of spatial coverage in the southern Kaipara and a lack of temporal detail in the northern Kaipara. The limited data that is available indicates that water quality is relatively poor in many areas, but the overall lack of coverage and detail makes it difficult to assess whether broad environmental changes have occurred. The resource consent monitoring studies currently being undertaken for sand mining and discharges provide data relevant to those specific activities but do not capture any cumulative impacts and are not very useful for assessing the overall environmental quality of the harbour. Therefore, although the resource consent monitoring studies are related to specific activities, they could have wider relevance if the monitoring was standardised as far as practicable. Modifications to the existing monitoring studies, and synergies amongst them, are identified.

Threats: Many activities threaten the environmental values of the Kaipara coastal marine area. Key issues include: landuse activities which generate sediment and other contaminants, fishing, sand extraction, tidal energy generation, aquaculture, and the spread of invasive species (marine and terrestrial). Attempts were made to assess the scale of influence that these activities have had on the Kaipara Harbour, although this was seriously hampered by a lack of detailed information on many of the activities. Activities managed under the Resource Management Act (1991), Fisheries Act (1996), and Biosecurity Act (1993) all appear to be affecting the environmental quality and values of the harbour in multiple ways. The impacts of existing landuse activities are evident in many parts of the harbour (e.g. high turbidity and sedimentation, and elevated levels of wastewater contaminants) and are likely to increase in scale and intensity if not managed appropriately. Recent reviews also indicate that the grey mullet, school shark, rig, and scallop fisheries all have sustainability issues within the Kaipara. Problems with biosecurity resulting in the spread of invasive species are also apparent. The potential impacts of activities such as sand mining, aquaculture and tidal power generation are poorly understood but, potentially, magnify the cumulative or indirect impacts of other activities. All of the above threats, both individually (e.g. landuse) or when combined (e.g. sand mining and tidal energy extraction together impacting on the flood tidal delta) have the potential to cause large-scale cumulative impacts that cross planning boundaries.

Integrated management and knowledge gaps: The general lack of environmental information about the Kaipara coastal environment is a genuine barrier to the integrated management of the Kaipara Harbour. The following information gaps were identified:

- Lack of an integrated, harbour-wide, water quality monitoring programme.
- Detailed information on long-term plans for catchment development and the sediment-related effects on the harbour.
- Ecological maps for the northern Kaipara (similar to those produced by Tier II monitoring of the Southern Kaipara).
- Utilisation of Kaipara Harbour by Maui's dolphins.
- Biosecurity risks of consented activities; particularly construction and aquaculture.
- Aquaculture carrying-capacity of the harbour.
- Extent and nature of fishery interactions between the West Coast and the Kaipara Harbour.
- Uncertainty about the volume of sand being deposited in the Tapora area, relative to the amount being extracted.
- The effects of sand extraction on the sediment transport processes operating in the entrance of the Kaipara Harbour.
- The cumulative impacts of Resource Management Act activities; both individually and in combination with fishing and biosecurity threats.
- The effects of large-scale energy generation from tidal power.
- Lack of knowledge regarding areas that require protection because of their importance to a range of species (birds, fish, critical habitat).

Future studies: An investigation into the benthic marine habitats and communities of the northern Kaipara Harbour, similar to the Tier II SoE monitoring programme already performed for the southern Kaipara, is a priority. Amalgamation of data from both studies would provide an overview of the whole harbour, which would benefit a variety of end-users and help to guide resource management decisions.

Integration and expansion of the existing water quality monitoring carried out in the northern and southern areas of the Kaipara, instigation of short-to-medium term Tier I SoE monitoring in selected locations, development of standardised methods for resource consent monitoring, and assessment of the long-term, cumulative impacts of various landuse scenarios on the entire harbour (in order to guide policy and plan provisions) would help to fill critical knowledge gaps. This improved knowledge would aid the development of a comprehensive management strategy which, in turn, will ensure the sustainability of the harbour.

1 Introduction

The Kaipara Harbour is the largest harbour and estuary complex in New Zealand. It is nationally significant for its intrinsic and amenity value, natural and physical resources, and cultural and historical importance. It occupies a total area of 94,700 ha, including 40,900 ha of intertidal mudflats and sandflats, and has a coastline estimated to be around 900 km long (Heath 1975, Fahy et al. 1990). A number of local and national government organisations share responsibility for the management of the harbour, its catchments, and resources.

Despite its size, the harbour has not been studied in great detail when compared to adjacent large harbours in the Auckland Region such as the Manukau or Waitemata. This is possibly due to its size, its distance from major population centres, and its dangerous bar which extends ~7 km out to sea. In comparison, the entrances to the Manukau and Waitemata Harbours, which provide access to Auckland's ports, are more navigable.

The limited number of environmental studies carried out within and around the Kaipara have made it clear that the harbour is extremely important for a range of birds, mammals, and fish; and that it contains many important and comparatively rare ecological communities, particularly in southern areas (Hewitt and Funnell 2005). It has recently been suggested that ~80% of the West Coast snapper emanates from within the Kaipara (FRST 2003).

Due to the abundance of natural resources (timber, seafood, and sand) within and around the Kaipara, the harbour has been utilised extensively for more than 150 years. Consequently, a variety of sustainability issues have developed over this time. Communities in the Auckland and Northland regions have a range of concerns over the impacts of human activities on the harbour, including their cumulative effect. These concerns include: the effects of extractive process such as fishing, sand mining, tidal energy, and aquaculture; the destruction or modification of habitats due to reclamation; and landuse activities that generate sediment and other contaminants.

Community concern has recently been heightened by an increase in resource consent applications for activities within the harbour, intensified catchment development, and a growing awareness of the causes and effects of sediment and other contaminants. For example, in the Auckland Region within the past five years, the ARC has received applications for:

- Large-scale sand extraction (several applications, some of which have been granted).
- A 30 Ha mussel farm and a 104 Ha oyster farm.
- Components of a tidal power generation 'farm', subsequently lodged with Northland Regional Council.

In addition:

- The Auckland Regional Growth Strategy has advocated the expansion of several rural centres draining into the Kaipara.
- Private plan changes have been proposed for urban expansion in the Waimauku catchment which drains into the Kaipara.
- Small-scale residential developments have occurred in a number of rural settlements such as Shelly Beach.
- Rural subdivision and associated development has increased in the Kaipara catchment.
- Plans for a gas-fired power station on the banks of the Kaukapakapa River have been scoped.

