HAWKE'S BAY REGIONAL COUNCIL

AHURIRI ESTUARY

ENVIRONMENTAL EVALUATION

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BIORESEARCHES

Consulting Biologists & Archaeologists - Est. 1972
P.O. Box 2828, Auckland 1, New Zealand
www.bioresearches.co.nz

Hawke's Bay Regional Council

Ahuriri Estuary

Environmental Evaluation

JULY 2004

FOR : Hawke's Bay Regional Council
BY : Bioresearches
S E White, M.Sc (Hons)

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C O N T E N T S

1 INTRODUCTION

The Ahuriri Estuary is a remnant of the Ahuriri Lagoon or Napier Inner Harbour. This large impounded water body was dramatically reduced in size in 1931 when the Napier earthquake lifted the bed of the lagoon between 1.5 and 3.4 metres, exposing approximately 1300 hectares of the bed of the lagoon. A variety of works and reclamations have further reduced the area of the estuary by around 1700 hectares to its current size.

The estuary has two road crossings, a low level bridge or ford and a railway crossing and has approximately 175 hectares of wetland area in the reclaimed land adjacent to the estuary proper. This includes Northern Pond, Westshore Lagoon and Southern Marsh.

The 275 hectares of high tide estuarine water area are divided into several management compartments. The area from Pandora Bridge to the Embankment Bridge is referred to as the Lower Estuary, the area from the Embankment Bridge to immediately upstream of the confluence with the Taipo Stream is referred to as the Middle Estuary and the area above the confluence with the Taipo Stream is referred to as the Upper Estuary. The area seawards of the Pandora Bridge is known as the Inner Harbour and is outside the study area but is of relevance as the seawater entering the estuary must pass through the Inner Harbour and therefore the quality of the estuarine waters can be profoundly affected by activity within the Inner Harbour.

The Inner Harbour opens to Hawke Bay and is demarked to the west by the Pandora Bridge. This small boat harbour has a groyned entrance with a large breakwater to prevent bar formation, however, the entrance still requires maintenance dredging to maintain sufficient depth for safe navigation. The Inner Harbour contains the Iron Pot, a berthage facility constructed in a natural deep basin just inside the entrance. The Inner Harbour is surrounded by factories, warehouses, bars, restaurants and a yacht club on the southern shore, and by houses, water related industries and community facilities on its northern shore.

The Lower Estuary features broad tidal flats and shallow channels with a partial impoundment area known as Pandora Pond. This area is flanked on its southern edge by industrial development and supports various recreational activities such as sailing, windsurfing, swimming and canoeing.

The Middle Estuary is essentially a narrow stop banked stretch featuring islands and channels as well as a low level bridge or ford. The Middle Estuary has 38 hectares of recreation reserve and wetlands to the north, namely the Northern Pond and the Westshore Lagoon while to the south lies the Southern Marsh. These wetlands are separated from the estuary by stop banks, however, Westshore Lagoon is connected to the estuary via a culvert. The upstream end of Middle Estuary is generally more shallow than the downstream end. The lands bordering the Middle Estuary are drained pastoral lands, including the airport to the north, while further to the south the industrial development of Onekawa and the residential neighbourhoods of Tamatea and Greenmeadows contribute stormwater to the estuary. At the head of the Middle Estuary the Taipo Stream enters from the south.

The Upper Estuary swings northward above the confluence with the Taipo Stream around the base of the Poraiti Hills. A stop bank defines the eastern shoreline while the western shore is close to the original shoreline of the lagoon. Several small streams enter the estuary through ponding and wetland areas on the western shore from the Poraiti Hills, which support low density rural-residential development. The Upper Estuary, while still tidal, is progressively less saline toward the upper reaches. At Maori Head a long canal enters the estuary from the north through an area of raupo swamp.

Most of the estuary's 13,128 hectares of catchment has been developed for pastoral use with few areas of native vegetation remaining. Some areas of unproductive land have been developed into forestry woodlots, while some crops are grown in the Tannery Road and Meeanee areas and there are orchards, vineyards and market gardens north of Maori Head. The area between Pandora Bridge and the low level bridge, including Westshore Lagoon and the Southern Marsh (*i.e.* the Lower Estuary and most of the Middle Estuary), has been declared a Wildlife Refuge (Gazette, 1958, p.654) under the Wildlife Act 1953.

The Ahuriri Estuary's unique geological history, significant wildlife habitats, marine fisheries, education and recreation values coupled with the fact that it's the only sizeable east coast estuarine wetland system between the Bay of Plenty and Wellington make it a resource of local, regional and national significance.

The Hawke's Bay Regional Council commissioned a study to investigate the Ahuriri Estuary to provide baseline data against which future shifts in habitat and infaunal communities could be compared, to improve the understanding of the current impacts of stormwater on the Estuary, to identify areas of concern within the catchment and to identify areas of significant conservation or ecological value as well as areas of particular sensitivity.

The methodology for the investigation was specified as following the Ministry for the Environment (2002) *Estuarine Environmental Assessment and Monitoring Protocol* as a guide for the methods of habitat mapping and assessment, flora and fauna monitoring, however, sediment quality and sediment texture analyses were to be conducted by another agent working for the Hawke's Bay Regional Council. The investigation specifications included a requirement to assess habitat type, dominant vegetation cover, aquatic plants and algae, benthic infauna, benthic epifauna, benthic microalgae and water quality.

The fieldwork for this investigation was conducted from 29 September 2003 till 3 October 2003.

2 HABITAT TYPE AND TERRESTRIAL VEGETATION

The study area comprised the shoreline of the Lower Estuary, the adjacent wetlands west of the railway and the new expressway and the shores of the main estuary channel, up to c. 10 km from the opening to the sea, to what is more or less the top of the tidal part of this channel. This area was surveyed from 29-31 September 2003.

The main features of botanical interest are presented here as a set of captions relating to six parts (A-F) of the study area, which themselves are subdivided, to make a total of 20 habitat areas. Most of these are found in the Lower Estuary or somewhat further westwards; the locations of these habitat areas are shown in Figures 2.1 and 2.2.

Scientific names for plants and corresponding names are given in Section 2.2 of this report.

2.1 Habitat Types (refer to Figure 2.1 and 2.2)

A. Lower Estuary

A1. Humber St Beach

Mown turf, mainly of sickle grass, at the edge of fine beach gravels. Further west, along foot of the Pandora Road embankment, vegetation is lacking.

A2. Meeanee Quay Frontage and Northern Shore to Railway Embankment.

A slope of mown grassland descends from the road onto a fringe of sickle grass (with a notable amount of silver beet, *Beta vulgaris*) and then, on the sandy ground at mean high water, a fringe of glasswort mostly 1-2 metres wide. Projecting into the estuary here in a southwest direction there is a broad strip of low, irregular-surfaced gravelly ground, carrying paths and boardwalks. Its drier parts carry grassland (bromes, legume herbs, etc) with ngaio plantings and a few boneseed bushes. A few colonies of ice-plant were the only natives seen. Along the south facing shore the glasswort fringe is generally continuous and 5 metres or more wide. Further west there is another low strip of projecting ground. It appears at least partly to be composed of coarse fill and its seaward edges have only a limited development of glasswort (with *Samolus repens*) mostly just above mean high water rather than in the muds below. There are only a few sea-rush tussocks here. Similarly, the rubbly foot of the railway

