Auckland Regional Council
TE RAUHĪTANGA TAIAO

Mahurangi Harbour Soft-Sediment Communities:

Predicting and Assessing the Effects of Harbour and Catchment Development

April TR 2009/040

Auckland Regional Council
Technical Report No.040 April 2009
ISSN 1179-0504 (Print)
ISSN 1179-0512 (Online)
ISBN 978-1-877528-49-1

This report is part of a series of reports that were commissioned during the period 1993-1999 that were used to support the establishment of the Mahurangi Action Plan. They are being made available following a review of technical information.

Reviewed by:

Name: Megan Stewart

Position: Project Leader Marine

Organisation: ARC

Date: 1/04/09

Approved for ARC Publication by:

Name: Grant Barnes

Position: Group Manager Monitoring & Research

Organisation: ARC

Date: 1/04/09

Recommended Citation:

Cummings, V.J.; Thrush, S.F.; Pridmore, R.D. and Hewitt, J.E. (1994). Mahurangi Harbour Soft-Sediment Communities: Predicting and Assessing the Effects of Harbour and Catchment Development. Prepared by the National Institute of Water and Atmospheric Research for Auckland Regional Council. Auckland Regional Council TR 2009/040.

Mahurangi Harbour Soft-Sediment Communities:

Predicting and Assessing the Effects of Harbour and Catchment Development

Cummings, V.J.
Thrush, S.F.
Hewitt, J.E.

Prepared for
Auckland Regional Council

NIWA Consultant Report
Report No. ARC222
Hamilton

Contents

1 Executive Summary

As part of the Mahurangi Harbour Management Plan, NIWA Ecosystems was contracted to assess both the present ecological status of Mahurangi Harbour and the potential effects of future catchment and harbour development on resident infauna.

1. The present intertidal and subtidal benthic communities of Mahurangi Harbour are documented to provide baseline data against which future shifts in infaunal communities can be compared.
2. Possible future developments/uses of Mahurangi Harbour and its catchment are considered in order to identify associated environmental effects which could potentially alter the ecology of the harbour.
3. Potential environmental effects as a result of increased sedimentation are considered the major concern in the development of Mahurangi Harbour and its catchment. Detailed investigations into the effects of sedimentation on the harbour's ecology are needed.
4. Suspension-feeding organisms are considered the most sensitive to potential environmental effects resulting from future harbour development/use.
5. Because of a lack of extensive information on the sensitivity of communities to potential environmental effects, resource management should proceed with caution until more information is obtained on the influences of specific environmental effects on infauna.
6. To underpin the above, a biological monitoring programme incorporating both intertidal and subtidal sites within Mahurangi Harbour is recommended to provide information on harbour condition, and to document ecological changes which may occur as a direct/indirect consequence of catchment or harbour development.

2 Introduction

Mahurangi Harbour and its catchment have been identified by ARC Environment as an area with high potential for increasing pressure on land and water use in the near future. Recognising that planning and catchment management decisions, or developments within the harbour itself, may alter the environmental quality of the harbour, they have initiated a major study of the harbour and catchment.

As part of this process, NIWA Ecosystems was contracted to assess the present ecological status of Mahurangi Harbour. A survey was designed and conducted to:

1. Document the present intertidal and subtidal benthic communities of Mahurangi Harbour.
2. Collect baseline data against which shifts in infaunal communities may later be compared.
3. Report on how different catchment and harbour developments/uses might affect the ecology of the harbour, and identify limits to the predictions we are currently able to make.
4. Identify infaunal species, communities and habitats which are likely to be sensitive to changes within the harbour or in catchment inputs.
5. Identify sites and recommend methodology for future long-term monitoring of benthic communities within the harbour.

Information gained from this survey will aid in future management decisions concerning catchment/harbour development. It will also complement and be used in other studies being conducted by NIWA Ecosystems as part of the Mahurangi Harbour Management Plan.

3 Methods

In order to provide a broad characterisation of benthic communities throughout the harbour, a total of 29 sites were chosen. These included 12 intertidal mudflat, 8 intertidal sandflat and 9 subtidal sites (Figure 1). All of the sites were in soft-sediment habitats, which dominate the harbour environment. Sites were situated in areas representative of locations predetermined from maps of the harbour. Once established, the exact location of a site was fixed using a satellite navigation system. Detailed descriptions of habitat type were also made at each site (Table 1).

From each site, 5 core samples (10 cm dia., 15 cm deep) were taken, each 5 m apart at intertidal sites and 2 m apart at subtidal sites. Sediments were sieved (500 µm mesh) and the residues stained with rose bengal and preserved in 10 % formalin in seawater. Samples were sorted, identified to the lowest possible/practical taxonomic level, counted and stored in 70 % isopropanol.

To identify similarities in community composition between sites, and assess overall gradients in community composition down the harbour, multivariate analyses were conducted. Data were analysed using the ordination technique of detrended correspondence analysis (DECORANA, Hill 1979) and the clustering technique of two way indicator species (TWINSPAN, Hill 1979). For the purposes of this report, differentiation of sites into groups has been restricted to the third level of the Twinspan classification.

Figure 1
Map of Mahurangi Harbour, showing locations of subtidal and intertidal sites sampled

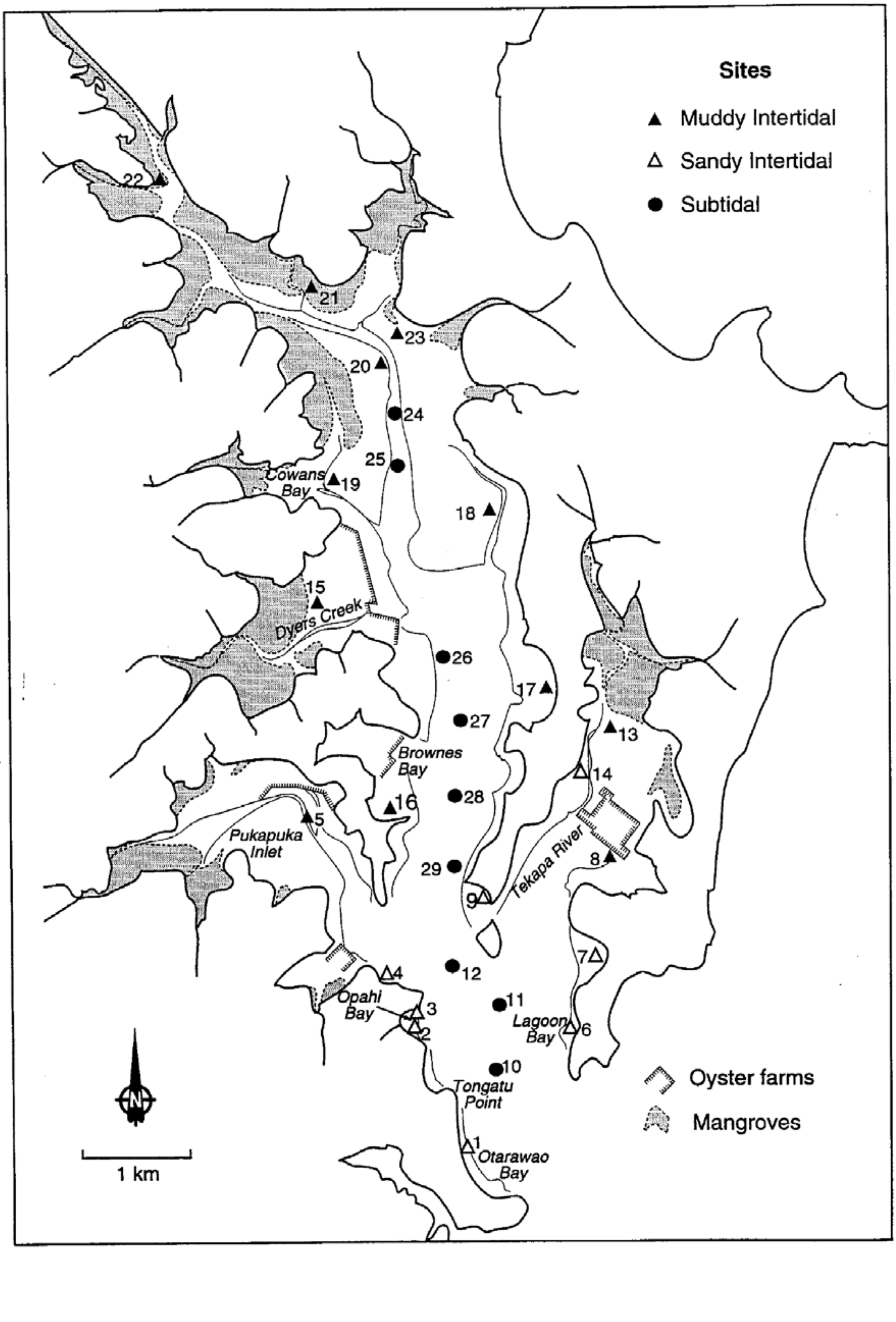


Table 1

Habitat descriptions of sites sampled in the Mahurangi Harbour.

Site	Location	Depth	Habitat description
1	Otarawao Bay	Intertidal	Sand: coarse grained, poorly sorted. Shell bands.
2	Opahi Bay	Intertidal	Sand: muddy, poorly sorted. Heterogeneous with gravel, large pebbles. Large pipis (*Paphies australis*) and cockles (*Austrovenus stutchburyi*).
3	Opahi Bay	Intertidal	Sand: muddy, well compacted. Decaying eel grass (*Zostera*), large crab burrows.
4	Jameson Bay	Intertidal	Sand: muddy, pebbles, large stones. Eel grass patches (2-3 m).
5	Pukapuka Inlet	Intertidal	Mud: clay, sticky.
6	Lagoon Bay	Intertidal	Sand: fine, muddy. Eel grass patches (1-2 m).
7	Te Kapa Inlet	Intertidal	Sand: medium-fine, well sorted. Large shelly flat, thin Eel grass beds.
8	Te Kapa Inlet	Intertidal	Mud: deep, unconsolidated. Crab burrows.
9		Intertidal	Sand: coarse grained, with gravel. High numbers of gastropods on surface.
10	Tongatu Point	16 m	Mud/sand. Shell fragments, broken scallop shells, patches of sponge, large burrows. Horse mussels (*Atrina zelandica*) present.
11		8 m	Mud: fine. Extensive horse mussel beds (30-50 m^{-2}), diatoms.
12		14 m	Mud: sandy, shelly. Horse mussels (1/10 m^{2}), patches of sponge, large burrowing anenomes and gastropods (*Cominella adspersa*). Scallops present.
13	Te Kapa Inlet	Intertidal	Mud: deep, unconsolidated.
14	Te Kapa Inlet	Intertidal	Sand: shelly. Heterogeneous.
15	Dyers Creek	Intertidal	Mud: firm. Young mangroves, gastropod trails.
16	Browns Bay	Intertidal	Mud: sandy, sulphurus. Burrows, faecal mounds, gastropod trails.
17		Intertidal	Mud: clay. Large cockle beds.
18		Intertidal	Mud. Extensive flat, crab burrows.
Site	Location	Depth	Habitat description
19	Cowans Bay	Intertidal	Mud: shelly. Extensive flat, crab burrows.
20		Intertidal	Mud: unconsolidated. Many crab burrows.
21		Intertidal	Mud: very fine, unconsolidated. Mangroves. Crab burrows.
22		Intertidal	Mud: very thick, fine, unconsolidated. Mangroves. Crab burrows.
23		Intertidal	Mud. Mangroves, crab burrows.
24		1 m	Mud: fine. Crab burrows, similar to intertidal areas.
25		2.5 m	Mud: fine. Crab burrows, similar to intertidal areas.
26		3 m	Mud: fine. Crab burrows.
27		5 m	Mud: fine. Extensive horse mussel beds.
28		6 m	Mud: fine. Horse mussel beds - smaller animals cf. Site 27.
29		9 m	Mud: fine. Horse mussel beds.