Project aims and scope

The ARC required a predominantly desktop study to collect available environmental information on the Kaipara Harbour, with the following objectives:

- Collate and summarise environmental information on the whole Kaipara Harbour and coastal environment, and assess what is known about the current environmental state of the harbour and its coastal environment.
- Identify any significant environmental studies proposed or currently being carried out by key agencies.
- Determine what monitoring is carried out in the Kaipara Harbour and assess whether it is sufficient to assess broad changes in the environmental quality of the harbour. This includes monitoring carried out by local and regional councils, government departments, and resource consent holders.
- Identify the potential for synergies between independent programmes being carried out by various parties.
- Identity issues which potentially threaten the environmental values of the harbour and provide (at least) a qualitative assessment of their scale of influence and likely impacts on environmental values.

A primary interest of the ARC was to understand the cumulative effects of activities managed under the Resource Management Act that may be leading to a deterioration in the quality of the harbour. However, the effects of other non-Resource Management Act activities also required consideration in order to:

- Provide a broader context to the study by assessing the relative influence of various pressures on the environmental values and sustainability of the harbour (e.g. the relative influence of activities managed under the Resource Management Act compared with those managed under the Fisheries Act).

- Identify resource management issues that potentially affect fisheries, conservation management, or biosecurity.
- Identify environmental issues that cross planning boundaries and assess their significance to the overall harbour quality.
- Identify knowledge gaps that are critical barriers to integrated management associated with the above issues, and make recommendations on what information is required to fill those gaps.

The review is concerned solely with the coastal environment and focussed primarily on the factors that affect the quality or values of the coastal marine area. For the purposes of this review, the coastal environment is considered to include three interrelated parts. These are the:

- coastal marine area,
- active coastal zone,
- landward component.

2 Methodology

A range of environmental information exists for the Kaipara Harbour coastal marine area, although much of this information is diffuse 'grey literature' ranging from unpublished data through to technical reports and a few published peer-reviewed articles. This review attempts to bring together this existing information.

A comprehensive literature review and interviews with government departments were undertaken. Some of the information used included the ARC, NRC, and university libraries and databases; and the Department of Conservation, Ministry of Fisheries, Forest and Bird, and Guardians of the Kaipara libraries. Environmental information collected for this study consisted of:

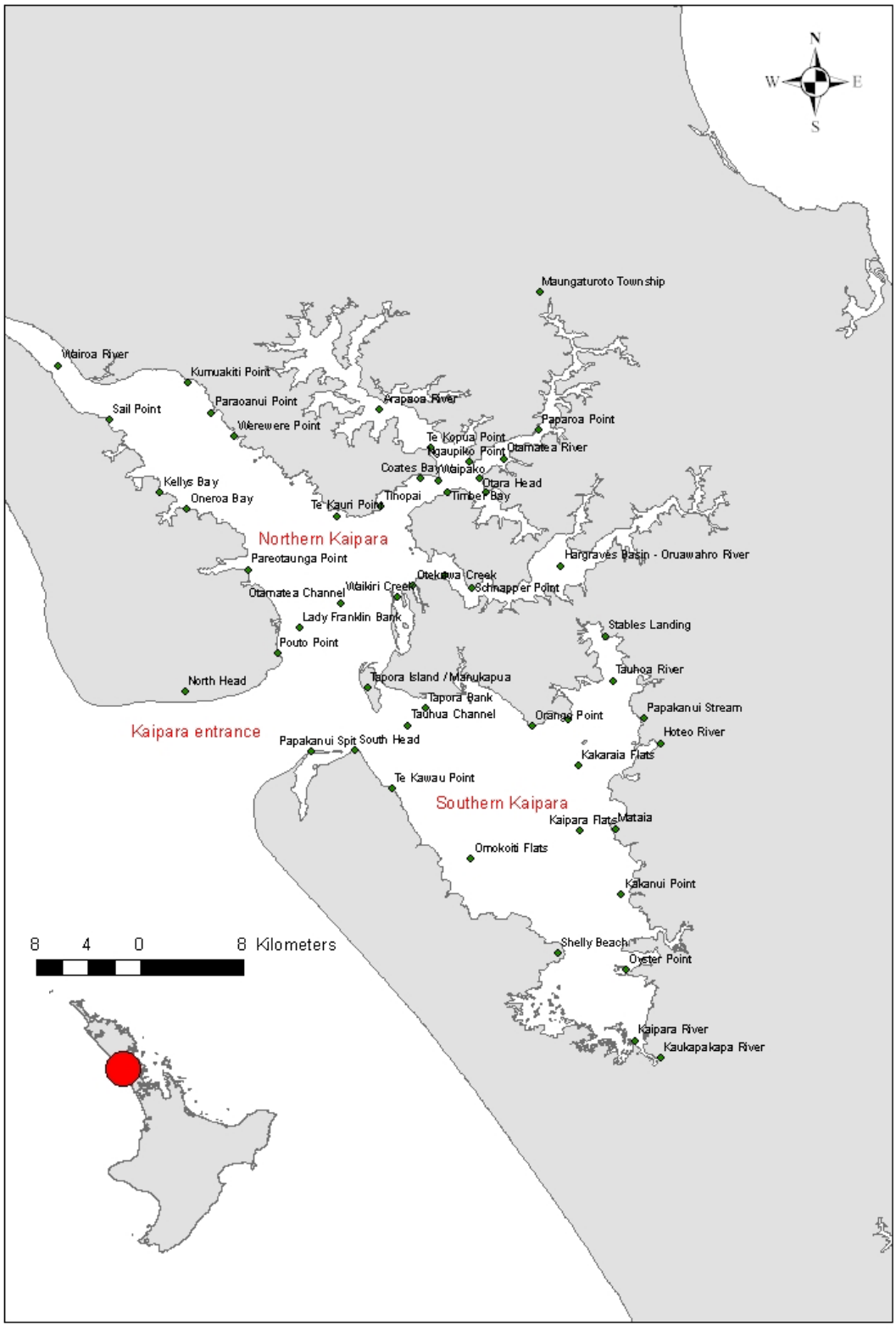
- Ecological information regarding coastal, intertidal, subtidal habitats and sub-habitats, vegetation, birds, fish, shellfish, invasive species, and so on.
- Fisheries' catch rates and stock status.
- Physical oceanography information concerning water quality, hydrology, tidal currents, and sediment movement.
- Geological and geographical properties of the main catchments, and catchment-related properties.
- Local knowledge of culturally significant areas such as fishing grounds and habitats.
- Local knowledge concerning the locations of activities such as recreational fishing (this is not comprehensive data).