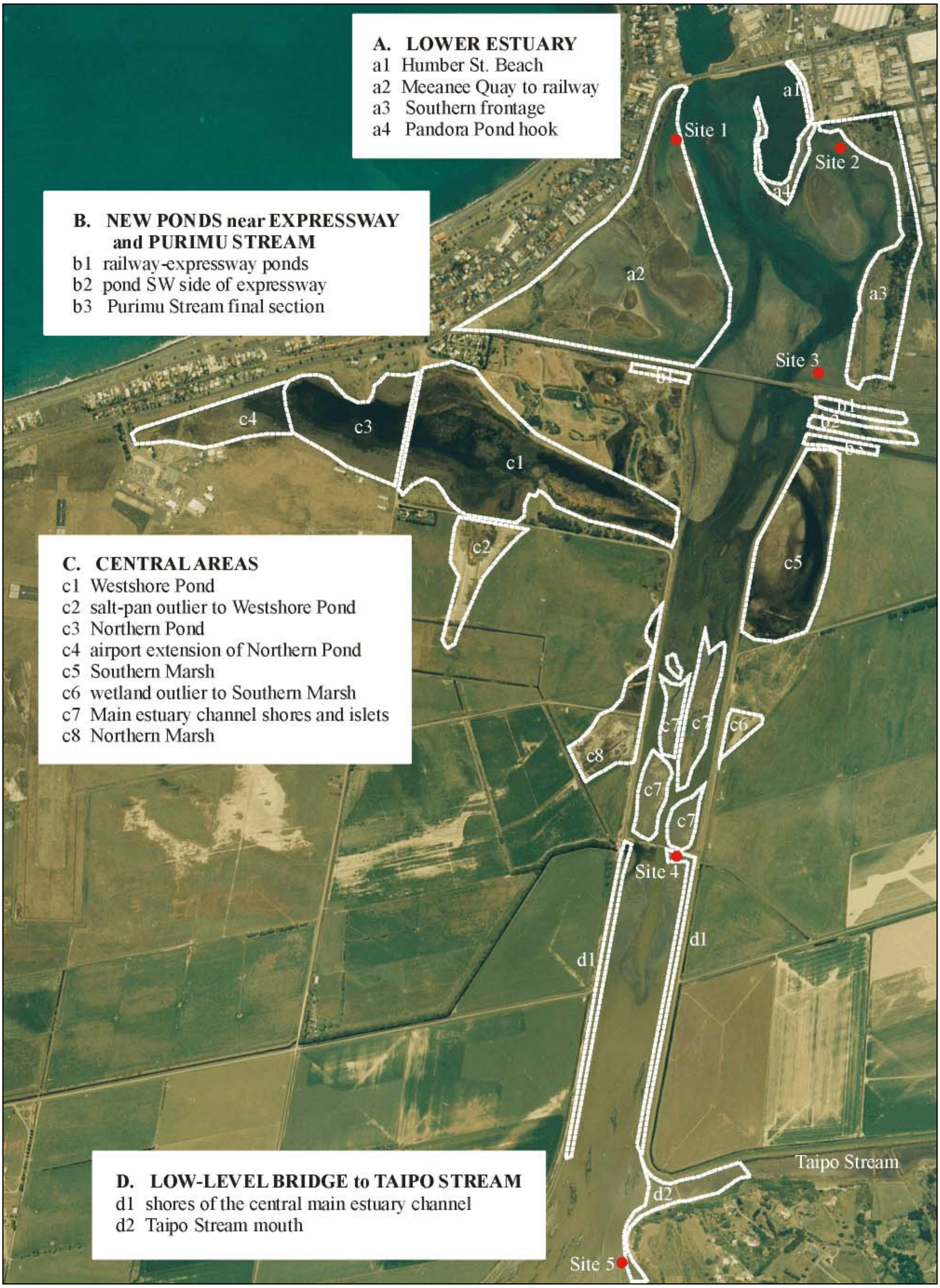


Figure 2.1: Habitat Types Identified in Lower and Middle Ahuriri Estuary

embankment has old glasswort plants in a band c. 1 metre wide immediately above mean high water, but none lower down, and sea-rush is lacking. An infestation of small tamarisk bushes at one place on the shore has been controlled, though a few were not quite dead.

A3. Southern Frontage

There is an embayment of somewhat irregular-surfaced ground less than a metre above mean high water. This seems to be natural terrain and composed mostly of sand rather than gravels. Its landward side has been planted with eucalypts and ngaio. Its seaward side is a grassy expanse of humocked tall fescue and patches of blackberry, but knob-rush is quite common and there are also what would seem to be old relic tussocks of sea-rush.

An artificial channel cuts off an outer sliver of this grassland; its sides, and the estuary frontage here have both glasswort and sea-rush, often with a loose turf between the sea-rush tussocks of buckshorn plantain and sea spurrey. Knob-rush flourishes on the tops of the exposed places, perhaps in response to small accumulations of sand.

The large drains of Tyne Street and Thames Street define the inner edge of the southern frontage. The former one has scattered glasswort bushes up to its floodgate, the latter hardly any. Knob-rush is plentiful along the drain tops, in the open and among plantings of trees.

A4. Pandora Pond's Hook

Formed on partially cemented gravels and shells, this narrow low feature is just high enough (c. 50 cm or so) above mean high water, at least in its basal part, to have a cover of weedy grasses, white clover, etc. A similar green turf covers its last 100 metres or so (not investigated); its middle and slightly lower portion though is covered by spring tides and is vegetated entirely in glasswort. An islet just to the southwest of the hook's curve has its surface right at mean high water, and is covered in glasswort, however, three 1 metre tall bushes have established here, apparently recently; one of them is a boneseed, the others may be boxthorn or ngaio.

B. New Ponds Near Expressway and Purimu Stream Mouth

B1.

Between the embankments of the railway and the new expressway, on both sides of the main estuary channel, two broad strips remain as ponds. The one on the northern side is cut off from the main estuary channel by a low transverse embankment, and the one on the south, by floodgates.

The pond on the northern side of the main estuary channel has been disturbed by gravel-getting, etc. in its northern half or so and its sides and floor have only a sparse growth of weeds, particularly sea spurrey, with some batchelor's button. There are a few young plants of knob-rush on slightly higher ground among annual weeds like *Pseudognaphalium luteoalbum*. Further south, along the foot of the railway embankment but not opposite on the new slope up to the expressway, there is a fringing growth of glasswort in shallow water and then, in the last 100 metres or so until the transverse embankment is reached, a relic piece of sea-rush/*Samolus* marsh, greatly degraded by tall fescue. The pond on the southern side of the main estuary channel similarly has relic glasswort and sea-rush along its railway embankment side; in the north this is a narrow fringe, but southwards it comes to occupy much of the pond's breadth. On the opposite slope up to the expressway there is a sparse growth of weeds.

B2.

On the western side of the expressway embankment, south of the main estuary channel, there is also a shallow rectangular ponded piece of gravelly ground. It has no relic vegetation, just a few weeds and some failed plantings (submerged at time of survey) of flax and cabbage tree.

B3. Purimu Stream.

This broad artificial channel enters the main estuary channel west of the expressway. Its final several hundred metres long stretch is defined by a pair of floodgates. There is not much vegetation along the sandy channel sides, just a narrow discontinuous band of sea-rush with a few herbs (*Samolus repens*) buckshorn plantain, *Isolepis cernua*, arrow-grass, sickle-grass, and bachelor's button. Towards each of the gates even these fringes are more or less absent.

C. Central Areas

C1. Westshore Pond (a.k.a. Westshore Wildlife Reserve)

This is apparently a natural inlet, now embanked at its top and bottom. There has been gravel-quarrying here but it is not clear that the western and eastern shorelines are other than natural ones. A considerable amount of both the native and the Australian species of

Myporum, and also flax (*Phormium tenax*), have been planted on its southern and eastern sides but there is no true coastal shrubbery here; knob-rush however is increasing around the drier plantings, sometimes with pampas grass.

The shores mostly have extensive growths of glasswort or sea-rush, perhaps according to depth of water or the salinity of each area becomes in summer. Centrally, on the eastern side, such taller vegetation is lacking and the damp compacted gravelly ground has a turf of *Selleria radicans*, sea spurrey, buckshorn plantain, *Isolepis cernua*, *Puccinellia fasciculata*, etc.

The western side of the pond, inside the road, carries a damp mown grassland with planted eucalypts; between this and the shore's fringe of searush there is generally a distinct zone of turf (*Selleria*, sea spurrey, etc). On this side, at the lower ground coming in from across the road to the west, there is a limited extent of salt-pan turf in which the grass *Puccinellia fasciculata* is conspicuous.

C2. Salt-pan Outlier to Westshore Pond

A shallow triangular depression almost 500 metres long runs down from the airport runway into the western side of the Westshore Pond. At the time of the survey (spring high tide, and after some fair amount of rain) this salt-pan contained shallow water for c. 50 metres against its eastern edge, the Pump Road embankment. In the water stands an open and not especially vigorous looking growth of sea-rush with native musk and bachelor's button, the latter two species growing best in the deepest water against the embankment. On the slightly higher ground to each side, and higher (west) in the pan itself for c. 100 metres, the dry ground had a cover of *Puccinellia fasciculata* in discontinuous stripes and patches, rooting in a thin layer of sand over cemented finer sand. *Samolus repens* grows with this grass but the cemented surface itself is largely bare, the only plants on it being small compact tufts of sea spurrey. On black and white aerial photographs the puccinellia community shows as grey; the bare cemented surface shows as white, and occupies almost all of the higher part of the depression. Pasture of good quality surrounds at least the lower part of the depression, and in the grassy turf against the bare ground there is a fair amount of puccinellia.