4 Results and Discussion

4.1 Present Composition of Benthic Communities

A total of 162 taxa were collected from around the harbour (see Appendix 1), with the greatest variety represented in the outer half of the harbour. Distribution of these taxa varied between sites depending upon substrate type, tidal height and degree of exposure. Subtidal sites were generally the most diverse in terms of the number of taxa recorded. Multivariate analysis of community composition showed differences between subtidal and intertidal sites (Figure 2, Figure 3), with further subgroups of sites revealing a general trend of changes in community composition up the harbour. Both these analyses, and a visual examination of species composition at each site, enabled us to objectively group sites with similar characteristics. It is important to note that the presence of horse mussels (*Atrina zelandica*) at some of the subtidal sites were not incorporated into the Decorana or Twinspan analyses as the large size of these bivalves meant they could not be sampled by coring. We have, however, indicated in Figure 3 the sites at which horse mussels were present. Our visual observations were taken into account when grouping the subtidal sites into community types.

Figure 2

Decorana ordination of the communities of the 29 sites sampled in Mahurangi Harbour. A distance of 400 units along either axis denotes a complete turnover in community composition. Horse mussels were present at all subtidal sites except those marked by an *.

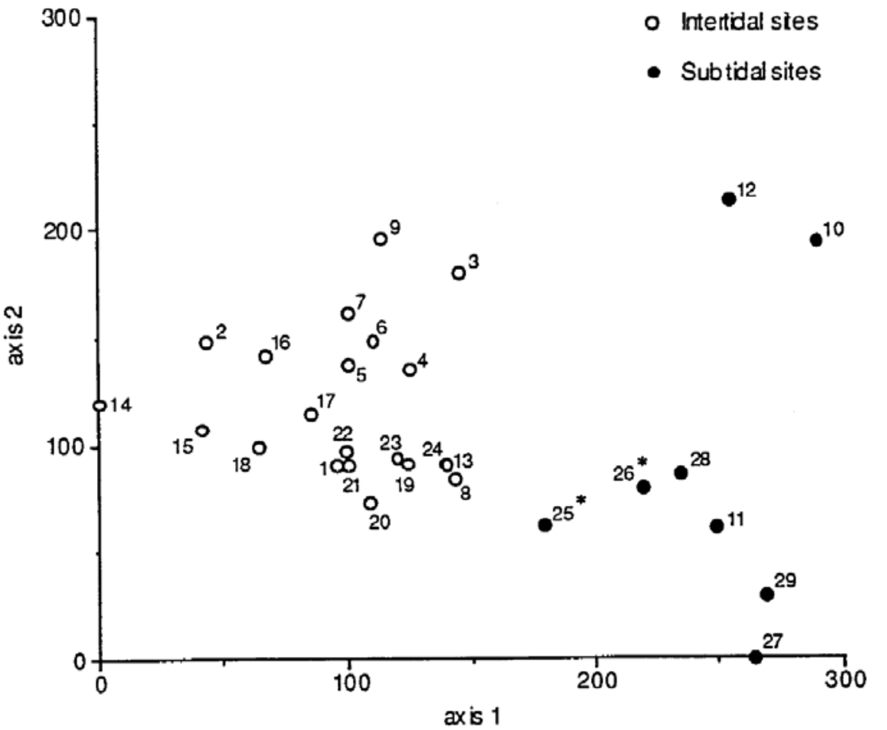
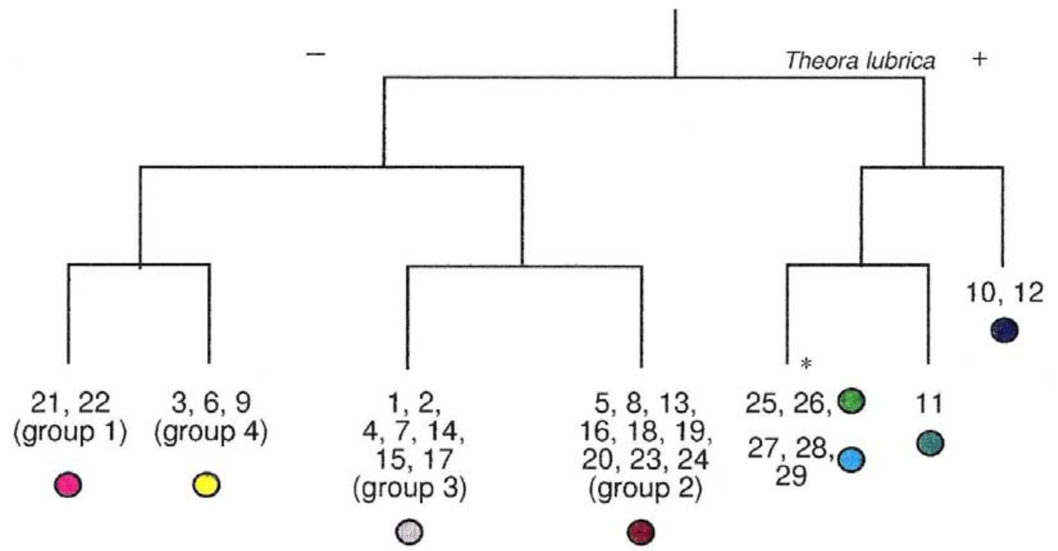


Figure 3
Twinspan classification of the communities of Mahurangi Harbour. Sites on the right-hand side are subtidal sites, groups 1-4 are intertidal sites. Group 1 = polydorid-dominated; group 2 = polychaete/muddy; group 3 = bivalve/sandy, group 4 = outer harbour/sandy.

*Note that this section has been further divided on the basis of presence/absence of horse mussels which dominated communities when present.



Based on this classification, the infaunal communities of Mahurangi Harbour can be described as follows:

4.1.1 Subtidal sites

The subtidal sites (i.e. Sites 10 -12 and 24 - 29) were composed of mainly muddy sediments (see Table 1).

Sites 10, 11, 12, 27, 28 and 29 had substantial populations of horse mussels. At these sites, large horse mussel beds reached densities of 30-50 m^{-2} and completely dominated the habitat (Plate 1). The fine sediments between the horse mussels contained large numbers of very small deposit feeding worms and larger deep burrowing crustaceans. The horse mussels also provide habitats for a number of epifaunal grazers and detritivores including sea cucumbers (e.g. Plate 2), nudibranchs, and terebellid polychaetes. These features highlight how the presence of high numbers of horse mussels constrain community structure in these habitats. The sponges growing on the horse mussels (see Plate 2) indicate relatively low sedimentation rates in these areas.

Horse mussels were absent from the upper harbour subtidal sites (i.e. Sites 24, 25 and 26). Although visibility at these sites was very poor, a large number of crab burrows (*Helice* sp.) were noted.

Subtidal sites, with the exception of Site 24, were distinctly different in community composition to the intertidal sites (Figure 3). Site 24 was situated on the edge of the main harbour channel in shallow water (Figure 1). The sediment characteristics and community composition at this site were very similar to those of several intertidal sites (Figure 2).

The remaining subtidal sites can be separated into 4 groups:

1. Upper harbour

   The upper harbour subtidal sites (i.e. Sites 25 and 26) were characterised by having no horse mussels and relatively low numbers of taxa. The bivalves *Theora lubrica* and *Arthritica bifurca*, and Oligochaetes were prevalent at both sites. Numerous crab burrows were observed at these sites.

2. Inner harbour

   Inner harbour subtidal sites (i.e. Sites 27, 28 and 29) differed from the upper harbour sites in generally supporting dense beds of horse mussels. Sites 28 and 29 had high numbers of taxa with no one species particularly dominant. *Theora lubrica* was amongst the most dominant taxa at all three sites. Oligochaetes and crustaceans were also common, although their densities varied between sites.

3. Outer harbour - deep

   Outer harbour Sites 10 and 12 were the deepest of the subtidal sites (i.e. about 16 and 14 m respectively) and had distinctly different communities. The communities at each of these sites are amongst the most diverse of all sites sampled in this survey. Sediments at Site 10, close to the mouth of the harbour, were heterogeneous and contained large quantities of shell hash (Plate 3). Its community was dominated by capitellid and cirratulid polychaetes. At Site 12, oligochaetes comprised 75 % of the total individuals.

4. Outer harbour - transitional

   Site 11, at the entrance to Te Kapa Inlet, represents a transitional site between the above inner and outer harbour groups. The community here had affinities with the inner harbour sites. The bivalve *Theora lubrica* was the most dominant taxa, and there was a substantial horse mussel population. However, the crustaceans Tanaid B and Cumacean sp.4 and the polychaete *Prionospio cirrifera*, all common at Site 11, were not represented at the inner harbour subtidal sites.

4.1.2 Intertidal sites

Intertidal sites (i.e. Sites 1 - 9 and Sites 13 - 23) covered a wide range of substrate types (see Table 1, Plates 4, 5 and 6) and differed considerably in community composition between the inner and outer harbour.

The intertidal communities of Mahurangi Harbour can be classified into 4 groups.

1. Polydorid dominated

   Sites 21 and 22 were situated at the northern most end of the harbour, in the muddy, mangrove lined upper estuary. The communities at these sites were dominated by small surface dwelling worms. Polydorid polychaetes accounted for 60.4 % and 56.0 %, and oligochaetes 10.5 % and 14.4 %, of the total individuals at Sites 21 and 22, respectively. Their abundance is further emphasised as these sites recorded the 1st and 3rd highest total numbers of individuals of all sites sampled.

2. Polychaete dominated muddy sites

   Sites 5, 8, 13, 16, 18, 19, 20, 23 and 24 are all situated in the mid-to-upper harbour and are composed of muddy sediments. These sites were mostly dominated by the *Heteromastus filiformis*, *Aricidea* sp., *Cossura* sp., Parionid-Type 2 and *Perinereis nuntia*. The bivalves *Austrovenus stutchburyi*, *Nucula hartvigiana* and *Theora lubrica*, common in group 3 below, were also represented at Sites 8, 16 and 18.

3. Bivalve dominated sandy sites

   Sites 1, 2, 4, 7, 14, 15 and 17 are situated in the mid-to-outer harbour, and generally were comprised of sandy sediments. Site 1 recorded the lowest number of taxa and number of individuals of all sites sampled. This was the most exposed site sampled and had affinities to open beach habitats. At this site the isopod *Exosphaeroma* sp. comprised over half the total number of individuals. *Exosphaeroma* sp. was also present at several of the other sites in this group.

   The bivalve *Austrovenus stutchburyi* was the most dominant species at all sites except Site 1. The bivalves *Nucula hartvigiana* and *Macomona liliana*, the polychaetes *Aquilaspio aucklandica* and Exogoninae 2, Nemerteans and the limpet *Notoacmea* sp. were also common at these sites, although their densities varied between sites.

4. Mixed community, outer harbour sandy sites

   Sites 3, 6 and 9 had sandy substrates, and were situated in the outer harbour. All three sites had low numbers of taxa. Sites 6 and 9 had relatively few species present in very high numbers (i.e. > 1 individual per core). The most common species at Site 6 were the crustaceans *Torridoharpinia hurlyei* and a Corophidae-complex, the polychaete *Magelona ?dakini* and Nemerteans. The polychaetes *Heteromastus filiformis*, *Asychis* sp. and *Aricidea* sp. and the crustacean *Paracalliope novaezelandiae* were the most common taxa at Site 9. Site 3 was polydorid dominated like the upper harbour sites, although at this site they were much less dominant, only accounting for 32 % of the total individuals.