In addition, during this review, tidal modelling of the Kaipara Harbour was undertaken for a separate ARC project and provided some insight into the physical processes operating in the harbour (mainly the current circulation patterns and potential for sedimentation) by investigating the maximum water velocities and residual currents. Hume et al. (2003) also undertook a comprehensive study of the sand distribution in the harbour entrance, which built upon other investigations of the area (e.g. Wright 1969, Smith 1999). These reports provided information about the physical environmental at the entrance area.

Bird data were accessed from the Ornithological Society of New Zealand on wading bird counts (2000-2006) and observation data from Mark Bellingham and Alison Davis (1982-2002). Other data on bird habitats around the harbour was also made available by the Rodney District Council and the Auckland Regional Council (significant natural areas data). Data from the Department of Conservation's Protected Natural Areas Programme for the Kaipara Ecological District were not available at the time of writing and information on the Pouto-Ruawai area of the harbour may need to be amended later, with reference to that data.

The various Kaipara Harbour locations referred to throughout this report are shown in Figure 1.

Figure 1 Kaipara Harbour locations referred to in this report.

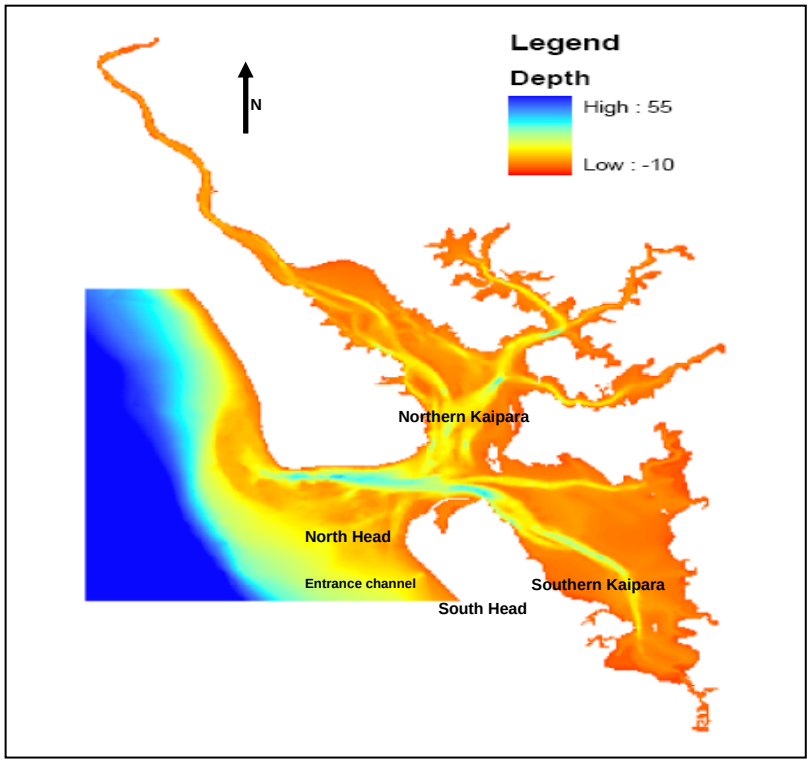


3 Summary of environmental information

3.1 The physical environment of Kaipara Harbour

Kaipara Harbour is one of the largest harbours in the world, and is claimed to be the largest in the southern hemisphere (Royal Forest and Bird Protection Society of New Zealand Inc, 2006). The harbour is an extensive drowned valley system with a combination of steeply cliffed margins and low, swampy Holocene flats (Heath 1975). It is very broad and shallow, although parts of the entrance channel are over 50 m deep, and covers 947 km^2 (including the entrance channel), of which some 409 km^2 is intertidal (Heath 1975, Fahy et al. 1990, Robertson et al. 2002). It has more than 900 km of shoreline and extends for some 60 km from north to south. The harbour entrance to the Tasman Sea constricts from approximately 13 km wide at the coast to 6 km at its narrowest point. The seaward margin of the harbour is bounded by two barrier spits, mainly comprised of post-glacial dune sand: one in the north, which forms the northern arm of the harbour; and one in the south that forms the southern arm of the harbour (Figure 2). Several large side branches also extend inland in the north-east. One of them ends near the town of Maungaturoto, just 10 km from the East Coast. The other is an extension of the Wairoa River, which flows into the northern end of the harbour (Figure 2).

Figure 2 Bathymetry grid of the Kaipara harbour showing depths to 55 m.



The harbour is characterised by strong tidal currents resulting from large volumes of water flowing through the restricted channels, giving a maximum tidal range of ~4.2 m and a tidal prism of approximately 1990 million m^3 during a spring high tide. Current speeds exceeding 2 m/s (~4 knots) have been recorded in the harbour entrance channel, and this resource is currently the target of a resource consent application for a tidal power generation development (Crest 2007). The harbour is ebb-dominated; that is, the ebb current is of shorter duration and higher velocity than the flood current.

The arms of the harbour are shallow and well flushed by the tides, although water circulation in the harbour is unlikely to be dominated by tidal flow alone: the large fetches inside the harbour and the shallow average depths are conducive to wind-driven circulation patterns. In addition, the harbour entrance is exposed to large, and sometimes extreme, wave conditions. This part of New Zealand's West Coast has an average wave height of 2.7 m (with annual return wave heights of almost 7 m) meaning that waves can penetrate to Tapora Island and the northern Kaipara during large wave events and higher tidal phases.

Hewitt and Funnell (2005) provide the following broad description of the South Kaipara substrates: Most of the intertidal area of the Southern Kaipara is mid- to low-intertidal, with few areas exposed for more than 7 hours on a tidal cycle. Extensive mangroves (often densely packed) fringe much of the southern Kaipara, with the exception of the South Head area and the sand dunes opposite the mouth. Extensive *Zostera capricorni* beds stretch over the intertidal flats (which are mainly sandy) in the middle of the main harbour and near the mouth. Much of the intertidal area between Helensville and just south of Sandy Beach is predominantly muddy. Seaward of this point, mud is generally confined to the mangrove edges and small drainage channels. In more exposed areas, firm packed rippled sand is common and in a few areas intertidal rocky reef occurs (e.g. inner channel of South Head).