The depression contains two shallow drains which converge eastwards into the sea-rush by the road. They are conspicuous by the narrow raised line of vigorous puccinellia tuffets along the edges, much of the ground just a few centimetres away being cemented and quite bare.

C3. Northern Pond (Watchman Road Reserve)

Like Westshore Pond, this is also a wildlife refuge. The open water is surrounded by a broad fringe of sea-rush (rather sparse along the Watchman Road side). Some other wetland shrubbery (flax, etc) occurs on the eastern shore, perhaps some of it being plantings. Masses of the native aquatic *Ruppia polycarpa* were seen washed up among the sea-rush along the foot of Watchman Road.

C4. Airport Continuation of Northern Pond

Damp land below the entrance drive into Hawke's Bay Airport has searush in it lower half or so and then, north of a low roadway, a saline herbfield of glasswort, buckshorn plantain, sea spurrey and puccinellia, which grades up to the airport drive into a compact turf mostly of Selliera radicans, rooting on a thin crumbly peat over shelly sand and gravel. Arrow-grass dominates in small wet peaty depressions. The drain reaching up from Northern Pond carries sea-rush right to the entrance drive.

C5. Southern Marsh

A shallow-water embayment some 750 metres long and 250 metres deep extent, this has the Main estuary channel's stopbank as its northern frontage, while on its southern side it runs gently up (no fence) to the pasture of Lagoon Farm. Its dominant plants are sea-rush and glasswort, patterned in broad nearly monospecific stripes and patches, perhaps reflecting the original topography of gravel river deposits. Deeper water backed up at the stopbank foot contains native musk and bachelor's button among sea-rush.

Around its eastern and southern edges there is some development of a puccinellia salt-pan cover as in C2 above, though in a band generally just a few metres wide. On the upper edge of this cover, where it grades into the pasture, the puccinellia does seem to be able to coexist with the pasture grasses (and sicklegrass); new plants on the open crusty ground just below however are very infrequent.

C6. Wetland Outlier to Southern Marsh

Westwards of the Southern Marsh there is higher ground of coarse gravels (and with a roadway and a farm dump), then pasture and a small triangle of rather dry and degraded wetland. This was without standing water at time of survey. Its cover is like that of C3 above, but is much broken down by farm animals. Despite the presence of the latter and their droppings, bachelor's button appears to be lacking – perhaps it is too salty and dry in summer to suit this plant.

C7. Main Estuary Channel from Railway and Expressway Crossing Embankments up to Low-level Bridge.

The shores of this straight stop-banked section of the main estuary channel are mostly of coarse gravels and cobbles, and are not especially conducive to plant growth. The northern shore has a fringe of glasswort, to 10 metres wide at least towards the crossings, but narrowing upchannel. On the southern shore the glasswort bushes among the cobbles are few and rather battered-looking, except at the slight change of direction the main estuary channel makes towards the south-east, where there is a lee accumulation of finer gravels that suits the plant better); on this shore, silver beet and buckshorn plantain are glasswort's occasional associates.

There are islets immediately upstream from the expressway crossing and several more each side of the Low-level Bridge. The former islets appear to be entirely covered in glasswort. Some of the latter are too, or also have sea-rush, but some carry slightly higher ground and have developed a rough grassland of tall fescue and knob-rush. One islet has a group of small radiata pines and scattered clumps of pampas grass.

C8. Northern Marsh

This is situated opposite C4, inland form the stopbank along the northern side of the main estuary channel. It appears to be the end of a chain of broad shallow depressions that run up immediately inland of the airport; (the eastern edge of these follow the 0 metre contour on the metric topographical sheet). Only the lowermost 100 metres or so of this wet ground adjacent to the road and stopbank was investigated. All of it is accessible to farm animals. The cover is mostly of sea-rush in the east, and mostly glasswort in the west, with some salt-pan puccinellia turf at the upper edge of at least the eastern part. There is a drain down through the western part.

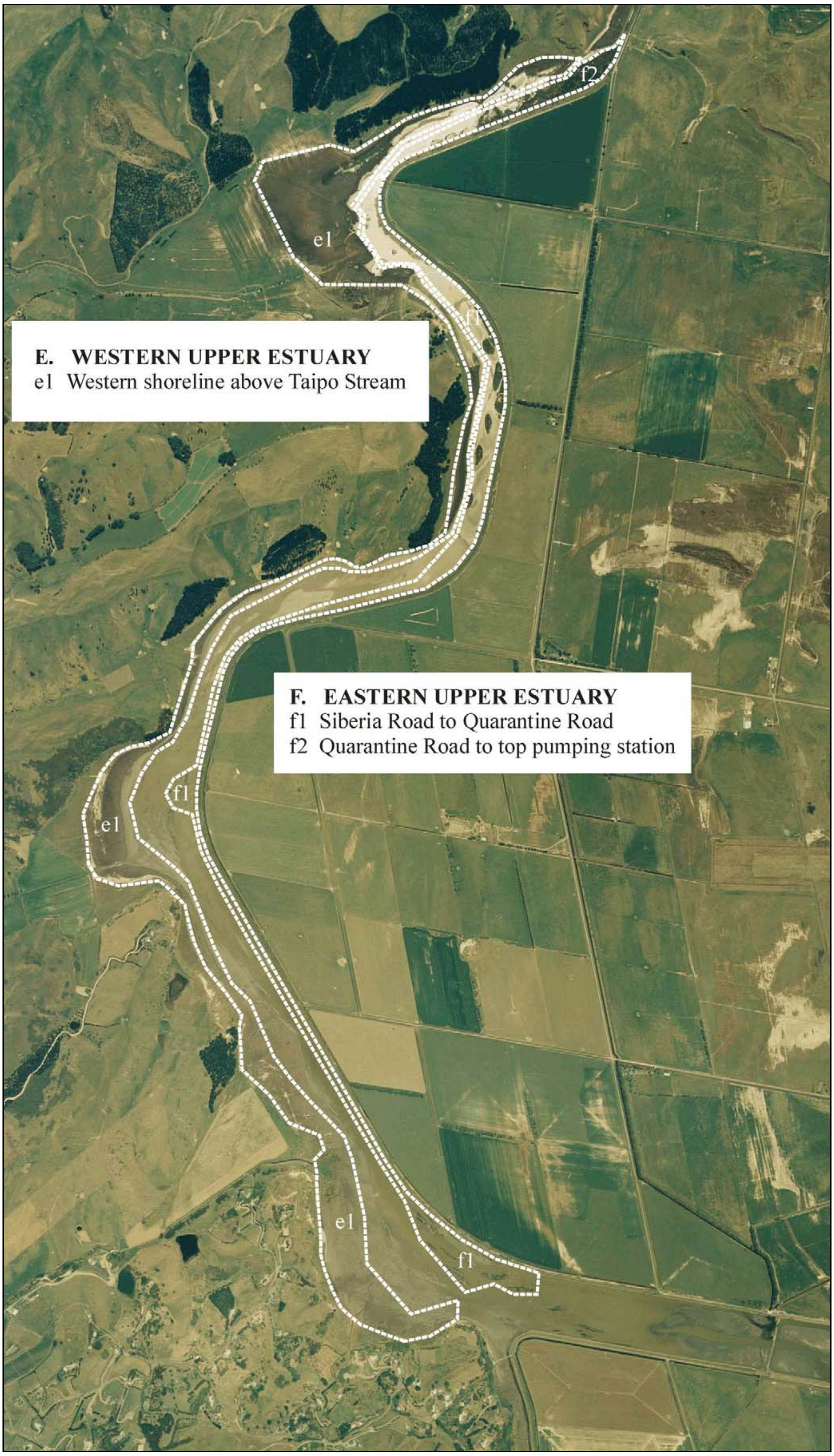


Figure 2.2: Habitat Types Identified in Upper Ahuriri Estuary

D. Low-level Bridge to Taipo Stream.

D1. Shores of Central Part of Main Estuary Channel

As further downstream, the shores here are composed of coarse gravel and cobbles, and have only sparse fringing vegetation. This consists almost entirely of scattered glasswort bushes; sea-rush appears to be lacking.