The multivariate analysis clearly shows the general patterns of change in macrobenthic community structure down the harbour (Figure 4). It also highlights some discrepancies in this general pattern. For example, the community at sandy Site 3 (Opahi Bay) was dominated by polydorid polychaetes, suggesting some affinity with the upper harbour muddy Sites 21 and 22. However, the substrate types are very different. The polychaete dominated muddy community type (group 2) and the bivalve dominated sandy community type (group 3) show some overlap in species composition in the mid harbour region. Sites 15 and 17, included in the group characterised by bivalve/sandy communities are actually muddy sediment sites dominated by bivalves. Sites 16 and 18, included with the polychaete/muddy community type are comprised of muddy sediments, but dominated by bivalves. This overlap can be partially accounted for by all these sites being situated in the middle of the ordination space (Figure 2) where it is most difficult for the Twinspan classification analysis to differentiate between sites. A visual examination of the dominant taxa at these sites reveals very similar communities (i.e. *Austrovenus stutchburyi*/*Nucula hartvigiana*/*Aquilaspio aucklandica* dominated). This suggests there may be a further mid harbour bivalve/muddy community type, transitional between the polychaete/muddy and bivalve/sandy community types. However, to establish this a more intensive sampling of the mid harbour region is needed. It is not considered this further level of classification is appropriate at this stage.

The analysis conducted here provides a description of the harbour as a whole; should more site specific information be necessary for the communities encompassed in intertidal groups 2 and 3 in future, this is likely to reveal the finer details of changes in community structure.

Figure 4

Map of Mahurangi Harbour Infaunal communities. Polydorid dominated = intertidal group 1; Polychaete/muddy = intertidal group 2; Bivalve/sandy = intertidal group 3; Outer harbour/sandy = intertidal group 4.

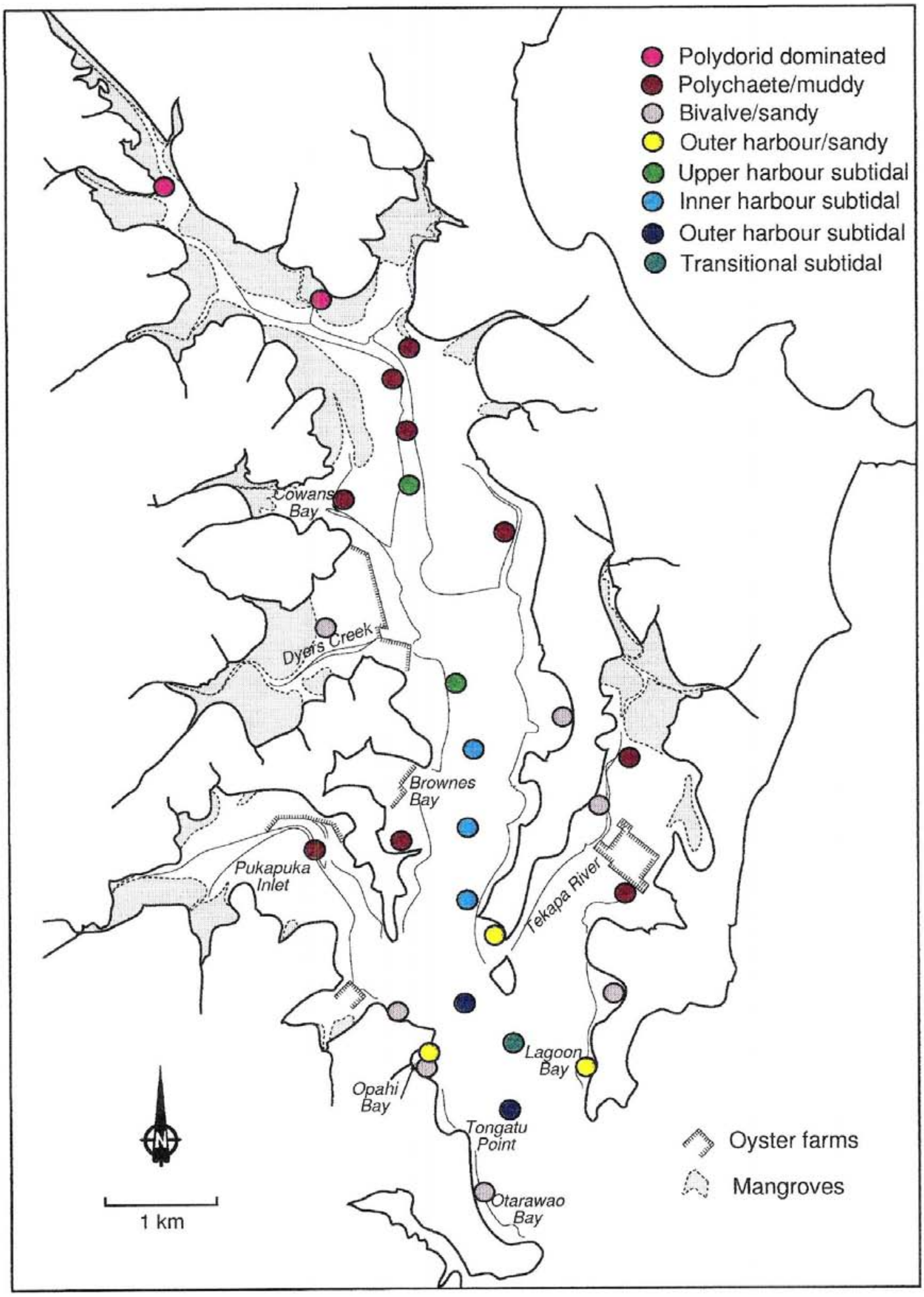


Plate 1

Dense subtidal horse mussel bed.

Plate 2

(Subtidal Site 11). Horse mussel bed showing sponge growth and a sea cucumber (*Sticopus mollis*). Note the fine sediment between mussels.

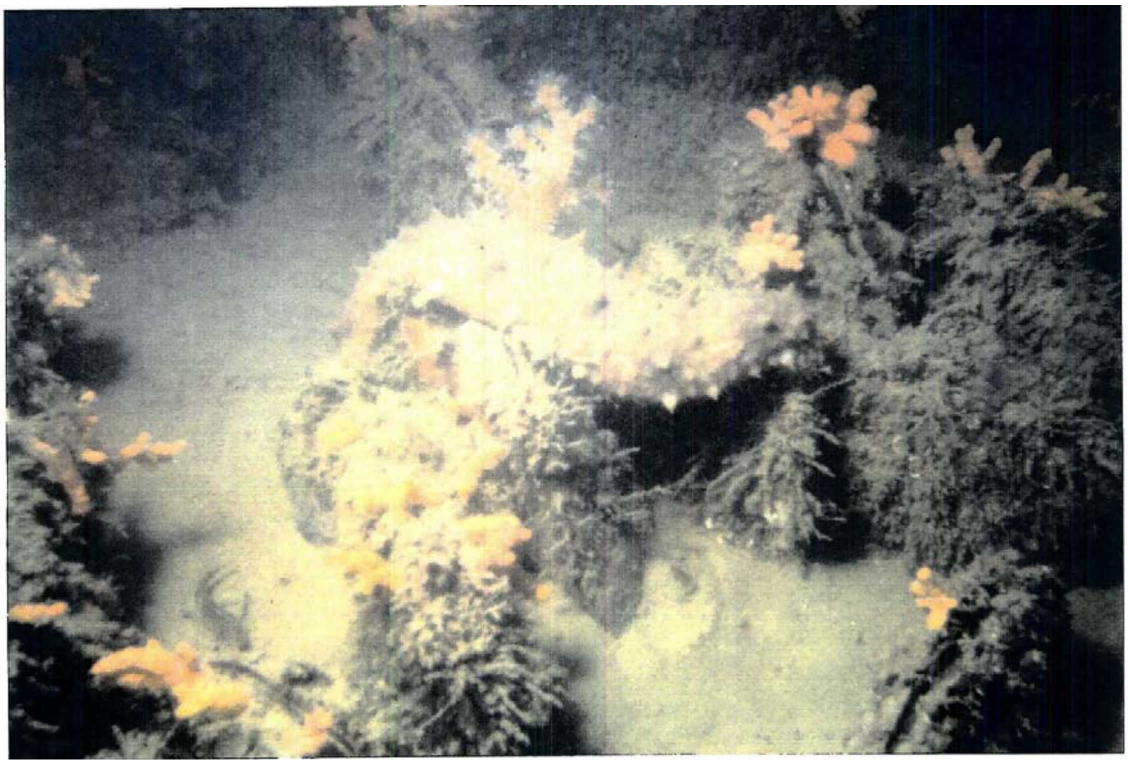


Plate 3

(Subtidal Site 10). Harbour floor littered with shell hash.

Plate 4

(Intertidal Site 2). Heterogeneous, poorly sorted substrate.

Plate 5

(Intertidal Site 7). Sandy, well sorted substrate, littered with shell.

Plate 6

(Intertidal Site 16). Muddy substrate. Note the numerous burrows and faecal mounds.

4.2 Harbour Uses and their Potential Ecological Effects

The variation in community types around Mahurangi harbour is to some degree a reflection of the variety of habitats. In attempting to identify sensitive communities, it is necessary to consider the likely sensitivities of individual species to environmental changes. In order to do this, we must identify possible future uses/developments of the harbour and its catchment, and any associated environmental effects which have the potential to alter the ecology of the harbour. In the following section, we briefly discuss possible uses/developments, consider their potential for environmental effects within the harbour and, where possible, identify species likely to be most affected by these actions.

4.2.1 Possible harbour uses

4.2.1.1 Aquaculture

An aquaculture venture relies on both natural productivity and environmental quality. If poorly managed, it can adversely affect the natural ecology and aesthetics of the harbour. Aquaculture has a substantial effect on the local environment, particularly in sheltered/low flow areas. On a large enough scale at a single site, it can reduce visual amenity and interfere with other uses of the area. Some aquaculture operations (e.g. fish farming) can be a major source of nutrients, while others (e.g. oyster farming) can be important in removing phytoplankton from harbour waters.

Mahurangi Harbour is an important area for spatfall, growth and harvesting of the New Zealand rock oyster *Saccostrea glomerata* Gould (Dinamani and Lenz 1977), and of the Pacific oyster *Crassostrea gigas* (Martin and Foster 1986). Oyster farming is already an important use of the harbour, and is at present the only type of aquaculture undertaken. The presence of an oyster farm alters the sediment and organic makeup of the local environment. Immediately under a farm, the sediments become unconsolidated, fine grained, littered with shell, and enriched with organic matter (Forrest 1991). In a study of two oyster farms in Mahurangi Harbour, Forrest (1991) concluded that, even at the more impacted site, local effects on the benthic community were restricted to within 30 m of the farm. However, even if the two farms studied represent the worst case situation, larger scale effects and effects due to the total number of farms in the harbour also need to be considered. In addition, no information is available at present on the affect of oyster farms in reducing food and larval supply via the oyster's filter-feeding activities.

4.2.1.2 Forestry

Harbour ecosystems are potentially affected by deforestation, road building/maintenance and application of fertilisers, herbicides and pesticides associated with forestry. Deforestation will change streamflow and runoff patterns, disturb the soil and expose it to erosion, and may result in increased sediment and heavy metal input to both streams and estuaries. Road building or maintenance will also increase rates of erosion and sedimentation (MacDonald *et al.* 1991). Runoff of fertilisers applied to growing trees results in increased nutrient input to waterways.

4.2.1.3 Urbanisation

Increasing the human population density within a harbour's catchment raises a number of issues. Construction activities and surface erosion of exposed bare soil during urban development, can result in increased sedimentation in waterways (Vant *et al.* 1993). Adequate stormwater treatment is needed to control likely increased concentrations of heavy metals, organic and microbial contaminants to the harbour as a result of urban runoff. It is important to note that the intensity of the above effects will depend upon rainfall, erosivity of the developed site, the manner of development and the proximity to the estuary, as well as the settling, accumulation, re suspension and dispersal processes acting within the estuary itself (Vant *et al.* 1993). An increased population will also put more pressure on existing harbour resources such as beaches, food (i.e. potential over-exploitation of natural stocks of intertidal shellfish species) and other recreational harbour activities. More intensive harbour use by recreational boats will see input of contaminants associated with boating operations. The building of additional large structures (e.g. marinas, moorings) within the harbour itself will modify flow conditions (potentially promoting sediment deposition) and may be a further contaminant source.