Similar broad-scale trends in sediment distribution are found in northern areas of the Kaipara. However, the North Kaipara has a relatively lower percentage of intertidal flats (Figure 2) and coarser sediments penetrate further into the northern branch of the harbour than the southern (Hume et al. 2003, Hewitt and Funnell 2005). Coarser sediment fractions are found towards the entrance of the harbour and in the fast flowing channels. This is probably due to the orientation of the harbour entrance along a southwest-northeast axis that allows the predominant waves and winds to penetrate further into the northern arm. Initial tidal modelling indicates that mixing between the north and south parts of the Kaipara Harbour is not great (Mead et al. in prep.). Interestingly, the Kaipara Harbour entrance represents the terminal point of the black ironsands of the West Coast on the South Head and the beginning of the yellow beach sands characteristic of North Head.

The most detailed studies of physical processes in the Kaipara have focused on the entrance area of the harbour. Previous studies have found that a great deal of sediment moves around the Kaipara Harbour entrance and that the positions of the channels and sandbanks have changed greatly over the past century. Hume et al. (2003) presents a

review of the changes recorded on nautical charts since 1877 and incorporates other studies of the physical processes at the Kaipara Harbour entrance (e.g. Wright 1969, Smith 1999). The interaction of strong tidal currents and extreme wind and wave events in the entrance area make this part of the harbour difficult to understand in terms of physical processes. While the seabed of the swift-flowing main channel is either scoured mudstone or shell-lagged compact sand, many other areas are characterised by large bed-forms (mega-ripples and sand-waves), which indicate a great deal of sediment movement (Hume et al. 2003, Hewitt and Funnell 2005). The main changes to the entrance morphology since the 19th century have been a northward progression of the South Head through accretion, a northward progression of the North Head by erosion, a seawards widening of both the North and South Heads, and changes in the size and position of the channels and Tapora Island, which is located inshore of the flood tidal shield.

Physical properties of the Kaipara Harbour catchment are presented in Figure 3 to Figure 6 and include soil induration (i.e. compactness/hardness), geology, particle size, and drainage. From these maps it can be seen that the areas of fine sediments and poor drainage (i.e. those most likely to provide a source of sediment runoff in the harbour) are prevalent in the inner regions of the harbour, in the north of the harbour between Ruawai and Oruawharo River, and in southern areas between Oruawharo River and Shelly Beach. In contrast, the massive barrier spits of the harbour, which terminate in the North and South Heads at the entrance, are composed mainly of well-draining sands.

Figure 3 Soil induration for the Kaipara Harbour catchment area (source: Land Environments New Zealand).

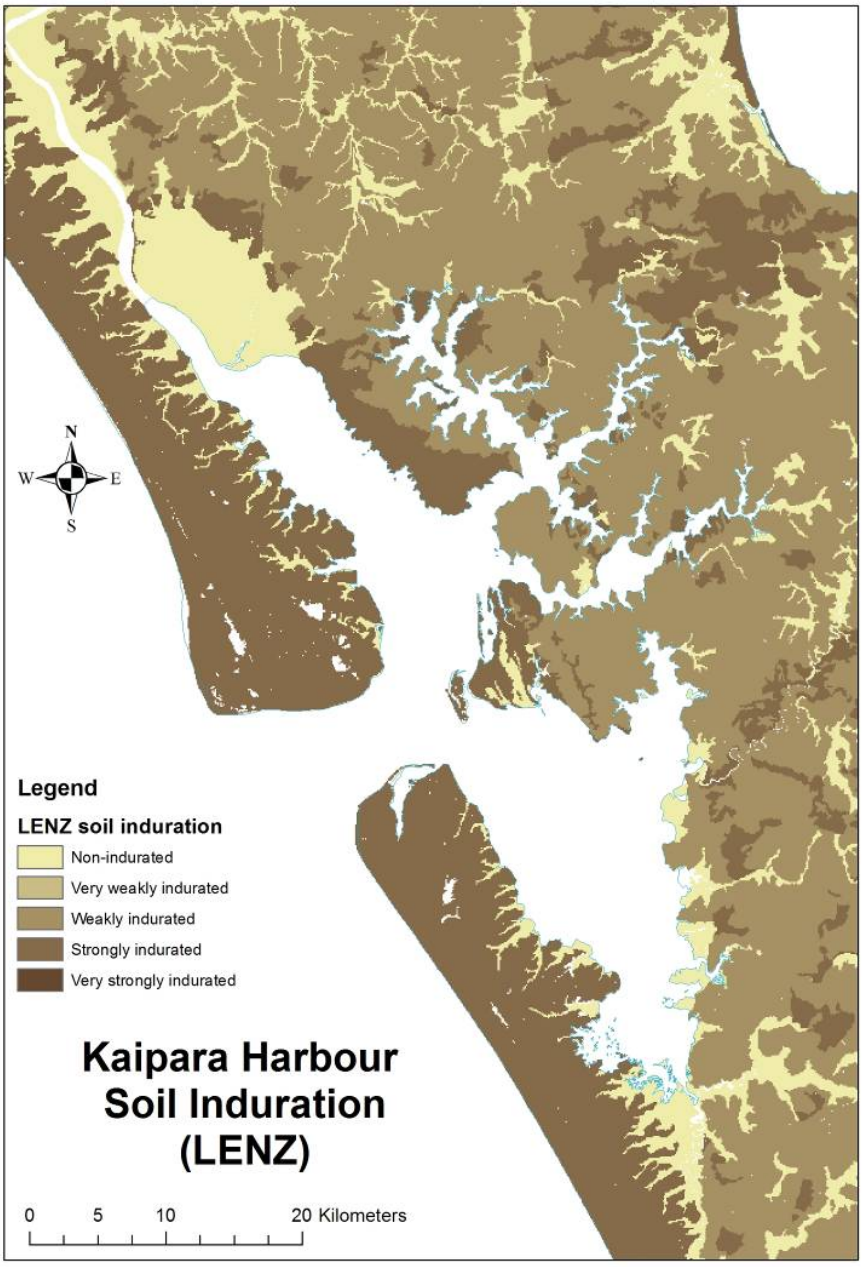


Figure 4 Geology of the Kaipara Harbour catchment (available information, source: Land Environments New Zealand).