D2. Taipo Stream Mouth

The stream flows freely into the main estuary channel without weir or stopbank (but can be crossed at its mouth by a farm bridge). There are extensive flats of glasswort at its mouth and also further north round into the embayment on the western side of the main estuary channel. In the southern (upstream) direction, opposite the Poraiti Hills settlement, sea-rush becomes dominant for at least 100 metres or more.

E. Western Shore of Main Estuary Channel Above Taipo Stream.

E1.

The entire shore falls under this heading. It was not investigated on foot, only viewed from several places along the stopbank on the eastern shore. There are large embayments along this western side which generally have both sea-rush and glasswort (the latter usually extensive on the inland side). Farm animals seem to roam much of this shore right to the water's edge.

F. Eastern Shore of Main Estuary Channel Above Taipo Stream

F1. Siberia Road (opposite Taipo Stream mouth) to End of Quarantine Road.

The sandy shore at the stopbank foot has a rather discontinuous sea-rush fringe, usually 1 to 3 metres wide. The smaller of the two *Bolboschoenus* species reaches its downstream limit here, growing as a sparse growth between the sea-rush tussocks, perhaps in slightly shallower water. Arrow-grass and native musk grow at the inner side of the sea-rush tussocks, if this ground is not taken over by tall fescue. Glasswort has now become uncommon and drops out at about the channel bend by Quarantine Road (but is still extensive opposite on the western shore, and , also on the islets between the ends of Turfrey Road and Quarantine Road).

F2. Quarantine Road to Top Pumping Station

This 1 kilometre length is marked by the appearance of raupo, which forms a wide fringe to the eastern shore (it is present though less extensive along the western shore). Sea-rush now occurs only patchily out towards the narrowed channel, and between it and the shore-line raupo there is a dense growth of the taller *Bolboschoenus* sp. The latter continues to dominate in the narrowed channel further upstream above the pumping station, which is probably an indication that tidal influences reach this far.

2.2 Flora

This is presented in two parts, first a list of the native species, then the exotics. The latter list is very incomplete, only containing the area's most common species and its worst weeds (potential or realised). In both lists, dicotyledons and gymnosperms are presented before monocotyledons.

Note that several widespread estuarine natives appear to be lacking form the study area. These are: sea-grass (*Zostera* sp. or spp.), jointed rush (*Leptocarpus similis*), needlegrass (*Stipa stipoides*), and umbrella sedge (*Cyperus ustulatus*).

Note also that two exotics troublesome in wetlands and salt marshes elsewhere in the country appear to be lacing, viz. *Spartina* spp. (cordgrass) and sea paspalum (*Paspalum vaginatum*). Also, the common reed (*Phragmites australis*), known to have been present elsewhere around Napier, seems to be lacking too.

2.2.1 Native species

Cotula coronopifolia bachelor's button.
There are colonies usually not more than a few square metres in extent in the central wetlands and in the shallows of the new ponds along the edge of the new expressway. But even in places most enriched by farm animal and bird excretions this plant is not especially conspicuous.

Mimulus repens native musk
Commonly forming a loose growth between sea-rush tussocks in permanent slightly brackish shallows of the central wetlands, for example along the stopbank frontage of the Southern Marsh.

Disphyma australe native ice-plant

Infrequent on damp fine gravels on the north side of the Lower Estuary near Meeanee Quay. Perhaps it has been grazed out by animals elsewhere. It was not seen in any of the salt-pans.

Plagianthus divaricatus marsh ribbonwood

A single old-looking plant, c. 1 metre tall, grows at the shore on the level fround on the south side of the Lower Estuary. No young plants were noted nearby.

Sarcocornia quinequeflora glasswort

Forms extensive mats around the gravelly shores of the Lower Estuary, its shoots floating at the time of high spring tide. Glasswort-fringed islets lie in the main estuary channel between the expressway bridge and the low-level bridge. Here and in most of the Lower Estuary the plants would seem to be rooted in a compact sandy-gravelly substrate.

A somewhat different habitat is provided on the sheltered (northern and western) sides of the Lower Estuary, where the species grows in the crevices among rocks and rubble, in a distinct band whose lower edge is about at high water mean; it seems not to be able to grow here on the mud immediately below. Glasswort often grows immediately landward of sea-rush stands, either in a narrow fringe at the base of rising ground (sometimes among organic debris), or else on extensive sandy inner flats. Another habitat, in the level ground on the south side of the Lower Estuary, is provided by shallow sandy-floored small depressions. These are isolated from the sea, at least under usual conditions, but the salty groundwater that would infiltrate into them would be concentrated by evaporation and so prevent growth of any other species.

In the middle and upper parts of the main estuary channel glasswort occurs on the eastern side as a narrow band at the stopbank foot up to about the end of Quarantine Road; on the western side of the main estuary channel it dominates wide sandy flats of the embayments. Glasswort is present in the various wetlands and nalt-pans alongside the lower part of the main estuary channel, but may have been reduced in abundance in these places through grazing and trampling by farm animals.

Samolus repens

Usually found among sea-rush in shallow water, on sandy substrates, wherever wave-exposure is not too great. Also common in salt-pans among the puccinellia grass tuffets, but relatively uncommon in the turfy pasture edges around these pans.

Selliera radicans

Often co-dominant with sea spurrey and buckshorn plantain in grazed turf on the inland edges of wetlands and alt-pans, e.g. above the top of the Northern Pond, by the airport. But the most vigorous colonies seen were on the western side of the mouth of the Taipo Stream, some metres away form the shoreline but still subject to salt spray; they flourish here in the light shade and compact litter provided by overarching *Cupressus macrocarpa* trees.

***Bolboschoenus* sp.** (or *Schoenoplectus pungens*)

This was only seen in its spring condition, as sterile shoots of c. 30 cm tall, the leaves somewhat blue-green and fleshy. It forms loose growths along the eastern side of the middle part of the main estuary channel, more or less associated with the sea-rush fringe.

***Bolboschoenus* sp.** three-square

Dominant over extensive areas at the topmost part of the main estuary channel by the pumping station (and also further northwards beyond the study area). Only the dead remains of last year's growth (stems to 1 metre tall) was to hand, and none of it was fertile, so the identification could not be completed.

Juncus krausii sea-rush

Dominant in the shallow brackish water of many of the wetlands, sea-rush was most extensive in the upper part of the Westshore Pond and even more so in the Northern Pond. In the Lower Estuary it fringes the southern shore but is almost entirely absent on the northern side. It is infrequent up-channel along the sides of the main estuary channel until the Taipo Stream mouth is reached, presumably because the coarse gravels and relatively strong currents do not suit it, but above here it is conspicuous on both the western shore (sometimes in wide colonies) and eastern shore (as a broken fringe a metre or so deep).

Isolepis cernua

This little sedge is found in most pieces of grazed turf at wetland edges, among Selliera, etc. It is not a component of the ringing vegetation of the Lower Estuary.

Isolepis nodosa knob-rush

Strictly speaking, this is not a wetland plant, but it does occur on somewhat damp ground, in particular on sand accumulations around the southern edges of the Lower Estuary and on some of the islets near the Low-level Bridge.

Ruppia polycarpa horse's mane

A large amount of sheared off strands of this aquatic plant was found at the foot of the Northern Pond (Watchman Road). It was also seen in the shallow water of the pond itself. The similar *R. megacarpa* was not seen during the survey, but the herbarium of the Auckland War Museum has a specimen obtained in 1945 from "Ahuriri Lagoon, in saline ponds and lagoons".

Triglochin striatum arrow-grass

Inconspicuous in grazed turf of the Northern Pond and Westshore Pond. More common in the upper half of the main estuary channel, at least on its eastern shore, where it makes a thin fringe just above the sea-rush, on stable sandy substrates.

Typha orientalis raupo

Only seen in the uppermost 500 metres or so of the main estuary channel, particularly along the edge of the eastern shore in the relatively deep water (perhaps benefiting from some freshwater input from the top pumping station).

2.2.2 Exotic species

Chrysantemoides moniliera boneseed

Frequent in rough grassy or rocky ground around the Lower Estuary, and descending to just above high water mean at the shore here down into the edge of the glasswort zone. Occasional bushes are seen even in very wet and exposed places like the glasswort-dominated islet immediately southwest of Pandora Hook.

Carpobrotus edulis Hottentot fig

Local on the low grassy gravels of the Lower Estuar at Meeanee Quay and further west to the railway and expressway crossings; not seen immediately above here along the main estuary channel sides, although the coarse substrate seems suitable enough.