4.2.1.4 Horticulture/Agriculture

Runoff from fertiliser treated fields and from intensive stock raising is a major source of nutrients (especially nitrogen (N) and phosphorous (P)) and contaminants (e.g. microbes, pesticides). Sediment, N and P are commonly viewed as the most widespread agriculturally derived pollutants (Smith *et al.* 1993). Modern pesticides (i.e. herbicides, insecticides and fungicides) are generally thought to be less persistent and more specific than those previously used, and most are non-bioaccumulating (e.g. Montgomery 1993). Smith *et al.* (1993) note the quality of many New Zealand rivers declines progressively on moving downstream, almost invariably matching intensifying rural land use. It can be anticipated that these effects will culminate in estuarine areas.

4.2.1.5 Industrial waste

There are no major industrial complexes within the catchment of Mahurangi Harbour at present. Small industries however, through accidental chemical spillages and poor waste management practices, may collectively result in significant inputs to the harbour.

4.2.1.6 Domestic waste

Sewage consists largely of organic matter and nutrients, but may also contain pathogens, trace metals and other chemicals (OECD 1991). Potential environmental consequences of sewage discharge are of recognisable public concern (e.g. see ARC 1990). These concerns are particularly important when the receiving waters are used for aquaculture, the gathering of natural fish/shellfish stocks, and bathing, as is the case for Mahurangi Harbour. Input of nutrients and micro-organisms are obvious potential problems, but contaminants (e.g. pesticides used in domestic gardens) should also be considered when evaluating potential impacts. Bacterial degradation of sewage can lower dissolved oxygen, and sewage wastes may interfere with phytoplankton productivity (OECD 1991).

4.2.1.7 Fishing

The removal of species and the destruction of habitats (some of which are very likely to be important nursery areas) as a result of both commercial and amateur fishing can potentially have major effects on coastal ecosystems. While commercial dredging/fishing is banned within all New Zealand harbours, such effects due to amateur dredging are likely in Mahurangi Harbour, particularly around the harbour entrance where scallop beds occur. Of particular note are the possible effects on the extensive horse mussel beds in the mid-to-outer harbour. Horse mussels are highly susceptible to damage from fishing (Thrush *et al.* 1993).

Four major categories of environmental effects (i.e. sedimentation, nutrient input, contamination, habitat modification) can be identified as a result of these harbour uses. The relationships between use and effect are summarised in Table 2.

Table 2

Possible harbour uses and their potential effects.

Activity	Sedimentation	Nutrient input	Contamination	Habitat Modification
Aquaculture	✓	✓		✓
Forestry	✓		✓	✓
Urbanisation	✓		✓	✓
Horticulture/Agriculture		✓	✓	
Industrial waste			✓	
Domestic waste		✓	✓	
Fishing				✓

4.2.2 Potential effects

In the above paragraphs we have attempted to summarise various development activities and their potential effects. These effects may be localised or harbour-wide, and may be either short-lived or result in long-term changes which are unlikely to be reversed simply by removing the activity. It is important to stress the difficulties in predicting effects, particularly in the case of a harbour like Mahurangi where little is known about how the ecosystem functions.

Challenges to the system are most likely to result from insidious changes due to diffuse source inputs (especially sediments). Site specific issues (e.g. discharges, harbour engineering works) will have local effects and can be readily identified for separate consideration/treatment. However, it is important to consider and assess the cumulative effects of these, often small, localised activities. For example, local engineering works may modify only a small portion of the harbour's shoreline and impact very localised areas, but the total proportion of the shoreline which is modified as a result of these activities is the important consideration.

The sites which will be impacted by sedimentation, nutrient and contaminant inputs are at least partially dependent upon the circulation patterns and flushing time of the area. Thus to fully quantify the influences on harbour communities/habitats it is apparent that detailed information on the hydrodynamic conditions of Mahurangi Harbour is needed.

In the following section we consider the four potential ecological effects identified in Table 2, and attempt to predict the communities most sensitive to them. In most cases, predictions are not based on extensive information. This highlights the need for both the generation of appropriate information, and for resources to be managed in light of the current uncertainties and various risks associated with the different management options.

4.2.2.1 Sedimentation

Large scale and potentially long term effects on infaunal communities can result from changes in sediment distribution associated with increased sediment inputs. Although little data are available, this would appear to be one of the major environmental effects which has occurred in Manukau Harbour, Upper Waitemata Harbour and Tamaki Estuary associated with the increasing urban development of Auckland. Other forms of catchment development may also result in increased sediment input to the harbour.

An increase of suspended sediments, and sedimentation to the harbour floor are likely to have the most direct, adverse affect on suspension-feeding organisms. Hence, horse mussels and other bivalves will be most susceptible to sediment inputs to Mahurangi Harbour. Suspension-feeding bivalves can have a major influence over energy flow and plankton dynamics of coastal ecosystems (Peterson *et al.* 1994), so any effect on these organisms can potentially have cascading effects on the harbour ecology as a whole. Suspended sediments will also alter the water clarity and hence the productivity of the system. Areas of Mahurangi Harbour identified as more prone to sediment deposition are inlets (particularly those with stream inputs) and the mid-upper harbour area in the vicinity of sites 19, 20, 23 and 24 (T.M. Hume, NIWA Ecosystems, pers comm. Figure 1). As the muddy, mangrove fringed areas are already zones of deposition, these communities are unlikely to be dramatically effected by further sedimentation. These areas also have high numbers of burrowing crabs which actively rework the sediment, leading to the transport of sediment down the harbour. Exceedingly high levels of sedimentation would be needed to smother these benthic communities or drown mangroves - such effects are therefore unlikely. However, should such high sedimentation occur, major changes to the ecology of the harbour would result.

4.2.2.2 Nutrients

Nutrients can enter an estuary via sewage wastes, agricultural runoff, some industrial effluent's, and aquaculture operations (discussed above), as well as via wind driven upwelling, regeneration from coastal sediments, and the atmosphere. Above certain nutrient thresholds (which vary according to a number of biological and physical factors) coastal ecosystems lose the ability to efficiently cycle nutrients. Elevated levels of nutrients (especially nitrogen and phosphorous) can enhance phytoplankton productivity, potentially causing eutrophic conditions. Increased eutrophication alters the subsurface light regime, and may effect seagrass growth. Eutrophication is also known to cause dramatic declines in abundance of suspension-feeding bivalve populations (Peterson *et al.* 1994). Some phytoplankton species produce toxins which contaminate shellfish; phytoplankton blooms can potentially destroy aquaculture operations. Control and monitoring of many nutrient sources (particularly domestic sewage) via treatment of sewage and stormwater is comparatively straight forward, although input may result from poor catchment management. Determination of nutrient levels likely to create eutrophication problems are feasible given information on nutrient dynamics and hydrodynamic conditions.

4.2.2.3 Contamination

Contamination of a harbour may result mainly from agricultural/horticultural runoff or disposal of domestic and industrial waste.

Potential contamination effects are important in Mahurangi Harbour because of its high aesthetic value and the use of the harbour for aquaculture. Given the surface topography of the Mahurangi catchment (in particular the lack of large (> 100 ha) intensively farmed flat areas), the present level of pesticide usage and the comparatively ready degradation of modern pesticides (Montgomery 1993), it is unlikely that appreciable concentrations will enter the water course and subsequently the estuarine environment (R.J. Wilcock, NIWA Ecosystems, pers comm.). Past use of organochlorines (e.g. DDT) is also unlikely to result in contamination associated with erosion as has occurred in other areas of New Zealand (e.g. Canterbury), due to the historically low usage of organochlorines and the relatively high rainfall of the Mahurangi area.

Contamination by heavy metals (e.g. Cadmium, Lead, Zinc, Mercury) may occur as a result of industrial and domestic waste disposal or agricultural runoff (particularly from intensively fertilised areas). High concentrations will have toxic effects on benthic organisms, and can accumulate and concentrate in higher food chain organisms.

Adequate treatment of stormwater, domestic and industrial wastes (i.e. point sources) is likely to control potential contamination problems. Further assessment of potential effects resulting from agricultural runoff is needed.

At the time of this survey, no area of Mahurangi Harbour visited showed obvious signs of contaminant effects.

4.2.2.4 Habitat modification

Modification of habitat(s) may occur from a wide variety of activities (e.g. from amateur dredging, construction of bridges/causeways, reclamation and urban encroachment). These activities result in either a direct physical disturbance of habitats/communities, or they may modify hydrodynamic conditions (e.g. circulation patterns) and effect the movement and abundance patterns of infauna (e.g., Davis *et al.* 1982).

It is difficult to identify communities which will be sensitive to habitat modification, as these effects will be site specific and dependent upon the nature of the modification.

In conclusion, the monitoring and adequate treatment of stormwater and sewage will go a long way towards controlling potential effects as a result of point source input of contaminants and nutrients to the harbour. Similarly, careful planning of catchment and harbour developments can minimise modification of habitats. We consider sedimentation to be the major concern in the development of Mahurangi Harbour and it's catchment.

4.2.3 Sensitive habitats / communities

Due to the general lack of definitive information on the consequences of the above effects on infauna, it is very difficult to identify sensitive communities. Current information does, however, emphasise the potential for impacts on suspension-feeding organisms. Due to their feeding mode (i.e. filtering of, often large (e.g., oysters), volumes of water), suspension feeders are more susceptible to accumulation of contaminants and pathogens, and to siltation as a result of suspended sediments. In Mahurangi Harbour, the most abundant suspension-feeders are bivalve species.

As mentioned above, we consider the major concern in catchment development of Mahurangi Harbour to be sedimentation. The communities of the harbour likely to be most sensitive to sedimentation are the subtidal 'inner harbour' communities (i.e. Horse mussel and *Theora lubrica* dominated areas) and the intertidal 'bivalve dominated sandy' communities (refer Figure 4). The extensive horse mussel beds, for example, situated subtidally in the mid-to-outer harbour (see Section 1) are expected to have a major influence on the ecology of their local habitat, and on the stability, deposition and transportation of sediment throughout the harbour. They are highly susceptible to damage from fishing (e.g. dredging), and any localised large-scale depositions of sediment.

4.3 Monitoring Programme

It is important to note that defining limits to inputs/changes in order to avoid adverse effects on natural communities in the long-term is difficult. Some site specific research to help address this problem is needed. It is also important that the ecological condition of the harbour is monitored so that any community changes are detected. This will allow any shortcomings of predictions to be acted upon before deleterious changes occur. By using an appropriate monitoring programme to test predictions of change, the whole study will provide an important contribution to our understanding of the impacts on harbour ecosystems.

A biological monitoring programme provides information on natural long-term trends and variability in abundance of communities/populations. This enables detection of changes in the environment that deviate from the common pattern, and identification of possible problem areas worthy of more specific study. The value of monitoring the ecology of a system such as Mahurangi Harbour is evident from the long-term biological monitoring programme currently in place in Manukau Harbour (see Thrush *et al.* 1988, 1990, 1991, 1992, Hewitt *et al.* 1993).

The following biological monitoring programme is recommended to assess the overall condition of Mahurangi Harbour, and to document ecological changes which may occur as a direct/indirect consequence of catchment and harbour development. The affect of specific activities, or the ecological state of heavily impacted areas (e.g. around outfalls), which require impact assessment will be more appropriately investigated by site specific studies. However, such specific studies should complement the more general monitoring programme proposed.

The description of present biological resources within Mahurangi Harbour (Section 1) identifies a number of habitat and community types. Specific sites for future monitoring have been chosen on the basis of the locations of sensitive communities and areas likely to be impacted by potential development, and to provide as wide a geographic representation of the harbour as possible. We recommend monitoring the following intertidal and subtidal habitats/sites:

4.3.1.1 Intertidal sites

Five representative sites were chosen in the unvegetated sand/mud flat areas which are a major component of the harbour. As the bivalve/sandy community types have been identified as sensitive habitats (see above section), these are included amongst the sites to be monitored. We do not consider monitoring any sites in the muddy upper harbour (i.e. Polydorid dominated communities) to be useful in the general context of this monitoring programme due to the lack of variety of species, and the potentially highly variable abundance noted for such areas (Roper *et al.* 1988). Similarly, as the outer harbour sandy sites showed low numbers of taxa, and very different community types we do not recommend sampling these. Sites recommended for monitoring are: 4, 15, 18, 23, and 14.