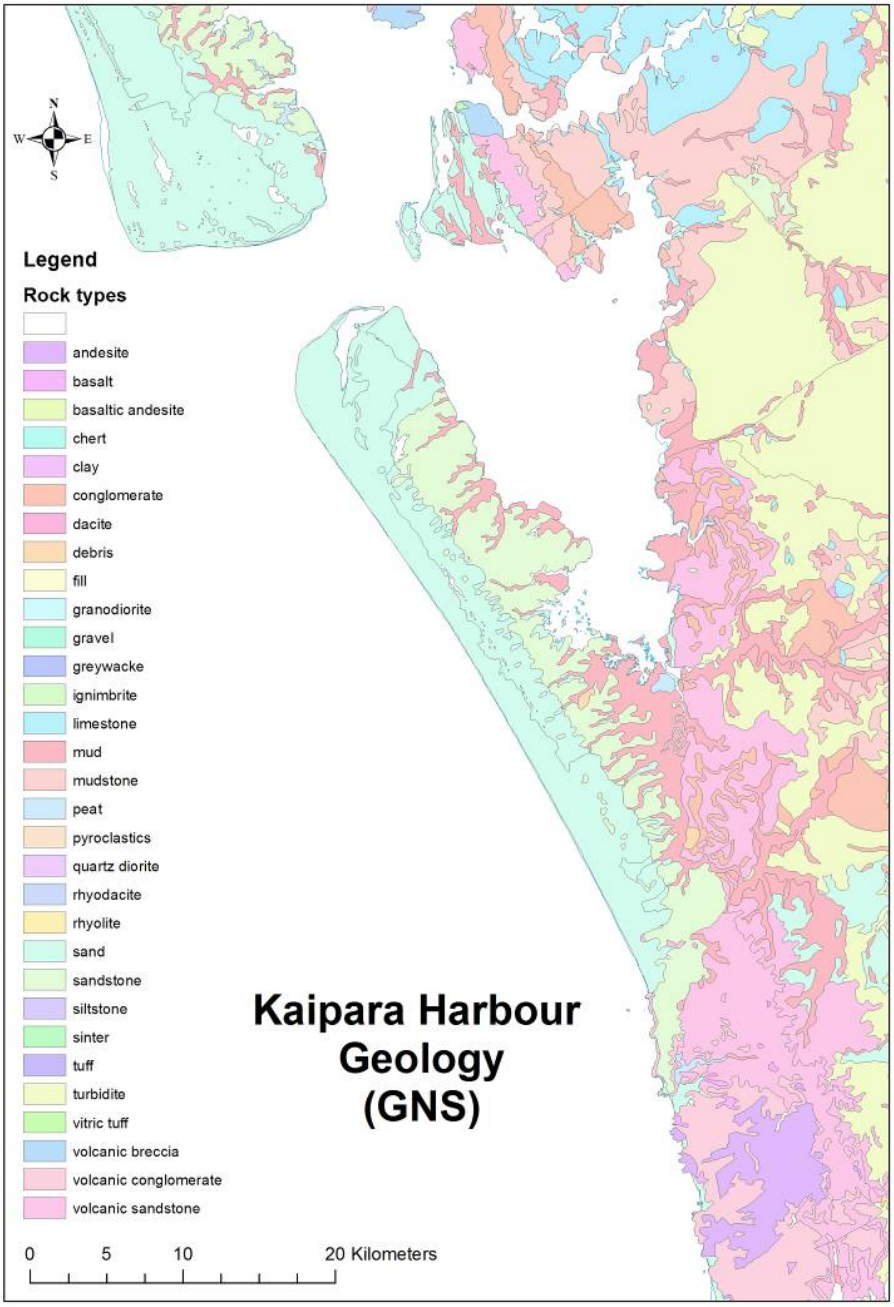


Figure 5 Sediment particle size for the Kaipara Harbour catchment (source: Land Environments New Zealand).