Lycium ferocissimum boxthorn

Most abundant in Ahuriri Farm, in neglected places along the main estuary channel stopbank and under *Cupressus macrocarpa* shelterbelts, etc. But occasional plants grow in the Lower Estuary, sometimes right at high water mean among drift debris.

Myoporum insulare boobialla, Australian ngaio

This species constitutes the bulk of the shelter plantings around the Lower Estuary and Westshore Pond, along with a smaller number of the very similar native species, ngaio (*M. laetum*). Young wild plants of both are scattered about, some on rocky ground by the shore, others on drain sides or even out in sea-rush stands. A particularly clear example of naturalization is at the south end of the Westshore Pond, where a dozen small myoporum bushes grow among shore debris left by a very high water level – perhaps abraded fruit-stones were deposited there. Some of these plants were boobialla, others were ngaio, and some can be supposed to be hybrids.

Pinus radiata pine

A few pines, to c. 10 metres tall, occur on one of the islets just east of the Low-level Bridge, in grassy ground with knob-rush. It would seem likely that this group represents a single colonisation by seed, with subsequent production of offspring on the spot. The nearest parent trees would occur further west neat the Taipo Stream mouth. All the way to the top of the main estuary channel, self-sown pines are very infrequent. This is possibly due to the seedlings being eaten down by rabbits.

Plantago coronopus buckshorn plantain

Very common in damp salty ground on finer gravels and peaty sand, and forming turf where there is grazing by farm animals, waterfowl and rabbits.

Spergularia media sea spurrey

Abundant in damp ground, including grazed salty turf, but also a weed of shallow, only slightly brackish water, especially in recently disturbed open sites like the wet gravels at the foot of the new expressway's embankment. Plants of more compact habit are found on the pans around the various central wetlands, where they grow on the hard lime-rich surface of the pan itself.

***Tamariscus* sp.** tamarisk

A local infestation on the northern side of the Lower Estuary, in damp ground, has recently been controlled, though a few of these small bushes are re-sprouting.

Cortaderia selloana pampas grass

Large fertile tussocks are seen mostly some way outside the study area, e.g. in the waste ground around the factories that adjoin the Lower Estuary's southern frontage, and along some of the large farm drains of the central-western part of Ahuriri Farm. However, small plants, some of them fertile, are quite common among the planted shrubberies of Westshore Pond, and also on wet open gravels here. Possibly, grazing by rabbits is currently restricting spread of the species.

Festuca arundinacea tall fescue

Very common on damp sandy ground just above the inner side of the sea-rush zone, the groundwater in such places being not so brackish as to produce conditions suitable for glasswort. Possibly, in some situations, it provides suitable shelter or nesting areas for birds; in any case, there is no practical control for it.

Parapholis incurva sickle grass

Often forms a narrow monospecific band immediately above the glasswort zone, usually on sand or fine gravels. It withstands grazing and mowing.

Puccinellia fasciculata puccinellia grass (sometimes "alkali grass", but not in NZ)

This medium sized blueish to pale green grass is confined to the salt-pans of the central wetlands, mostly just above the level of spring tides (though some large and vigorous plants were seen in shallow water in the western outlier to Westshore Pond). It generally grows on a thin layer of sand, a few centimetres above the pan's lime-rich crust, but not directly on the acrust itself. *Samolus repens* is it most typical associate. In open ground this grass forms rather circular tufts, flat-topped and up to 20 cm or more in diameter. These appear to be of fair age, but have no dead central patch. This grass has been in the study area since 1935 at least, when a specimen was obtained from "Westshore, Inner Harbour" by J Ronaldson (AK99152).

2.3 Conservation Recommendations

2.3.1 Lower Estuary

The native shore-line communities here are of only moderate botanical interest but are in a generally healthy state. They are reasonably free of weeds, but boxthorn and boneseed are both present, and since they can substantially alter shore-line and islet habitats, ought to be eliminated as far as possible. Another troublesome weed here is tamarisk; control of the infestation of this on the northern shore needs to be completed.

The "Australian ngaio" features in many of the plantings around the estuary, together with the "true ngaio". Both are appropriate, not least because they have some resistance to grassland fires, however, *M. insulare* is naturalising, and not only that, but some of the wildings may be hybrids with *M. laetum*. Without knowledge of the location of any natural stands of the latter near Napier it is not known how deleterious this local "genetic contamination" might be. Removing the wild plants as they appear would be a possible partial remedy.

2.3.2 Westshore Pond, Northern Pond and Adjacent Areas

The native communities are, again, of only moderate botanical interest, except perhaps for the abundance of the aquatic plant *Ruppia polycarpa* (and possibly *R. megacarpa*). These ponds may well be one of the best sites for these now rather uncommon plants, at least in the North Island. Weeds here requiring control are boneseed and pampas grass.

Each of these two reserves adjoins ground which has conservation value:
a) the extension of the Northern Pond up into airport land has sea-rush in its lower part, but its upper part is native herbfield. This appears to differ from other herbfields of the study area in being at least partially developed on a shallow peat rather than a saline crust. Some of this

herbfield has recently been destroyed by shallow quarrying, which seems a shame, since this area could easily be maintained just by occasional mowing.

b) there is a saline arm extending west from Westshore Pond. Its botanical interest is principally because it represents a kind of habitat not very common in New Zealand. (It should be stated that its most characteristic plant, the grass *Puccinellia fasciculata*, is in fact not a native species). The integrity of the pan is broken down by drainage and by the free access farm animals have. Unfortunately the long triangular shape of the site means that fencing it off permanently would be expensive, but electric fences around at least the lowermost 100 metres or so of the pan might be a satisfactory alternative.

2.3.3 Wetlands Each Side of the Lower Part of the Main Outfall Channel

These two shallow brackish wetlands have some salt-pan fringing herbfield around their upper edges; both are being degraded by farm animals. Protecting the larger and perhaps more diverse one, the Southern Marsh, would require additional permanent fencing only along its southern side. Before doing this, possible effects on the use of the site by birdlife should be considered.

2.3.4 Middle and Upper Parts of the Main Outfall Channel

No uncommon native plant species or extensive weed growths occur here. The embayments along the western shores were not visited, but it did seem that cattle had free access to the often extensive fringing saltmarsh in a number of the embayments.

3 AQUATIC ECOLOGY

3.1 Infauna

The location of sampling sites was specified by the Hawke's Bay Regional Council and these locations are indicated in Figure 2.1. The methodology proposed for this study and accepted by Hawke's Bay Regional Council involved the sampling of a 30 by 60 metre area at each sampling site. This methodology followed that specified in the Ministry for the Environment (2002) *Estuarine Environmental Assessment and Monitoring Protocol*. It became obvious that at some of the sampling sites specified by the Hawke's Bay Regional Council, such a large sampling area was not available and this sampling methodology could not be followed. This was discovered by the field team part way through the field data collection. As a consequence, the sampling areas for different sampling sites throughout the estuary are not consistent.

Each site was marked with a single PVC stake, which extended above the sediment approximately 150 mm. Three PVC corner pegs were placed to delineate the 30 by 60 metre sampling area, where such a sampling area was available, by marking three of the four corners of the sampling area. At sites where a 30 by 60 metre sampling area was not available, the largest contiguous area of habitat available for sampling was delineated with PVC corner pegs. These corner pegs extended above the sediment approximately 20-30 mm. The nearest corner of the sampling area was approximately one metre from the single marker peg and each sampling area was oriented so that the long side ran parallel to the nearest major channel.

Infauna was sampled using twelve replicate samples collected with a 130 mm stainless steel core sampler, which sampled to a sediment depth of 150 mm. All sampling was conducted in accordance with the Ministry for the Environment (2002) *Estuarine Environmental Assessment and Monitoring Protocol*.

Each sample was individually sealed in clean polyethylene 'ziplok'-type bags, labelled and then sieved as soon as practicable by washing each whole sample through 0.5 mm mesh sieves with seawater. The material retained on the sieves was resealed in fresh clean polyethylene 'ziplok'-type bags, labelled and preserved with a 10% formalin solution and packed into plastic containers for transportation to the laboratory. After at least 24 to 48 hours each sample was rinsed with fresh water and transferred to a 70% isopropyl alcohol solution for storage prior to sorting and identification. Organisms picked out of the samples during the sorting were placed in a 70% isopropyl alcohol solution prior to taxonomic identification. Data was entered into a Microsoft Excel 2000 spreadsheet.

The results of the benthic biota sampling are presented in Table 3.1.