4.3.1.2 Subtidal sites

Three representative subtidal sites should be monitored. As increased sedimentation is considered to be a major concern in the development of Mahurangi Harbour and its catchment, and is likely to have a major effect on horse mussels, these sites should contain horse mussels. We recommend sampling Sites 11, 27 and 29, all of which have horse mussel beds.

4.3.1.3 Sampling

The five intertidal sites should be sampled at 3 monthly intervals, and the three subtidal sites at 6 monthly intervals. Twelve core samples should be collected and processed using the same methodology referred to in this survey (see methods). In addition, at the subtidal sites, underwater videos should be taken to assess the size and densities of the horse mussel populations.

4.3.1.4 Monitored species

The recommended species to be monitored are listed in Appendix 2. These species were selected on the basis of their ecology, likely sensitivity to environmental change, and the practicality of sampling, so that any changes in their abundances are likely to reflect important changes within the harbour. Keystone species (i.e. those which have great influence over community structure and function, e.g. predators), species which occupy a variety of niches (e.g., deposit- and suspension-feeding species, surface dwellers and species which live deeper in the sediments), prey species (i.e., taxa important for humans, birds and fish) and taxa which respond to disturbance and pollution stress are all represented amongst the recommended monitored species. The most abundant species, as well as rarer ones, are also included. As the taxa present at intertidal and subtidal habitats are markedly different, separate lists of species' recommended for monitoring are provided for the intertidal and subtidal sites. A few of these species require more specific taxonomic identification (see Appendix 2).

5 Conclusion

In summary, this report has

1. Documented the present intertidal and subtidal benthic communities of Mahurangi Harbour.
2. Collected baseline data against which shifts in infaunal communities may later be compared.
3. Reported on how different catchment and harbour developments/uses might affect the ecology of the harbour, and has identified limits to the predictions we are currently able to make.
4. Identified infaunal species, communities and habitats which are likely to be sensitive to changes within the harbour or in catchment inputs.
5. Identified sites and recommended methodology for future long-term monitoring of benthic communities within the harbour.

This information will aid in making future decisions concerning catchment/harbour development, and will complement/enhance the other environmental data and models being acquired/developed as part of the Mahurangi Harbour Management Plan.

6 Acknowledgements

We thank John Nagels for assistance with field work, and Stephanie Turner and Don Morrisey for comments on this report.

7 References

ARC, Auckland Regional Water Board 1990. Manukau Harbour Action Plan. 196pp.

Davis, N., Van Blaricom, G.R., Dayton, P.K. 1982. Man-made structures on marine sediments: effects on adjacent benthic communities. Marine Biology 70: 295-303.

Dinamani, P. and Lenz, P.A. 1974. Some aspects of spatfall of the New Zealand rock oyster during 1974. The Veliger 20(1): 17-26.

Forrest, B.M. 1991. Oyster farm impacts on the benthic environment: a study in Mahurangi Harbour. MSc thesis, University of Auckland, New Zealand.

Hewitt, J.E., Thrush, S.F., Pridmore, R.D., Cummings, V.J. 1994. Ecological monitoring programme for Manukau Harbour: analysis and interpretation of data collected October 1987 to February 1993. Unpublished report prepared for the Auckland Regional Council. NIWA Ecosystems Consultancy Report No. ARC120/5. 81p.

MacDonald, L.H., Smart, A.W., Wissmar, R.C. 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific North west and Alaska. U.S. Environmental Protection Agency, Region 10, Center for Streamside Studies EPA 910/9-91-001. Seattle, Washington. 166 p.

Martin, A.T., and Foster, B.A. 1986. Distribution of barnacle larvae in Mahurangi Harbour, North Auckland. New Zealand Journal of Marine and Freshwater Research 20: 67-76.

Montgomery, J.H. 1993. Agrochemicals Desk Reference Environmental Data. Lewis Publishers, Chelsea, Michigan. 625p.

OECD 1991. The state of the environment. Organisation for Economic Co-operation and Development, Paris. 297p.

Peterson, C.H., Irlandi, E.A., Black, R. 1994. The crash in suspension-feeding bivalve populations (Katelysia spp.) in Princes Royal Harbour: an unexpected consequence of eutrophication. Journal of Experimental Marine Biology and Ecology 176: 39-52.

Roper, D.S., Thrush, S.F., Smith, D.G. 1988. The influence of runoff on intertidal mudflat benthic communities. Marine Environmental Research 26: 1-18.

Smith, C.M., Wilcock, R.J., Vant, W.N., Smith, D.G., Cooper, A.B. 1993. Towards sustainable agriculture: freshwater quality in New Zealand and the influence of agriculture. MAF Policy Technical Paper 93/10. 208p.

Thrush, S.F., Cummings, V.J., Hewitt, J.E. 1993. Ecological impacts of shellfish dredging on coastal soft-sediment communities: technical report. Unpublished report prepared for the Department of Conservation. NIWA Ecosystems Consultancy Report No. DOC121a. 68p.

Thrush, S.F., Pridmore, R.D., Hewitt, J.E., Cummings, V.J., Latimer, G.J. 1990. Ecological monitoring programme for the Manukau Harbour: presentation of data collected up to February 1990. Unpublished report prepared for the Auckland Regional Water Board. Water Quality Centre Consultancy Report No. 8046. 53p.

Thrush, S.F., Pridmore, R.D., Hewitt, J.E., Cummings, V.J., Latimer, G.J. 1991. Ecological monitoring programme for the Manukau Harbour: presentation of data collected up to February 1991. Unpublished report prepared for the Auckland Regional Water Board. Water Quality Centre Consultancy Report No. 6120. 67p.

Thrush, S.F., Pridmore, R.D., Hewitt, J.E., Cummings, V.J., Latimer, G.J. 1992 Ecological monitoring programme for the Manukau Harbour: presentation of data collected up to February 1992. Unpublished report prepared for the Auckland Regional Council. Water Quality Centre Consultancy Report No. 6120. 78p.

Thrush, S.F., Pridmore, R.D., Hewitt, J.E., Roper, D.S. 1988. Design of an ecological monitoring programme for the Manukau Harbour. Unpublished report prepared for the Auckland Regional Water Board. Water Quality Centre Consultancy Report No. 7099. 62p.

Vant, W.N., Williamson, R.B., Hume, T.M., Dolphin, T.J. 1993. Effects of future urbanisation in the catchment of Upper Waitemata Harbour. Unpublished report prepared for the Auckland Regional Council. Consultancy Report No. ARC220R. 92p.

Appendix 1

Summary of survey results (includes only those taxa which were collected in core samples).

TAXA	*SITE*	*TOTAL*	*AVE*	*MED*	*RANGE*
Aglaophamus macroura	*3*	*1*	*0.2*	*0*	*0*
Aglaophamus macroura	*4*	*2*	*0.4*	*0*	*1*
Aglaophamus macroura	*5*	*1*	*0.2*	*0*	*0*
Aglaophamus macroura	*6*	*1*	*0.2*	*0*	*0*
Aglaophamus macroura	*7*	*1*	*0.2*	*0*	*0*
Aglaophamus macroura	*9*	*1*	*0.2*	*0*	*0*
Aglaophamus macroura	*26*	*1*	*0.2*	*0*	*0*
Aglaophamus macroura	*29*	*1*	*0.2*	*0*	*0*
Amalda australis	*3*	*1*	*0.2*	*0*	*0*
Amalda australis	*6*	*1*	*0.2*	*0*	*0*
Amalda australis	*9*	*1*	*0.2*	*0*	*0*
Ampelisca sp.	*10*	*5*	*1.25*	*1*	*2.5*
Ampelisca sp.	*28*	*1*	*0.2*	*0*	*0*
Amphipod sp. 1	*2*	*9*	*1.8*	*2*	*2*
Amphipod sp. 1	*3*	*1*	*0.2*	*0*	*0*
Amphipod sp. 2	*2*	*2*	*0.4*	*0*	*1*
Amphipod sp. 3	*3*	*1*	*0.2*	*0*	*0*
Amphipod sp. 4	*3*	*1*	*0.2*	*0*	*0*
Amphipod sp. 5	*12*	*1*	*0.2*	*0*	*0*
Amphipod sp. 6	*12*	*1*	*0.2*	*0*	*0*
Amphipod sp. 7	*12*	*1*	*0.2*	*0*	*0*
Amphipod sp. 8	*12*	*1*	*0.2*	*0*	*0*
Amphipod sp. 9	*12*	*1*	*0.2*	*0*	*0*
Amphipod sp. 9	*22*	*1*	*0.2*	*0*	*0*
Amphipod sp. 10	*12*	*1*	*0.2*	*0*	*0*
Amphipod sp. 11	*12*	*1*	*0.2*	*0*	*0*
Amphipod sp. 12	*11*	*1*	*0.2*	*0*	*0*
Amphipod sp. 12	*28*	*1*	*0.2*	*0*	*0*
Amphipod sp. 13	*11*	*1*	*0.2*	*0*	*0*
Amphipod sp. 13	*12*	*1*	*0.2*	*0*	*0*
Amphipod sp. 13	*28*	*2*	*0.4*	*0*	*0*
Amphipod sp. 14	*22*	*5*	*1*	*0*	*0*
Amphipod sp. 15	*27*	*1*	*0.2*	*0*	*0*
Amphipod sp. 16	*27*	*1*	*0.2*	*0*	*0*
Amphipod sp. 17	*27*	*1*	*0.2*	*0*	*0*
Amphipod sp. 18	*27*	*1*	*0.2*	*0*	*0*

TAXA	SITE	TOTAL	AVE	MED	RANGE
Amphipod sp. 18	*29*	*4*	*0.8*	*1*	*1*
Amphipod sp. 19	*12*	*3*	*0.6*	*1*	*1*
Amphiura sp.	*10*	*3*	*0.75*	*0*	*1.5*
Amphiura sp.	*12*	*5*	*1*	*0*	*2*
Amphiura sp.	*28*	*1*	*0.2*	*0*	*0*
Anemone	*2*	*9*	*1.8*	*1*	*3*
Anemone	*5*	*1*	*0.2*	*0*	*0*
Anemone	*7*	*2*	*0.4*	*0*	*0*
Anemone	*9*	*1*	*0.2*	*0*	*0*
Anemone	*14*	*1*	*0.2*	*0*	*0*
Anemone	*15*	*1*	*0.2*	*0*	*0*
Anemone	*17*	*2*	*0.4*	*0*	*1*
Anemone	*18*	*2*	*0.4*	*0*	*1*
Aonides oxycephala	2	4	0.8	1	1
Aonides oxycephala	14	15	3	3	2
Aonides oxycephala	15	2	0.4	0	0
Aonides oxycephala	16	1	0.2	0	0
Aonides oxycephala	17	1	0.2	0	0
Aphroditidae	21	1	0.2	0	0
Aphroditidae	28	2	0.4	0	1
Aquilaspio aucklandica	2	64	12.8	12	5
Aquilaspio aucklandica	5	1	0.2	0	0
Aquilaspio aucklandica	7	4	0.8	1	1
Aquilaspio aucklandica	9	2	0.4	0	1
Aquilaspio aucklandica	12	4	0.8	1	1
Aquilaspio aucklandica	13	14	2.8	1	1
Aquilaspio aucklandica	14	1	0.2	0	0
Aquilaspio aucklandica	15	59	11.8	9	6
Aquilaspio aucklandica	16	12	2.4	2	2
Aquilaspio aucklandica	17	8	1.6	2	1
Aquilaspio aucklandica	18	4	0.8	1	1
Aquilaspio aucklandica	19	3	0.6	1	1
Aquilaspio aucklandica	20	2	0.4	0	1
Aquilaspio aucklandica	23	13	2.6	2	2
Aquilaspio aucklandica	24	1	0.2	0	0
Aricidea sp.	3	2	0.4	0	1
Aricidea sp.	5	5	1	1	1
Aricidea sp.	6	3	0.6	0	1
Aricidea sp.	8	23	4.6	5	2
Aricidea sp.	9	7	1.4	1	1
Aricidea sp.	10	6	1.5	0.5	3
Aricidea sp.	12	21	4.2	2	5
Aricidea sp.	13	112	22.4	18	12
Aricidea sp.	15	2	0.4	0	1