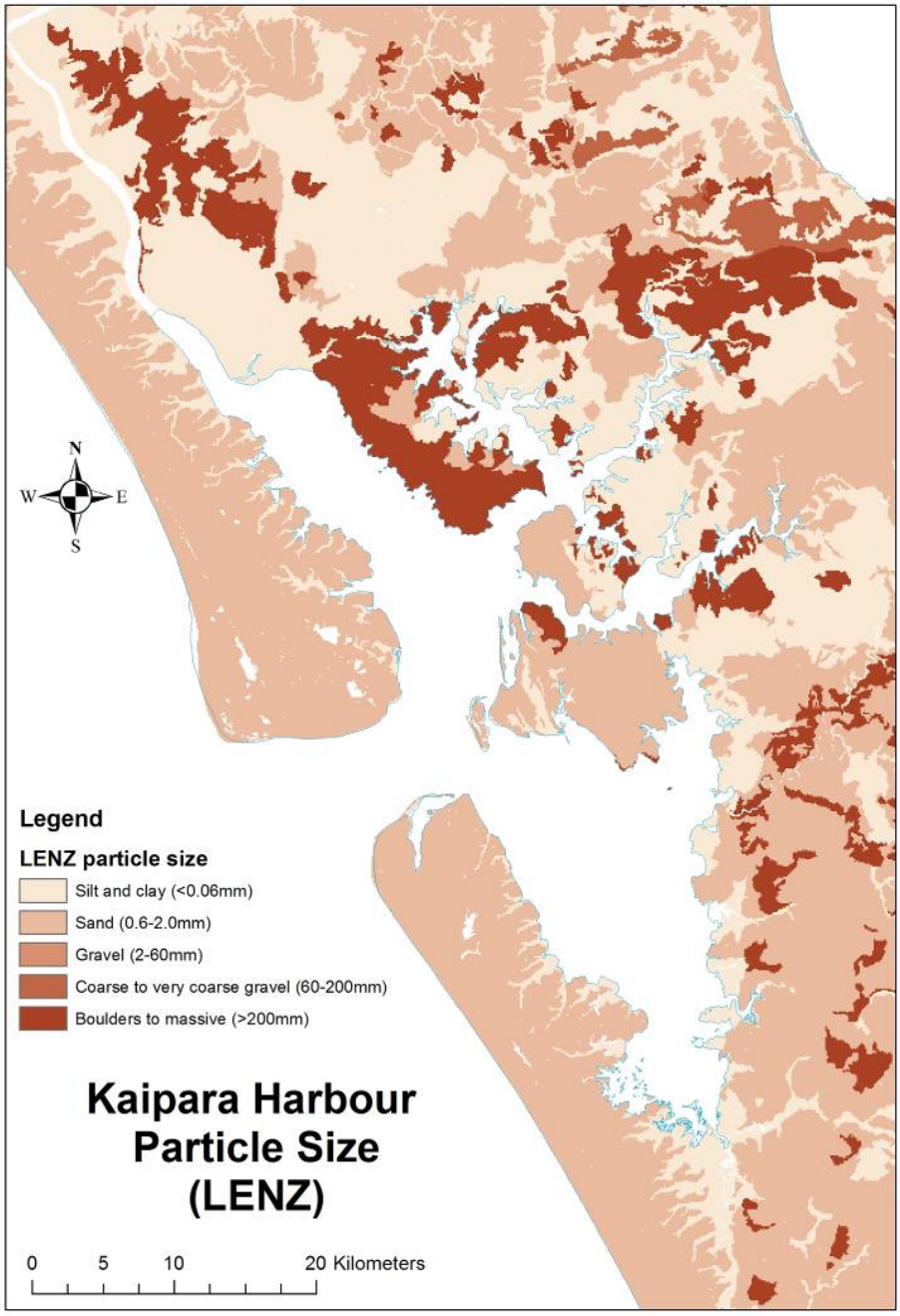
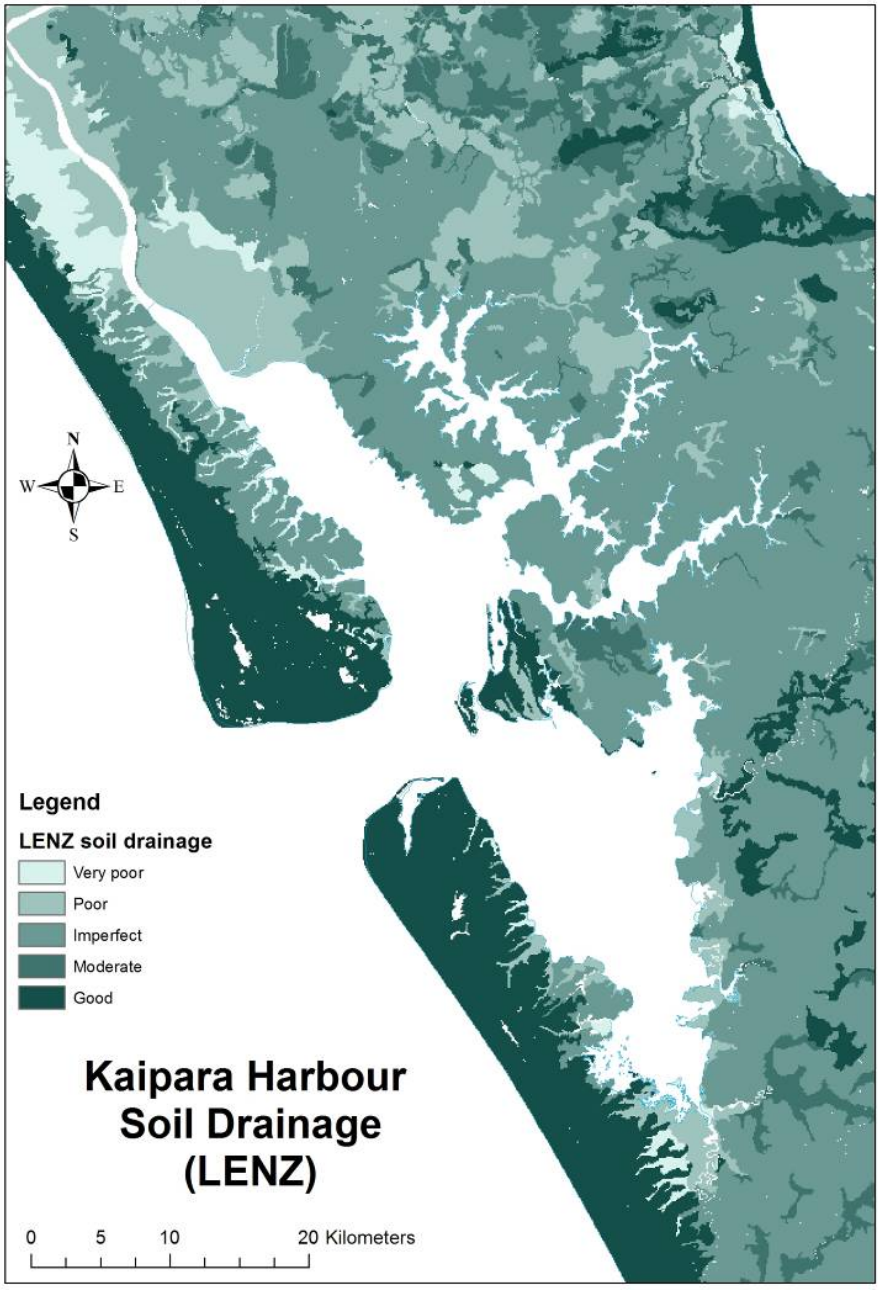


Figure 6 Soil drainage for the Kaipara Harbour catchment (source: Land Environments New Zealand).



3.2 Benthic communities

3.2.1 Southern Kaipara Harbour

Information on the benthic marine habitats and communities of Kaipara Harbour as a whole is relatively limited. The main sources of information are from a recent State of the Environment study of the South Kaipara (Hewitt and Funnell 2005), resource consent monitoring reports (e.g. Grace 1995-2004), mangrove studies (Morrisey et al. 2007), several studies carried out for aquaculture (Kelly et al. 2001, Biomarine 2005), and assessments of environmental effects (AEEs).

General intertidal and subtidal habitat types diagnosed by Hewitt and Funnell (2005) are presented in Figure 7. From their analysis, the harbour was divided into seven intertidal and eight subtidal areas. The seven intertidal areas were: the Oruawharo (O) and Tauhoa (T) arms, the upper part of the Kaipara River arm (U), the eastern (E) and western (W) areas of the outer Kaipara River arm, the area of sand dune in the Tapora region opposite the mouth (Ex), and the Waionui Inlet (I) (Figure 7). The eight subtidal areas were the Oruawharo (O) and upper Tauhoa (UT) arms, the upper (U) and middle (M) areas of the Kaipara arm, the high current area near South Head (H), the shallow subtidal area between the Kaipara River and Tauhoa arm (S), the exposed deep area in the mouth (Ex), and the outer area of the Tauhoa arm (OT) (Figure 7). A concise description of the main taxa within these habitats is provided in the following sections.