The most striking feature of the benthic biological results is the low diversity and abundance of organisms at most sampling stations. There do not appear to be definitive reasons for this low diversity and abundance, however, it may be related to the challenging abiotic conditions within the estuary, e.g. variations in salinity, tidal exposure, nutrient supply, etc or observed abundance and diversity of benthic biota may be influenced by sediment or water contamination.

The diversity or inventory balance of an ecosystem is a function of species richness (number of species/groups of organisms present) and evenness (the abundance of each species or group). The Shannon-Weiner diversity index is calculated by the following equation:

$$H' = -\sum_{i=1}^{k} p_i \log p_i$$

H′ - symbol for the diversity in a sample of S species or kinds
p_i - the proportion of observations of the i^{th} species, (n_i/N)
n_i - number of individuals of i^{th} species
k - the number of species in the sample
N - total number of individuals per sample

The Shannon-Weiner diversity index is relatively independent of sample size and is not strongly affected by the way organisms are classified. High diversity is recorded from populations with large numbers of species, which are equally abundant, while populations with a few abundant species and many rare species are of low diversity.

Figure 3.1 presents mean Shannon - Wiener diversity index values for each site with 95% confidence limits.

The mean Shannon –Wiener diversity index decreases from Site 1 to Site 4, *i.e.* the further up the estuary away from the sea. The mean diversity index calculated for Site 5, the sampling station furthest up the estuary, lies between those calculated for Site 1 and Site 2.

It is possible that the saltwater influence at Site 1 was high enough to produce a relatively diverse benthic biological community of a principally marine nature. Further up the estuary the benthic biological communities were exposed to a weakening saline influence and the diversity and evenness of the biological communities decreased in the more challenging environmental conditions.

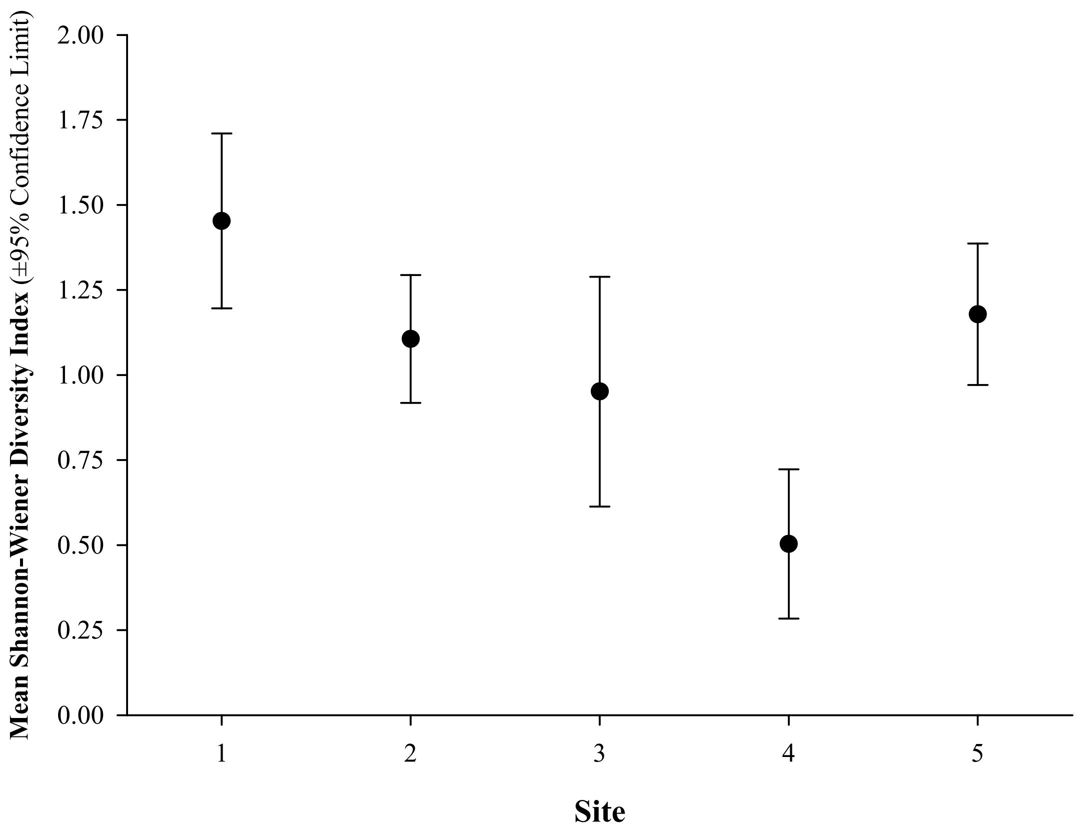


Figure 3.1: Mean Shannon-Wiener Diversity Index (±95% Confidence Limits)

The benthic biota data was subjected to a principal components analysis (PCA) to reduce the data set from thirty-two dimensions to two dimensions. Principle components analysis is a multivariate analytical technique, which preserves the straight line Euclidean distances between samples and finds the axes that maximize the total variation through the data cloud. Subsequent axes are then chosen which are perpendicular, and thus linearly independent to previous axes, which explain the next largest amount of variation. Principal component 1 accounted for 52.461% of the variability in the benthic biota data, while principal component 2 accounted for 15.430% of the variability in the data; a total of 67.891% of the variability in the data accounted for by these two principal components.

The results of the Principal Components Analysis are presented in Figure 3.2. It can be seen that while Sites 2, 3 and 4 are grouped close to each other, *i.e.* were similar, Site 1 and Site 5 were quite different to each other and to the other three sites. The differences displayed through the PCA appear to be strongly linked to the position within the estuary and the influence that physical factors, such as proximity to the sea, salinity, tidal variation, temperature, etc, may have upon the benthic biota at each site.

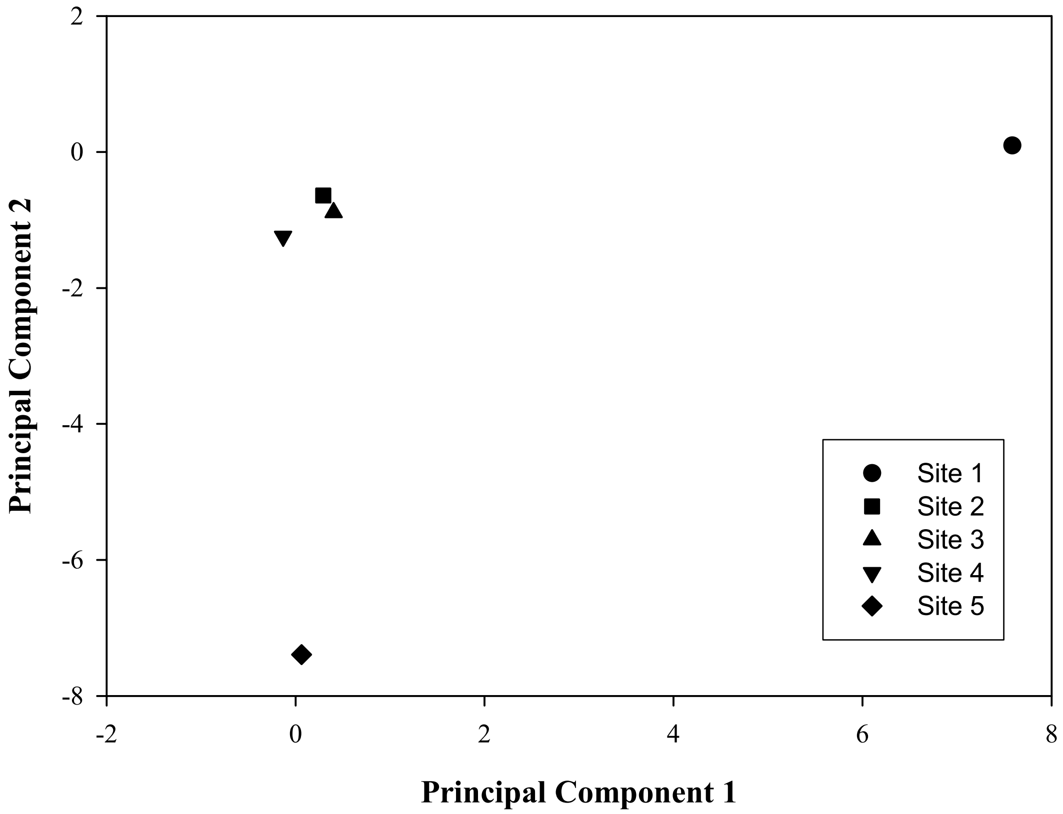


Figure 3.2: Results of the Principal Components Analysis for Sites

When the results of the infauna sampling are compared against data from the eight reference estuaries assessed as part of the national estuarine monitoring protocol (MfE, 2002), it can be seen that the Ahuriri Estuary is different from, but similar to these data. A comparison is presented in Table 3.2.