TAXA	SITE	TOTAL	AVE	MED	RANGE
Aricidea sp.	16	4	0.8	1	1
Aricidea sp.	17	1	0.2	0	0
Aricidea sp.	18	23	4.6	4	2
Aricidea sp.	19	41	8.2	9	6
Aricidea sp.	20	11	2.2	2	1
Aricidea sp.	21	14	2.8	3	2
Aricidea sp.	23	29	5.8	4	2
Aricidea sp.	24	24	4.8	4	2
Aricidea sp.	25	17	3.4	3	0
Aricidea sp.	26	5	1	1	2
Aricidea sp.	27	5	1	1	1
Aricidea sp.	28	8	1.6	2	1
Aricidea sp.	29	17	3.4	4	3
Armandia maculata	2	14	2.8	2	2
Armandia maculata	3	1	0.2	0	0
Armandia maculata	4	2	0.4	0	0
Armandia maculata	6	1	0.2	0	0
Armandia maculata	7	5	1	1	2
Armandia maculata	8	2	0.4	0	1
Armandia maculata	10	1	0.25	0	0.5
Armandia maculata	11	9	1.8	2	2
Armandia maculata	12	8	1.6	1	0
Armandia maculata	13	1	0.2	0	0
Armandia maculata	17	1	0.2	0	0
Armandia maculata	27	2	0.4	0	1
Armandia maculata	28	4	0.8	1	1
Armandia maculata	29	3	0.6	1	1
Arthritica bifurca	2	1	0.2	0	0
Arthritica bifurca	5	3	0.6	0	0
Arthritica bifurca	8	1	0.2	0	0
Arthritica bifurca	10	1	0.25	0	0.5
Arthritica bifurca	11	2	0.4	0	0
Arthritica bifurca	12	2	0.4	0	1
Arthritica bifurca	13	2	0.4	0	1
Arthritica bifurca	15	1	0.2	0	0
Arthritica bifurca	17	11	2.2	0	1
Arthritica bifurca	19	7	1.4	0	3
Arthritica bifurca	23	7	1.4	1	1
Arthritica bifurca	25	90	18	21	8
Arthritica bifurca	26	10	2	3	3
Arthritica bifurca	27	5	1	1	1
Arthritica bifurca	28	7	1.4	1	2
Arthritica bifurca	29	8	1.6	1	1
Asychis theodori	4	1	0.2	0	0

TAXA	SITE	TOTAL	AVE	MED	RANGE
Asychis theodori	5	1	0.2	0	0
Asychis theodori	6	1	0.2	0	0
Asychis theodori	9	7	1.4	1	1
Asychis theodori	13	2	0.4	0	1
Asychis theodori	16	1	0.2	0	0
Asychis theodori	18	1	0.2	0	0
Asychis theodori	19	2	0.4	0	1
Austrovenus stutchburyi	2	68	13.6	13	3
Austrovenus stutchburyi	4	1	0.2	0	0
Austrovenus stutchburyi	5	3	0.6	0	1
Austrovenus stutchburyi	6	1	0.2	0	0
Austrovenus stutchburyi	7	26	5.2	6	5
Austrovenus stutchburyi	8	2	0.4	0	1
Austrovenus stutchburyi	14	59	11.8	10	3
Austrovenus stutchburyi	15	103	20.6	17	9
Austrovenus stutchburyi	16	12	2.4	1	5
Austrovenus stutchburyi	17	49	9.8	8	1
Austrovenus stutchburyi	18	48	9.6	6	11
Austrovenus stutchburyi	19	19	3.8	3	2
Austrovenus stutchburyi	20	1	0.2	0	0
Austrovenus stutchburyi	21	49	9.8	10	4
Austrovenus stutchburyi	23	3	0.6	0	0
Bubble shell	10	1	0.25	0	0.5
Bubble shell	16	3	0.6	0	1
Capitella sp.	2	2	0.4	0	0
Capitella sp.	3	4	0.8	1	1
Capitella sp.	4	3	0.6	1	1
Capitella sp.	6	3	0.6	0	1
Capitella sp.	8	1	0.2	0	0
Capitella sp.	13	3	0.6	1	1
Capitella sp.	15	2	0.4	0	0
Capitella sp.	17	5	1	0	1
Capitella sp.	20	2	0.4	0	1
Capitella sp.	21	47	9.4	7	7
Capitella sp.	22	17	3.4	4	4
Capitella sp.	23	2	0.4	0	1
Capitella sp.	28	1	0.2	0	0
Capitellid (3 spined)	2	1	0.2	0	0
Capitellid (3 spined)	21	5	1	0	0
Capitellid (3 spined)	22	1	0.2	0	0
Capitellid (5 spined)	21	6	1.2	0	0
Capitellid (6 spined)	3	4	0.8	0	2
Capitellid (6 spined)	8	1	0.2	0	0
Capitellid (6 spined)	10	19	4.75	6	3.5

TAXA	SITE	TOTAL	AVE	MED	RANGE
Capitellid (6 spined)	12	31	6.2	6	1
Capitellid (7 spined)	9	1	0.2	0	0
Capitellid (7 spined)	21	1	0.2	0	0
Capitellid (8 spined)	12	1	0.2	0	0
Capitellid (caps + hooks)	23	1	0.2	0	0
Caprelliidae	11	1	0.2	0	0
Caryocorbula zelandica	12	2	0.4	0	1
Chiton	2	5	1	1	0
Chiton	7	1	0.2	0	0
Chiton	9	1	0.2	0	0
Chiton	10	2	0.5	0.5	1
Chiton	12	3	0.6	1	1
Chiton	14	1	0.2	0	0
Chiton	17	3	0.6	0	1
Cirratulidae	1	1	0.2	0	0
Cirratulidae	10	10	2.5	2	4
Cirratulidae	12	5	1	1	0
Cirratulidae	13	2	0.4	0	0
Cirratulidae	15	5	1	1	2
Cirratulidae	17	16	3.2	2	3
Cirratulidae	19	8	1.6	1	1
Cirratulidae	27	9	1.8	1	3
Cirratulidae	28	11	2.2	2	3
Cirratulidae	29	21	4.2	4	0
Colurostylis lemurum	1	6	1.2	1	0
Colurostylis lemurum	4	2	0.4	0	0
Colurostylis lemurum	6	2	0.4	0	1
Colurostylis lemurum	8	1	0.2	0	0
Colurostylis lemurum	14	1	0.2	0	0
Colurostylis lemurum	26	2	0.4	0	0
Colurostylis lemurum	27	1	0.2	0	0
Colurostylis lemurum	28	3	0.6	0	0
Cominella adspersa	13	1	0.2	0	0
Corophidae - complex	3	5	1	0	1
Corophidae - complex	4	1	0.2	0	0
Corophidae - complex	5	1	0.2	0	0
Corophidae - complex	6	5	1	0	1
Corophidae - complex	9	1	0.2	0	0
Corophidae - complex	10	2	0.5	0.5	1
Corophidae - complex	11	2	0.4	0	1
Corophidae - complex	17	1	0.2	0	0
Corophidae - complex	21	5	1	0	2
Corophidae - complex	22	70	14	12	8
Corophidae - complex	26	1	0.2	0	0

TAXA	SITE	TOTAL	AVE	MED	RANGE
Corophidae - complex	27	17	3.4	0	1
Corophidae - complex	29	3	0.6	0	0
Cossura sp.	3	2	0.4	0	1
Cossura sp.	4	8	1.6	1	1
Cossura sp.	5	7	1.4	1	1
Cossura sp.	6	3	0.6	0	1
Cossura sp.	8	13	2.6	3	1
Cossura sp.	10	1	0.25	0	0.5
Cossura sp.	11	2	0.4	0	1
Cossura sp.	12	2	0.4	0	0
Cossura sp.	13	67	13.4	13	6
Cossura sp.	18	1	0.2	0	0
Cossura sp.	19	3	0.6	1	1
Cossura sp.	20	33	6.6	6	4
Cossura sp.	21	3	0.6	1	1
Cossura sp.	22	1	0.2	0	0
Cossura sp.	23	58	11.6	12	11
Cossura sp.	24	10	2	2	0
Cossura sp.	25	7	1.4	2	2
Cossura sp.	28	4	0.8	1	1
Cossura sp.	29	4	0.8	0	2
Cumacean sp. 1	11	1	0.2	0	0
Cumacean sp. 1	12	1	0.2	0	0
Cumacean sp. 1	27	14	2.8	0	0
Cumacean sp. 1	29	26	5.2	4	7
Cumacean sp. 2	26	1	0.2	0	0
Cumacean sp. 2	27	3	0.6	0	0
Cumacean sp. 3	27	9	1.8	0	4
Cumacean sp. 3	28	25	5	3	5
Cumacean sp. 3	29	2	0.4	0	0
Cumacean sp. 4	11	14	2.8	2	2
Cumacean sp. 4	12	1	0.2	0	0
Cumacean sp. 4	26	2	0.4	0	1
Cumacean sp. 4	27	1	0.2	0	0
Cumacean sp. 4	29	39	7.8	9	4
Diloma subrostrata	2	1	0.2	0	0
Diloma subrostrata	14	2	0.4	0	1
Dosinia zelandica	10	2	0.5	0	1
Dosinia zelandica	12	2	0.4	0	1
Echinocardium australe	10	1	0.25	0	0.5
Edwardsia sp.	2	1	0.2	0	0
Euchone sp.	16	4	0.8	0	2
Eunicidae	12	1	0.2	0	0
Exogone sp.	7	1	0.2	0	0

TAXA	SITE	TOTAL	AVE	MED	RANGE
Exogone sp.	21	12	2.4	3	2
Exogone sp.	22	5	1	1	0
Exogonidae 1	3	2	0.4	0	0
Exogonidae 1	5	2	0.4	0	0
Exogonidae 1	14	2	0.4	0	1
Exogonidae 1	15	3	0.6	0	1
Exogonidae 1	19	2	0.4	0	0
Exogonidae 1	22	1	0.2	0	0
Exogonidae 2	10	1	0.25	0	0.5
Exogoninae 1	21	62	12.4	14	8
Exogoninae 1	22	8	1.6	1	3
Exogoninae 1	29	3	0.6	0	1
Exogoninae 2	3	11	2.2	0	2
Exogoninae 2	6	2	0.4	0	1
Exogoninae 2	7	18	3.6	5	5
Exogoninae 2	9	4	0.8	0	1
Exogoninae 2	12	4	0.8	0	1
Exogoninae 2	16	5	1	0	2
Exogoninae 2	21	1	0.2	0	0
Exogoninae 2	22	1	0.2	0	0
Exogoninae 2	24	2	0.4	0	1
Exogoninae 2	25	1	0.2	0	0
Exogoninae 2	26	1	0.2	0	0
Exogoninae 2	28	5	1	1	1
Exogoninae 2	29	3	0.6	0	1
Exogoninae 3	7	4	0.8	0	0
Exogoninae 4	7	2	0.4	0	1
Exogoninae 4	12	3	0.6	1	1
Exogoninae 4	16	1	0.2	0	0
Exogoninae 4	17	1	0.2	0	0
Exogoninae 4	21	2	0.4	0	1
Exogoninae 4	22	1	0.2	0	0
Exogoninae 4	26	1	0.2	0	0
Exogoninae 4	29	1	0.2	0	0
Exosphaeroma sp.	1	33	6.6	7	8
Exosphaeroma sp.	2	2	0.4	0	0
Exosphaeroma sp.	7	1	0.2	0	0
Exosphaeroma sp.	8	1	0.2	0	0
Exosphaeroma sp.	14	2	0.4	0	1
Exosphaeroma sp.	17	2	0.4	0	1
Exosphaeroma sp.	18	1	0.2	0	0
Felaniella zelandica	16	1	0.2	0	0
Gastropod juvenile	7	1	0.2	0	0
Glycera americana	2	3	0.6	1	1