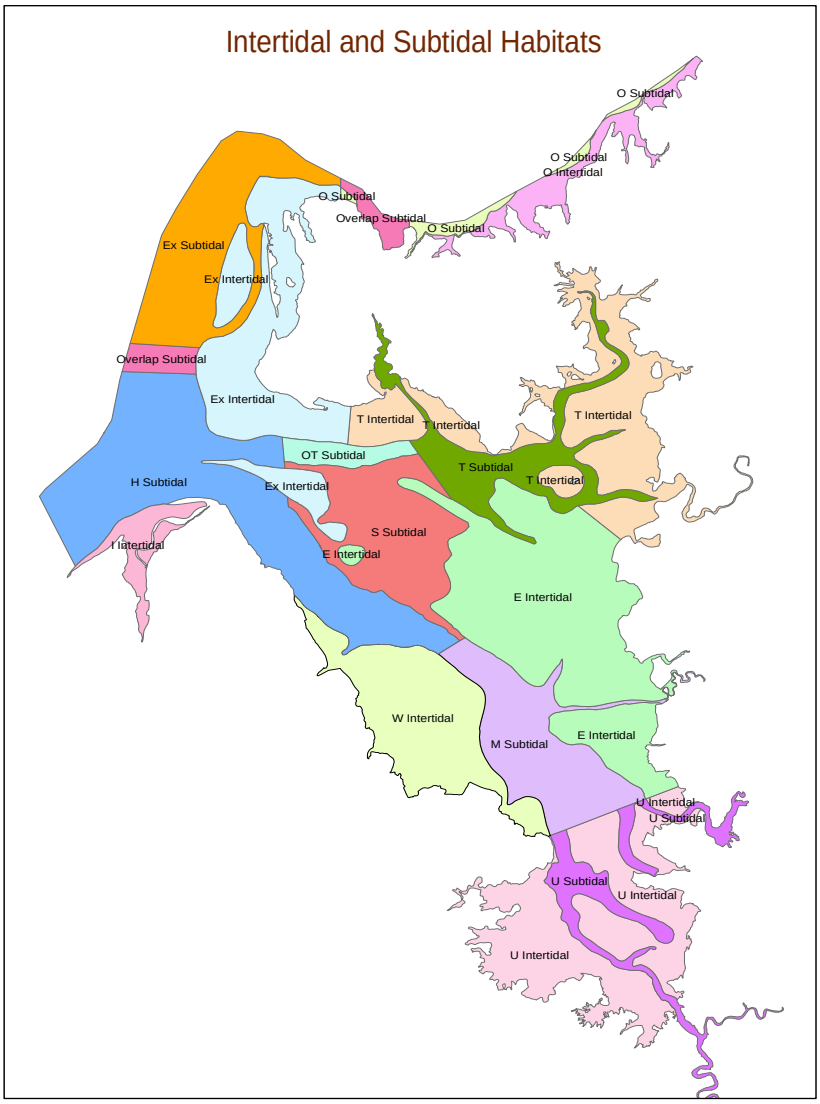
The marine habitats within the southern Kaipara are comprised of extensive intertidal and subtidal mud and sandflats, channels, and a limited amount of intertidal and subtidal reef. The area is also influenced by several relatively large rivers including the southernmost Kaukapakapa and Kaipara rivers, and the northernmost Hoteo, Tauhoa, and Oruawharo rivers (Figure 1). Biological communities across the area contain a mixture of common species found in many harbours and estuaries throughout the Auckland Region, but also include several rare and ecologically significant taxa and/or assemblages that are unique in the Auckland Region (e.g. tube building worms). Hewitt and Funnell (2005) indicate that a number of taxa (sponges, ascidians, bryozoans, hydroids, pipis, and echinoderms) within the southern Kaipara are commonly associated with pristine environments.

3.2.1.1 Area U: Kaipara River arm

Area U has five main habitat types: mangroves of varying densities, unvegetated intertidal mudflats that range from muddy to very muddy (>50% mud), sandflats, a small area of intertidal *Zostera,* and subtidal muds (Hewitt and Funnell 2005). The intertidal area south of Shelly Beach and Oyster Point is generally of modest diversity (Figure 8 to Figure 12), dominated by beds of the wedge shell *Macomona liliana* with the mudflat areas to the south typified by deposit-feeding bivalves and polychaetes, surface bioturbators, tube-dwellers, and polychaete predators/scavengers. Areas of mangrove are dominated by burrowers (e.g. the mud crab *Helice crassa*). Invasive

bivalves such as *Musculista senhousia* and/or *Crassostrea gigas* also occur throughout this area. The intertidal sandflats between the Kaipara River and Oyster Point contain *Macomona liliana* in tandem with cockles (*Austrovenus stutchbury*i), high densities of deposit-feeding polychaete worms, suspension-feeding bivalves and tube dwellers. Moderately diverse tube-building polychaete worms are present adjacent to Oyster Point, co-occurring with low densities of large organisms such as nemertean worms and holothurians. The subtidal region is composed of four ecological communities: deposit-feeding bivalves, tube-dwellers, sedentary epifauna, and surface bioturbators.

Figure 7 Intertidal and subtidal habitat types in the southern Kaipara (Hewitt and Funnell 2005).



3.2.1.2 Area M: Subtidal region between Omokoiti Flats and Kaipara Flats

Area M, the middle subtidal area of the Kaipara River arm, has a low ecological diversity relative to other subtidal areas of the South Kaipara (Figure 8 to Figure 12). Main community types within this area range from suspension-feeding bivalves, tube-dwellers, surface bioturbators, large fauna (i.e. gastropods, crabs and

predatory/scavenging polychaetes), hydroids, epifaunal complexes (typified by sponges with hydroids, bryozoans and/or anemones), filamentous seaweed, and areas dominated by *Fellaster*. Scallops (*Pecten novaezelandiae*) occur both intertidally and subtidally within and adjacent to the Kaipara Flats area (P. and C. Yardley, pers. comm. 2007) (Figure 20) but in recent years have declined in abundance and distribution. All scallop harvesting is restricted within the Kaipara Harbour (Ministry of Fisheries 2005).