The number of infauna core samples collected from within the Ahuriri Estuary and analysed is higher than for any of the reference estuaries. The core size used in the Ahuriri Estuary was the same as that used in the eight reference estuaries.

Overall, the number of individual organisms per core sample is similar to the Waimea Estuary and is within the range observed within the eight reference estuaries. Overall the number of taxa per core was lower than observed in the eight reference estuaries. Overall the number of taxa per site was similar to Kaikorai Estuary and within the range observed within the eight reference estuaries.

Table 3.2: Comparison of Ahuriri Estuary with New Zealand Reference Estuaries

	n	Core Size (m^2)	No. Individuals per core	No. Taxa per core	No. Taxa per Site
Ahuriri Estuary					
Site 1	12	0.013	130.1	9.8	27
Site 2	12	0.013	7.9	3.7	10
Site 3	12	0.013	15.8	4.1	15
Site 4	12	0.013	39.0	2.9	8
Site 5	12	0.013	29.9	5.2	13
Overall (all sites)	**60**	**0.013**	**44.6**	**5.1**	**14.6**
Reference Estuaries					
Kaipara (Otamatea Arm)	36	0.013	51.4	10.0	24.0
Ohiwa	48	0.013	73.1	14.9	34.3
Ruataniwha	36	0.013	34.8	9.0	26.3
Waimea	48	0.013	44.7	11.2	25.0
Havelock	24	0.013	17.3	9.0	28.5
Avon-Heathcote	36	0.013	242.7	12.6	27.3
Kaikorai	12	0.013	249.5	6.0	14.0
New River	48	0.013	67.0	9.4	20.5

Comparison of each sampling site within the Ahuriri Estuary to the eight reference estuaries shows that the numbers of individuals and taxa per core and the number of taxa per site varied from relatively high to very low.

Comparison of the biota results from this survey with previous results shows that, in general, the species found during this survey were consistent wit previous findings. More detailed comparisons than this are made impossible due to the differences in sampling methodology, the differences in areas sampled and the clearly different aims of the surveys and therefore the different nature of the data.

Knox, Bolton and Sagar (1978) and Kilner and Ackroyd (1978) conducted quite extensive biological investigations within Ahuriri Estuary using core samples from many sampling stations. Neither investigation used replicate samples, however, they both covered large areas and indicated distributions throughout the areas of the estuary under investigation. Statistical comparison of the data collected as part of this investigation with these 1978 data is made impossible by the broad scale, low detail approach taken by the 1978 surveys.

Tonks, Hannan and Lins (1993) shows shellfish distribution and density data for a specific area within the middle Ahuriri Estuary, however, no comparison can be made with these data as the sampling area of this 1993 survey was not investigated for benthic biota by the current investigation.

For much the same reasons as those cited for the 1978 surveys by Knox, Bolton and Sagar and by Kilner and Ackroyd, the macrofaunal distributions and abundance investigation undertaken by Marine Environmental Research Ltd (1994) cannot be compared with the current data beyond a comparison of the species found within the estuary. In this regard there is considerable overlap between the two datasets.

3.2 Epifauna and macroalgae

Macroalgae were sampled using twelve replicate 0.25 m^2 quadrats, which were all individually photographed for later macroalgal percentage cover estimates in the laboratory and kept as a permanent record of the characteristics of the site. The photographs are presented as Appendix 11.1. Macroalgal species present in each quadrat were noted in the field and voucher specimens collected for taxonomic confirmation if required. Epifauna and larger organisms, such as shellfish, were collected using twelve replicate 0.25 m^2 quadrats at each sampling site.

Shellfish found at each sampling station varied, most likely with position within the estuary. A summary of the shellfish densities found at each of the five sampling stations is presented in Table 3.3.

Table 3.3: Mean Numbers of Shellfish per Square Metre at Each Sampling Station

Species	Westshore		Pandora Rd		Railway Bridge		Pump Station		Poraiti	
	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE
Cockles	315.3	33.25	1.1	0.40	10.3	2.75	0	0	0.2	0.11
Pipi	0.3	0.22	0	0	0	0	0	0	0	0
Topshells	2.0	0.55	0	0	4.5	1.55	0	0	0	0
Whelks	0.1	0.08	0	0	1.0	0.35	0.3	0.13	0.1	0.08
Mudsnails	0	0	0	0	0.7	0.50	2.0	0.76	5.6	1.22

NB: n = 12 for all samples

Cockles (*Austrovenus stutchburyi*) were relatively common at sampling Site 1 (Westshore) and while there were some cockles found at other sampling stations they did not form what could be considered to be significant beds of shellfish attractive for recreational or customary harvest anywhere other than Westshore. Pipi (*Paphies australis*) were not common within the estuary and only four individuals were found at Site 1. Topshells (*Melagraphis aethiops*) were not common within the estuary but were found in low densities at Site 1 (Westshore) and Site 3 (Railway Bridge). Whelks (*Cominella glandiformis*) were found in low densities at all sampling stations except Site 2 (Pandora Road). Mudsnails (*Amphibola crenata*) were found higher in the estuary with the greatest densities found at Site 5 (Poraiti).

Cockle size/frequency relationship has been plotted for each sampling station and the size frequency distributions are presented as Figures 3.3 to 3.7. As numbers of other shellfish were generally low, no size/frequency distributions have been plotted for other species, however, size frequency data is included as Appendix 11.2.

The general rule of thumb is that cockles with a shell width of 25 mm or greater represent an attractive edible resource for recreational or cultural harvest. This size is probably conservative depending upon the cockle populations in the area, however, it can be seen that a significant proportion of the cockles found at Station 1 were of 25 mm or larger shell width (35.8%) and that they therefore represent a significant harvestable shellfish resource within the Westshore area.

Benthic macroalgae was not common at the five sampling station locations. The green alga *Ulva luctuca* (sea lettuce) was found in trace amounts (less than 5% cover) in one quadrat at Station 1 (quadrat 1C) and in one quadrat at Station 3 (quadrat 3I). The red alga *Gelidium caulacantheum* was found in trace amounts (less than 5% cover) in one quadrat at Station 3 (quadrat 3J) and in one quadrat at Station 5 (quadrat 5E). Benthic macroalgal cover did not appear to be a significant feature of the Ahuriri Estuary at the time of sampling.