TAXA	SITE	TOTAL	AVE	MED	RANGE
Glycera americana	9	1	0.2	0	0
Glycera americana	12	3	0.6	0	0
Glycera americana	15	2	0.4	0	1
Glycera americana	17	1	0.2	0	0
Glycera americana	18	2	0.4	0	1
Glycera americana	19	1	0.2	0	0
Glycera americana	23	1	0.2	0	0
Glycera americana	28	3	0.6	1	1
Goniada emerita	1	2	0.4	0	0
Goniada emerita	2	1	0.2	0	0
Goniada emerita	3	4	0.8	0	1
Goniada emerita	4	3	0.6	0	1
Goniada emerita	5	1	0.2	0	0
Goniada emerita	6	1	0.2	0	0
Goniada emerita	8	1	0.2	0	0
Goniada emerita	9	1	0.2	0	0
Goniada emerita	10	1	0.25	0	0.5
Goniada emerita	11	1	0.2	0	0
Goniada emerita	12	1	0.2	0	0
Goniada emerita	19	4	0.8	0	1
Goniada emerita	20	4	0.8	0	2
Goniada emerita	21	1	0.2	0	0
Goniada emerita	23	1	0.2	0	0
Goniada emerita	27	2	0.4	0	1
Goniada emerita	28	1	0.2	0	0
Halicarcinus whitei	4	1	0.2	0	0
Halicarcinus whitei	7	1	0.2	0	0
Halicarcinus whitei	12	1	0.2	0	0
Halicarcinus whitei	17	1	0.2	0	0
Halicarcinus whitei	28	2	0.4	0	1
Helice crassa	5	1	0.2	0	0
Helice crassa	15	1	0.2	0	0
Helice crassa	17	1	0.2	0	0
Helice crassa	18	1	0.2	0	0
Helice crassa	21	3	0.6	1	1
Helice crassa	22	9	1.8	2	1
Hemigrapsus crenulatus	15	2	0.4	0	1
Hesionid	2	2	0.4	0	0
Hesionid	29	2	0.4	0	0
Heteromastus filiformis	2	3	0.6	0	1
Heteromastus filiformis	3	2	0.4	0	0
Heteromastus filiformis	4	5	1	1	0
Heteromastus filiformis	5	2	0.4	0	1
Heteromastus filiformis	7	2	0.4	0	0

TAXA	SITE	TOTAL	AVE	MED	RANGE
Heteromastus filiformis	8	22	4.4	4	3
Heteromastus filiformis	9	10	2	2	1
Heteromastus filiformis	13	19	3.8	2	5
Heteromastus filiformis	14	2	0.4	0	0
Heteromastus filiformis	15	35	7	7	3
Heteromastus filiformis	16	4	0.8	1	1
Heteromastus filiformis	17	12	2.4	2	0
Heteromastus filiformis	18	15	3	3	1
Heteromastus filiformis	19	117	23.4	24	7
Heteromastus filiformis	20	80	16	17	1
Heteromastus filiformis	21	54	10.8	11	7
Heteromastus filiformis	22	48	9.6	10	2
Heteromastus filiformis	23	67	13.4	14	2
Heteromastus filiformis	24	24	4.8	3	5
Heteromastus filiformis	25	8	1.6	1	1
Hiatula siliquens	16	1	0.2	0	0
Hiatula siliquens	19	1	0.2	0	0
Hiatula siliquens	23	1	0.2	0	0
Holothurian 1	12	1	0.2	0	0
Holothurian 2	10	2	0.5	0	1
Holothurian 2	12	1	0.2	0	0
Holothurian 3	12	1	0.2	0	0
Holothurian 4	6	2	0.4	0	0
Isocirrus sp.	10	4	1	0.5	2
Leptomya retiaria	28	2	0.4	0	1
Lumbriconereis sp.	28	2	0.4	0	0
Macomona liliana	2	5	1	1	0
Macomona liliana	4	14	2.8	3	3
Macomona liliana	6	2	0.4	0	1
Macomona liliana	7	4	0.8	0	1
Macomona liliana	8	8	1.6	1	2
Macomona liliana	11	1	0.2	0	0
Macomona liliana	13	2	0.4	0	1
Macomona liliana	14	9	1.8	1	1
Macomona liliana	15	11	2.2	2	1
Macomona liliana	16	6	1.2	1	0
Macomona liliana	17	15	3	3	1
Macomona liliana	18	13	2.6	2	2
Macomona liliana	19	15	3	2	1
Macomona liliana	20	12	2.4	3	1
Macomona liliana	23	16	3.2	2	1
Macomona liliana	24	7	1.4	1	3
Macroclymenella stewartensis	12	4	0.8	0	1
Macroclymenella stewartensis	13	2	0.4	0	0

TAXA	SITE	TOTAL	AVE	MED	RANGE
Macroclymenella stewartensis	16	1	0.2	0	0
Macroclymenella stewartensis	19	1	0.2	0	0
Mactra ovata	18	1	0.2	0	0
Maera mastersi	12	5	1	0	1
Magelona ?dakini	6	6	1.2	1	1
Magelona ?dakini	15	2	0.4	0	1
Magelona ?dakini	16	2	0.4	0	1
Maldanidae sp. 1	3	1	0.2	0	0
Maldanidae sp. 1	4	1	0.2	0	0
Maldanidae sp. 1	5	1	0.2	0	0
Maldanidae sp. 1	6	1	0.2	0	0
Maldanidae sp. 1	7	2	0.4	0	1
Maldanidae sp. 1	8	1	0.2	0	0
Maldanidae sp. 1	9	2	0.4	0	1
Maldanidae sp. 2	10	2	0.5	0.5	1
Maldanidae sp. 3	26	1	0.2	0	0
Maldanidae sp. 3	28	1	0.2	0	0
Maldanidae sp. 3	29	1	0.2	0	0
Maldanidae sp. 4	12	4	0.8	0	0
Maldanidae sp. 5	27	1	0.2	0	0
Melliteryx parva	12	6	1.2	0	0
Methalimdeon sp.	24	1	0.2	0	0
Methalimdeon sp.	25	2	0.4	0	1
Modiolarca impacta	12	1	0.2	0	0
Musculista senhousia	21	8	1.6	0	0
Mysella hounselli	12	1	0.2	0	0
Mysella hounselli	28	1	0.2	0	0
Mysid shrimp	3	1	0.2	0	0
Mysid shrimp	7	1	0.2	0	0
Mysid shrimp	25	1	0.2	0	0
Mysid shrimp	27	1	0.2	0	0
Mytilidae	26	1	0.2	0	0
Nemertean	1	15	3	2	3
Nemertean	2	2	0.4	0	0
Nemertean	3	2	0.4	0	0
Nemertean	5	6	1.2	0	1
Nemertean	6	5	1	1	1
Nemertean	7	15	3	3	3
Nemertean	8	1	0.2	0	0
Nemertean	9	4	0.8	1	1
Nemertean	10	4	1	0.5	2
Nemertean	14	3	0.6	1	1
Nemertean	15	1	0.2	0	0
Nemertean	16	2	0.4	0	1

TAXA	SITE	TOTAL	AVE	MED	RANGE
Nemertean	17	4	0.8	0	1
Nemertean	18	4	0.8	0	2
Nemertean	19	9	1.8	1	0
Nemertean	21	9	1.8	1	2
Nemertean	22	3	0.6	1	1
Nemertean	23	3	0.6	1	1
Nemertean	25	3	0.6	1	1
Nemertean	26	1	0.2	0	0
Nemertean	27	1	0.2	0	0
Nemertean	28	4	0.8	1	1
Nemertean	29	3	0.6	1	1
Nicon sp.	20	6	1.2	0	1
Nicon sp.	23	3	0.6	0	0
Notoacmea sp.	2	2	0.4	0	1
Notoacmea sp.	4	3	0.6	1	1
Notoacmea sp.	6	1	0.2	0	0
Notoacmea sp.	14	32	6.4	4	1
Notoacmea sp.	15	13	2.6	1	0
Notoacmea sp.	17	7	1.4	1	2
Notoacmea sp.	18	1	0.2	0	0
Notomastus sp.	12	1	0.2	0	0
Notomithrax minor	12	2	0.4	0	1
Nucula hartvigiana	2	22	4.4	6	5
Nucula hartvigiana	4	33	6.6	5	1
Nucula hartvigiana	5	1	0.2	0	0
Nucula hartvigiana	6	3	0.6	0	1
Nucula hartvigiana	7	11	2.2	1	4
Nucula hartvigiana	8	12	2.4	2	2
Nucula hartvigiana	11	7	1.4	1	1
Nucula hartvigiana	14	5	1	1	1
Nucula hartvigiana	15	26	5.2	5	1
Nucula hartvigiana	16	47	9.4	6	4
Nucula hartvigiana	17	44	8.8	5	9
Nucula hartvigiana	18	31	6.2	5	8
Nucula hartvigiana	19	1	0.2	0	0
Nucula hartvigiana	20	1	0.2	0	0
Nucula hartvigiana	23	2	0.4	0	1
Nucula hartvigiana	25	6	1.2	1	1
Nucula hartvigiana	26	2	0.4	0	1
Nucula hartvigiana	28	1	0.2	0	0
Offadesma angasi	29	1	0.2	0	0
Oligochaete	2	15	3	0	0
Oligochaete	4	1	0.2	0	0
Oligochaete	5	1	0.2	0	0

TAXA	SITE	TOTAL	AVE	MED	RANGE
Oligochaete	7	6	1.2	0	1
Oligochaete	8	1	0.2	0	0
Oligochaete	9	2	0.4	0	0
Oligochaete	10	4	1	0	2
Oligochaete	11	7	1.4	0	0
Oligochaete	12	601	120.2	115	190
Oligochaete	13	3	0.6	1	1
Oligochaete	14	2	0.4	0	0
Oligochaete	15	2	0.4	0	1
Oligochaete	17	2	0.4	0	1
Oligochaete	18	2	0.4	0	0
Oligochaete	19	5	1	1	2
Oligochaete	20	7	1.4	0	2
Oligochaete	21	106	21.2	10	12
Oligochaete	22	91	18.2	9	16
Oligochaete	23	10	2	1	1
Oligochaete	24	2	0.4	0	1
Oligochaete	25	8	1.6	2	1
Oligochaete	26	6	1.2	0	1
Oligochaete	27	12	2.4	2	4
Oligochaete	28	60	12	11	2
Oligochaete	29	36	7.2	5	12
Ophiuroid	10	4	1	0.5	2
Ophiuroid	28	1	0.2	0	0
Ophiuroid	29	2	0.4	0	1
Orbinidae (juvenile)	8	1	0.2	0	0
Orbinidae (juvenile)	29	4	0.8	1	0
Ostracoda	1	1	0.2	0	0
Ostracoda	4	2	0.4	0	1
Ostracoda	5	1	0.2	0	0
Ostracoda	6	2	0.4	0	0
Ostracoda	7	2	0.4	0	0
Ostracoda	8	19	3.8	4	1
Ostracoda	10	2	0.5	0.5	1
Ostracoda	11	9	1.8	2	2
Ostracoda	12	4	0.8	0	1
Ostracoda	16	1	0.2	0	0
Ostracoda	17	2	0.4	0	0
Ostracoda	18	6	1.2	0	1
Ostracoda	19	2	0.4	0	0
Ostracoda	20	2	0.4	0	0
Ostracoda	23	3	0.6	0	1
Ostracoda	24	14	2.8	2	3
Ostracoda	25	7	1.4	1	2