3.2.1.3 Area W: Western intertidal flats (Omokoiti Flats)

Area W, the Omokoiti Flats area of the harbour, has a high ecological diversity typified by seagrass meadows together with *Austrovenus stutchburyi* and *Macomona liliana* communities. Unvegetated areas support a variety of community types including suspension-feeding bivalves, deposit-feeding polychaetes, tube-dwellers, polychaete predators/scavengers, surface bioturbators, and *Macomona liliana*. Mangrove habitat in this area is dominated by burrowers, with an *Austrovenus-Macomona* community also apparent.

3.2.1.4 Area E: Eastern intertidal flats

Area E, the eastern intertidal areas of the harbour containing the Kakaraia Flats and Kaipara Flats, is similar to the Omokoiti Flats. It is covered by extensive meadows of intertidal *Zostera*, concomitant with *Austrovenus stutchburyi* and *Macomona liliana* communities. Unvegetated sandflats within this area differ from the seagrass habitat, with suspension-feeding bivalves, deposit-feeding polychaetes, tube-dwellers, polychaete predators/scavengers, surface bioturbators, large fauna, and areas dominated by *Fellaster*. The unvegetated sandflats have a lower diversity than the areas dominated by seagrass, whereas muddy areas are typified by tube-dwellers. Mangrove habitat was not sampled within this section of the harbour but, based on equivalent habitat sampled in adjacent areas of the harbour (Kaipara River, Omokoiti Flats), Hewitt and Funnell (2005) suggest that the mangrove habitat is likely to be dominated by burrowing animals.

3.2.1.5 Area T: Tauhoa Arm

Area T, the Tauhoa arm, contains a similar suite of habitat types to that of the upper part of the Kaipara River arm. Mangrove and *Zostera* communities within this area are dominated by burrowers and *Macomona liliana,* with sandflat communities composed of deposit-feeding polychaetes, *Macomona liliana* and tube-dwellers. The subtidal upper reaches of the Tauhoa River are composed of finer sediments and have a diverse range of ecological communities including deposit-feeding bivalves, surface bioturbators, tube-dwellers, predatory/scavenging polychaetes, large fauna, and invasive species (*Musculista senhousia* and/or *Crassostrea gigas*). The outer subtidal areas of the Tauhoa arm are dominated by burrowing, tube-dwelling, and large faunal communities. Both the upper and outer reaches of the Tauhoa arm have high 'order' diversity.

3.2.1.6 Area S: Subtidal area adjacent Tauhoa and Kakaraia Flats

Area S, the shallow (<10 m depth at MLWS) subtidal area adjacent to the Tauhoa arm and Kakaraia Flats, is one of the most biologically diverse areas of the south Kaipara (Hewitt and Funnell 2005). This area contains fine sand with deposit-feeding bivalves, sedentary epibenthos, sponges, tube-dwellers, large fauna, surface bioturbators, subtidal *Zostera,* and *Atrina zelandica* beds. Subtidal seagrass beds are considered to be important for juvenile snapper recruitment within the harbour (FRST 2003).

3.2.1.7 Area OT: Tauhoa River

Analogous to other intertidal areas of the southern Kaipara, Area OT, the intertidal mudflats of the outer Tauhoa arm (the Tauhoa channel) is characterised by *Macomona liliana* at the entrance between Karaka Point and Breach Point. The subtidal areas at the mouth of the river are typified by epifaunal complexes and contain a high diversity of large animals (polychaete predators and scavengers), hydroids, and subtidal *Zostera capricorni,* with patches of *Musculista senhousia* adjacent to Stables Landing (Figure 8 to Figure 12) (Hewitt and Funnell 2005).

3.2.1.8 Area H: South Head and entrance region

Area H, the subtidal region adjacent to South Head has a high biological diversity (Figure 12) with rocky reef supporting diverse encrusting communities including: green-lipped mussels (*Perna canaliculus*), sponges, barnacles, and anemones. Surface bioturbators, tube-dwellers, large fauna, and *Fellaster* dominate the soft sediment habitats adjacent to South Head while the extensive sandy substratum characteristic of the harbour entrance is characterised by patches of *Fellaster zelandiae*, tuatua (*Paphies subtriangulata*), and a polychaete fauna with low biological diversity (Grace 2004).

3.2.1.9 Area I: Waionui Inlet

The intertidal sandflats characteristic of Area I, the Waionui Inlet, are of high-to-moderate diversity; typified by *Austrovenus stutchburyi*, surface bioturbators, and deposit-feeding polychaetes. The mudflat areas are dominated by deposit-feeding polychaetes.

3.2.1.10 Area EX: Intertidal and subtidal area adjacent Tapora Peninsula

Area EX, the intertidal areas adjacent to the mouth of the Oruawharo River, is typified by three main habitats: intertidal seagrass, sand, and subtidal sand. The seagrass habitat is dominated by a mix of large animals and dead cockle shells, whereas the intertidal sand contains a variety of communities such as: *Macomona liliana*, tube-dwellers, surface bioturbators, deposit-feeding bivalves, and polychaete predators/scavengers. The subtidal sandy habitat within this area is dominated by *Fellaster* and gastropods and the area as a whole has low-to-moderate biological diversity.

3.2.1.11 Area O: Oruawharo arm

The mudflat habitats in Area O, the Oruawharo arm, are dominated by polychaete predators/scavengers and deposit-feeding bivalves, with sandy areas dominated by *Austrovenus stutchburyi* in tandem with *Macomona liliana*. The mangrove areas in the Oruawharo arm have a different fauna to other regions of the South Kaipara, being dominated by the deposit-feeding bivalve *Arthritica* spp., polychaete predators/scavengers, and burrowers. Subtidal areas are generally muddy and dominated by deposit-feeding bivalves, sedentary epifauna, and *Fellaster* communities. Towards the mouth, surface bioturbators, tube-dwellers, and large fauna are common. Discrete patches of the horse mussel *Atrina zelandica* are present north of Schnapper Point (Hewitt and Funnell 2005). Subtidal mats of *Musculista senhousia* are extensive and widespread across the Oruawharo River. Patches of deposit-feeding bivalves, such as *Nucula hartvigiana,* and other smaller bivalves occur in the subtidal upper reaches of the river (Hewitt and Funnell 2005). The area between Raekau Wharf (Te Raekau) and Waingopai (Waingohe) Creek within the Oruawharo River (northern Kaipara) is presently designated as an oyster reserve (see section 3.3.2).