TAXA	SITE	TOTAL	AVE	MED	RANGE
Ostracoda	26	24	4.8	6	6
Ostracoda	27	17	3.4	4	3
Ostracoda	28	8	1.6	1	2
Ostracoda	29	15	3	3	3
Owenia fusiformis	4	2	0.4	0	1
Owenia fusiformis	7	2	0.4	0	1
Paguristes setosus	4	1	0.2	0	0
Paguristes setosus	9	1	0.2	0	0
Paguristes setosus	10	4	1	0.5	2
Paguristes setosus	12	4	0.8	0	0
Paguristes setosus	12	17	3.4	1	4
Paguristes setosus	28	2	0.4	0	0
Paphies australis	1	5	1	1	1
Paphies australis	2	17	3.4	2	1
Paphies australis	4	1	0.2	0	0
Paphies australis	5	2	0.4	0	1
Paphies australis	14	3	0.6	0	1
Paracalliope novizealandiae	2	2	0.4	0	0
Paracalliope novizealandiae	3	1	0.2	0	0
Paracalliope novizealandiae	4	7	1.4	1	2
Paracalliope novizealandiae	6	3	0.6	0	1
Paracalliope novizealandiae	7	13	2.6	1	3
Paracalliope novizealandiae	9	5	1	1	1
Paracalliope novizealandiae	11	3	0.6	0	1
Paracalliope novizealandiae	12	1	0.2	0	0
Paracalliope novizealandiae	13	2	0.4	0	0
Paracalliope novizealandiae	16	2	0.4	0	0
Paracalliope novizealandiae	17	1	0.2	0	0
Paracalliope novizealandiae	23	3	0.6	0	1
Paracalliope novizealandiae	24	3	0.6	0	0
Parionidae Type 2	3	6	1.2	0	1
Parionidae Type 2	5	32	6.4	4	6
Parionidae Type 2	12	1	0.2	0	0
Parionidae Type 2	21	5	1	1	1
Parionidae Type 2	22	6	1.2	0	1
Parionidae Type 2	23	1	0.2	0	0
Parionidae Type 2	24	1	0.2	0	0
Patellid starfish	12	1	0.2	0	0
Pectinaria australis	3	1	0.2	0	0
Pectinaria australis	8	1	0.2	0	0
Pectinaria australis	10	5	1.25	1.5	1.5
Pectinaria australis	11	1	0.2	0	0
Pectinaria australis	12	1	0.2	0	0
Pectinaria australis	19	2	0.4	0	1

TAXA	SITE	TOTAL	AVE	MED	RANGE
Pectinaria australis	23	1	0.2	0	0
Pectinaria australis	26	8	1.6	1	2
Pectinaria australis	28	3	0.6	0	0
Perinereis nuntia	7	1	0.2	0	0
Perinereis nuntia	8	2	0.4	0	1
Perinereis nuntia	13	17	3.4	3	1
Perinereis nuntia	14	17	3.4	2	3
Perinereis nuntia	15	9	1.8	1	1
Perinereis nuntia	16	4	0.8	0	1
Perinereis nuntia	17	4	0.8	0	2
Perinereis nuntia	18	8	1.6	1	2
Perinereis nuntia	19	41	8.2	6	7
Perinereis nuntia	20	10	2	1	1
Perinereis nuntia	21	3	0.6	0	1
Perinereis nuntia	22	6	1.2	1	1
Perinereis nuntia	23	6	1.2	0	2
Perinereis nuntia	24	1	0.2	0	0
Perinereis nuntia	28	3	0.6	0	1
Phoronida	6	2	0.4	0	1
Phoronida	7	2	0.4	0	1
Phoronida	9	1	0.2	0	0
Phoxocephalidae - complex	4	1	0.2	0	0
Phoxocephalidae - complex	12	1	0.2	0	0
Phoxocephalidae - complex	27	2	0.4	0	1
Phoxocephalidae - complex	28	1	0.2	0	0
Phoxocephalidae - complex	29	1	0.2	0	0
Phyllamphicteis sp.	10	1	0.25	0	0.5
Phyllodocidae sp. 1	2	1	0.2	0	0
Phyllodocidae sp. 2	12	1	0.2	0	0
Polydorid	2	8	1.6	0	1
Polydorid	3	32	6.4	1	1
Polydorid	4	8	1.6	1	3
Polydorid	5	2	0.4	0	1
Polydorid	7	5	1	1	0
Polydorid	8	4	0.8	0	0
Polydorid	12	16	3.2	0	1
Polydorid	13	3	0.6	1	1
Polydorid	14	4	0.8	1	1
Polydorid	15	2	0.4	0	1
Polydorid	16	5	1	1	2
Polydorid	17	1	0.2	0	0
Polydorid	18	7	1.4	1	1
Polydorid	19	36	7.2	6	5
Polydorid	20	13	2.6	2	1

TAXA	SITE	TOTAL	AVE	MED	RANGE
Polydorid	21	608	121.6	126	89
Polydorid	22	355	71	70	18
Polydorid	23	11	2.2	2	2
Polydorid	25	1	0.2	0	0
Polydorid	26	4	0.8	0	2
Polydorid	27	6	1.2	0	2
Polydorid	28	46	9.2	4	10
Polydorid	29	14	2.8	3	1
Prionospio cirrifera	10	2	0.5	0.5	1
Prionospio cirrifera	11	11	2.2	3	2
Prionospio multicrista	29	1	0.2	0	0
Prionospio sp.	19	1	0.2	0	0
Prionospio sp.	27	4	0.8	0	1
Prionospio sp.	28	9	1.8	2	3
Prionospio sp.	29	10	2	2	1
Purpurocardia purpurata	28	1	0.2	0	0
Ruditapes largillierti	12	2	0.4	0	0
Ruditapes largillierti	28	2	0.4	0	0
Sabellidae	6	4	0.8	0	2
Sabellidae	9	2	0.4	0	1
Sabellidae	21	1	0.2	0	0
Sabellidae	22	5	1	0	0
Schistomeringos sp.	27	1	0.2	0	0
Scolecolepides benhami	15	1	0.2	0	0
Scolecolepides benhami	17	1	0.2	0	0
Scoloplos cylindifera	14	22	4.4	4	3
Serpulidae	10	2	0.5	0	1
Serpulidae	12	1	0.2	0	0
Serpulidae	29	11	2.2	0	0
Sigapatella sp.	10	7	1.75	0	3.5
Sigapatella sp.	12	1	0.2	0	0
Spermosyllis sp.	25	1	0.2	0	0
Spermosyllis sp.	28	1	0.2	0	0
Sphaerosyllis sp.	12	1	0.2	0	0
Sphaerosyllis sp.	19	1	0.2	0	0
Spionidae juvenile	5	1	0.2	0	0
Syllidae	29	1	0.2	0	0
Syllis sp. 1	3	1	0.2	0	0
Syllis sp. 1	5	2	0.4	0	0
Syllis sp. 2	10	1	0.25	0	0.5
Syllis sp. 3	10	1	0.25	0	0.5
Tanaidae (Type B)	4	1	0.2	0	0
Tanaidae (Type B)	10	3	0.75	0.5	1.5
Tanaidae (Type B)	11	10	2	0	0

TAXA	SITE	TOTAL	AVE	MED	RANGE
Tanaidae (Type CI)	10	1	0.25	0	0.5
Tanaidae (Type LB)	10	1	0.25	0	0.5
Tanaidae (Type S)	3	1	0.2	0	0
Tanaidae (Type S)	4	1	0.2	0	0
Tanaidae (Type S)	7	1	0.2	0	0
Tanaidae	3	13	2.6	1	5
Tanaidae	4	2	0.4	0	1
Tanaidae	5	1	0.2	0	0
Tanaidae	6	3	0.6	0	0
Tanaidae	7	2	0.4	0	1
Tanaidae	9	4	0.8	1	1
Tanaidae	12	3	0.6	0	1
Tanaidae	26	1	0.2	0	0
Tanaidae	28	3	0.6	0	1
Tawera spissa	11	4	0.8	0	1
Tawera spissa	13	2	0.4	0	1
Tawera spissa	27	4	0.8	0	2
Tawera spissa	29	2	0.4	0	0
Terebellidae	11	1	0.2	0	0
Terebellidae	12	1	0.2	0	0
Terebellides sp.	27	2	0.4	0	0
Terebellides sp.	28	7	1.4	1	0
Theora lubrica	8	39	7.8	7	8
Theora lubrica	11	21	4.2	4	4
Theora lubrica	13	3	0.6	0	1
Theora lubrica	19	2	0.4	0	1
Theora lubrica	20	2	0.4	0	1
Theora lubrica	23	7	1.4	2	2
Theora lubrica	24	9	1.8	1	1
Theora lubrica	25	19	3.8	2	4
Theora lubrica	26	46	9.2	9	13
Theora lubrica	27	36	7.2	10	9
Theora lubrica	28	31	6.2	4	2
Theora lubrica	29	25	5	5	2
Torridoharpinia hurleyi	4	9	1.8	0	3
Torridoharpinia hurleyi	5	4	0.8	0	1
Torridoharpinia hurleyi	6	6	1.2	1	1
Torridoharpinia hurleyi	7	1	0.2	0	0
Torridoharpinia hurleyi	8	2	0.4	0	1
Torridoharpinia hurleyi	9	1	0.2	0	0
Torridoharpinia hurleyi	10	2	0.5	0.5	1
Torridoharpinia hurleyi	11	8	1.6	2	3
Torridoharpinia hurleyi	12	1	0.2	0	0
Torridoharpinia hurleyi	13	8	1.6	1	1

TAXA	SITE	TOTAL	AVE	MED	RANGE
Torridoharpinia hurleyi	15	3	0.6	1	1
Torridoharpinia hurleyi	17	2	0.4	0	0
Torridoharpinia hurleyi	18	6	1.2	1	1
Torridoharpinia hurleyi	19	5	1	1	2
Torridoharpinia hurleyi	20	7	1.4	1	1
Torridoharpinia hurleyi	21	1	0.2	0	0
Torridoharpinia hurleyi	23	10	2	3	3
Torridoharpinia hurleyi	24	2	0.4	0	1
Torridoharpinia hurleyi	25	4	0.8	0	1
Torridoharpinia hurleyi	27	11	2.2	2	1
Torridoharpinia hurleyi	28	10	2	0	1
Torridoharpinia hurleyi	29	19	3.8	3	4
Unident. juvenile bivalve	29	1	0.2	0	0
Waitangi brevirostris	2	2	0.4	0	0
Zegaluris tenuis	10	2	0.5	0.5	1
Zegaluris tenuis	28	6	1.2	0	1
Zenatia acinaces	28	1	0.2	0	0

Appendix 2

List of species' recommended for monitoring:

Intertidal		
Bivalves	*Polychaetes*	*Crustaceans*
Arthritica bifurca	*Aonides oxycephala*	*Paracalliope novizealandiae*
Austrovenus stutchburyi	*Aquilaspio aucklandica*	*Torridoharpinia hurleyi*
Macomona liliana	*Aricidea sp.*	*Helice crassa*
Nucula hartvigiana	*Cossura sp.*	
	Heteromastus filiformis	*Other*
Gastropod	*Perinereis nuntia*	*Nemerteans*
*Notoacmea sp.**	*Polydorids**	*Oligochaetes***
	Scoloplos cylindifera	
	Owenia fusiformis	

Subtidal †		
Bivalves	*Polychaetes*	*Crustaceans*
Arthritica bifurca	*Armandia maculata*	*Corophidae - complex**
Nucula hartvigiana	*Aricidea sp.*	*Torridoharpinia hurleyi*
Tawera spissa	*Cirratulids**	*Tanaid (Type B)**
Theora lubrica	*Polydorids**	*Cumacean sp.4**
	Prionospio sp.	
	Other	
	*Oligochaetes***	

* Denotes species which require more specific taxonomic identification.
** Also require more specific taxonomic identification. An attempt at this was made by a world expert, Prof. C. Erseus (Sweden) but, due to the lack of sexually mature specimens, was not possible.
† The list of subtidal species to be monitored includes only those organisms collected in core samples. Information on horse mussels, and any associated organisms will be obtained from analysis of underwater video footage.