Figure 3.3: Cockle Size/Frequency Station 1

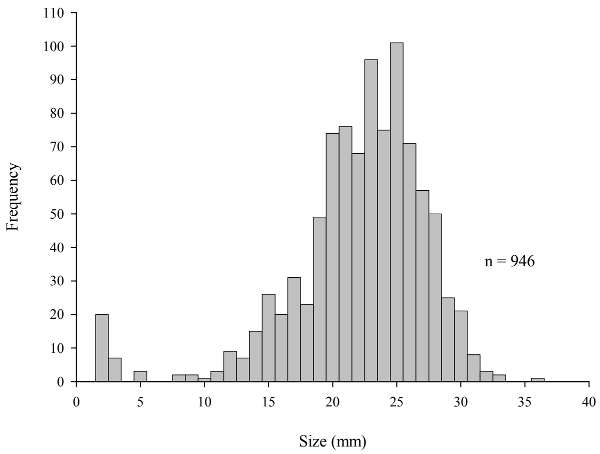


Figure 3.4: Cockle Size/Frequency Station 2

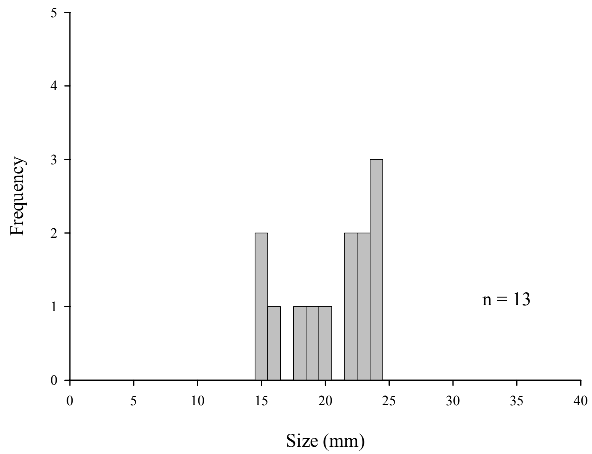


Figure 3.5: Cockle Size/Frequency Station 3

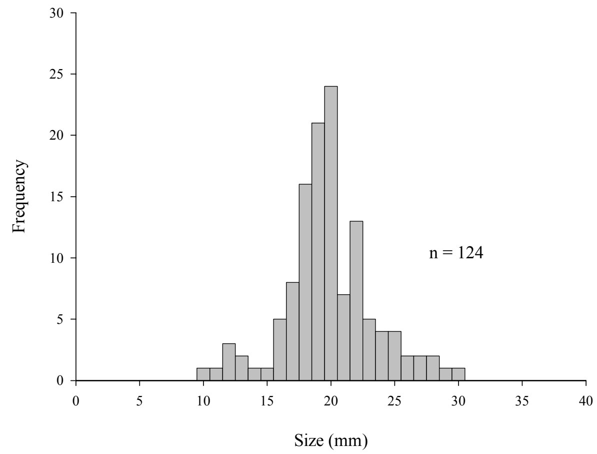


Figure 3.6: Cockle Size/Frequency Station 4

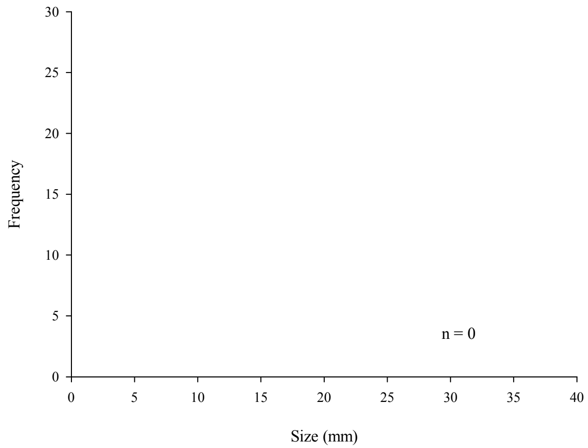
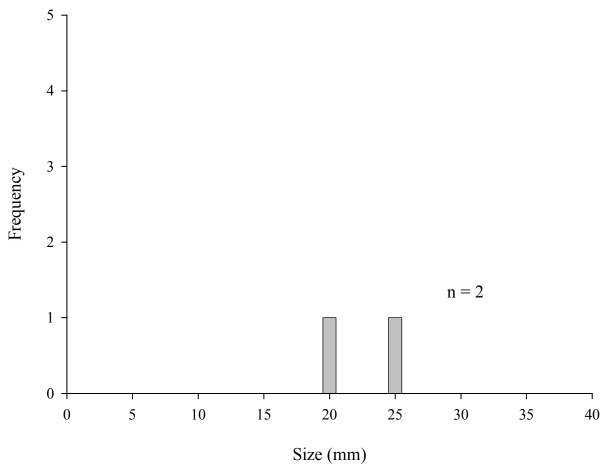


Figure 3.7: Cockle Size/Frequency Station 5



3.3 <u>Benthic microalgae</u>

Benthic microalgae were sampled by collecting a single composite sample per site each consisting of a composite of four replicate surface sediment samples. Benthic microalgae samples were chilled in the field and frozen as soon as practicable prior to despatch to Watercare Laboratory Services for analysis. The analyses requested were phaeophtin and sediment chlorophyll *a* concentrations as well as benthic microflora identification. Upon receipt of the samples the laboratory advised that they were unable to perform the phaeophytin or sediment chlorophyll *a* tests.

The results of the benthic microflora identification to genus level are presented in Table 3.3. A complete identification of the benthic microalgal flora is included as Appendix 11.3.

The dominant microalgal genus is shown in bold for each sampling site. The dominant microalgae at Site 1 (Westshore) was *Coccineis placentula*. The dominant microalgal genus at Sites 2 (Pandora Rd), 3 (Railway Bridge) and 4 (Pump Station) was the green alga *Ankistrodesmus*, a mix of *A. fusiformis* and *A. spiralis*. The dominant microalgal genus at Site 5 (Poraiti) was the blue-green alga *Chamaesiphon* sp.

The National Estuary Monitoring Protocol (MfE, 2002) lists *Pleurosigma/Gyrosigma* as the most common dominant microalgal taxon observed in reference estuary sediments with *Euglena*, *Achnanthes*, *Melosira*, *Nitzschia* and *Oscillatoria* as dominant or co-dominant taxa of lesser importance. *Coccineis*, *Ankistrodesmus* and *Chamaesiphon* are not listed in the microalgal taxa list in the National Estuary Monitoring Protocol (MfE, 2002).

Table 3.3: Benthic Microalgae Results (Number of Colonies per mL)

Genus	Site 1	Site 2	Site 3	Site 4	Site 5
Bacillariophyceae					
Achnanthes	1000	1250	3000	8000	500
Amphicampa					250
Coccineis	**2250**	1000	250		500
Cyclotella		250	250		
Cymbella	500	250	2000	5000	250
Cymatopleura				500	
Diatoma		750	1250	2500	750
Epithemia	500			500	
Eunotin	250		250		250
Fragilaria		250	750		
Frustulia	250	250	250		
Gomphonema	750	750	1500	7000	500
Melosira	250	1500	1000	2000	
Navicula	250	250	750	500	750
Nitzschia	1250	3750	3250	6500	250
Opephora	250	250	250		
Peronia			250	1000	750
Pinnularia			250		500
Pleurosigma					250
Rhoicosphenia	500	1000	250	2000	
Surirella		250			
Synedra	500	250	250	500	250
Tabellaria	750		250	500	250
Chlorophyceae					
Ankistrodesmus	1500	**9750**	**27250**	**81500**	500
Characiura	250		750	1500	
Closterium			250	500	
Coelestrum			250		250
Scenedesmus	250	1000	9500	26000	1000
Schroederia	750	750	1000	10000	
Ulothrix		250	250		
Cyanophyceae					
Chamaesiphon					**45500**
Oscillatoria	750			500	250
Total	**12750**	**23750**	**55250**	**156500**	**53500**

4 SEDIMENT TEXTURE AND QUALITY

Sediment texture and quality sampling was undertaken by Hawke's Bay Regional Council and the results were supplied for analysis. Results are considered on an "as received basis".

The location of the sediment texture and quality sampling sites are presented in Figure 4.1.

4.1 Sediment Texture

The results of the sediment texture analysis are presented in Table 4.1.

Table 4.1: Results of Sediment Texture Analysis

Site	**Gravel** (>2 mm) % dry weight	**Sand** (<2 mm, > 0.063mm) % dry weight	**Mud** (<0.063 mm) % dry weight	**Category**
Upper Estuary				
Ahuriri 1	0.00	7.49	92.51	M
Ahuriri 2	0.00	1.49	98.51	M
Ahuriri 3	7.25	54.31	38.44	gmS
Middle Estuary				
Ahuriri 4	0.08	86.72	13.20	mS
Ahuriri 5	0.02	94.07	5.91	S
Ahuriri 6	2.18	84.24	13.58	(g)mS
Lower Estuary				
Ahuriri 7	0.03	81.99	17.98	mS
Ahuriri 8	27.13	40.77	32.10	gmS
Ahuriri 9	0.05	69.27	30.68	mS
Ahuriri 10	0.07	69.31	30.62	mS
Ahuriri 11	5.79	43.83	50.38	(g)sM
Inner Harbour				
Ahuriri 12	0.00	99.90	0.10	S
Ahuriri 13	0.45	98.54	1.01	(g)S

Sediments are assigned a description based on the principle grain size fraction with modifiers based on the next important grain sizes. These descriptions are given as letter codes. For example, a sample which consisted of mostly sand with a significant proportion of silts and clays, would be described as muddy sand. This would be denoted **mS**. If the sample had a gravel component it would be described as slightly gravelly muddy sand. This would be denoted **(g)mS**. The descriptions of the sediments are based on criteria illustrated in Figure 4.2.

It can be seen that higher up the estuary, away from the sea, there is a high proportion of very fine sediment particles (Ahuriri 1 and 2). The sediments from the highest portion of the estuary are described as muds. A higher proportion of larger sediment particles were found further down the estuary at Ahuriri 3 and the sediments here are described as gravelly sandy muds.

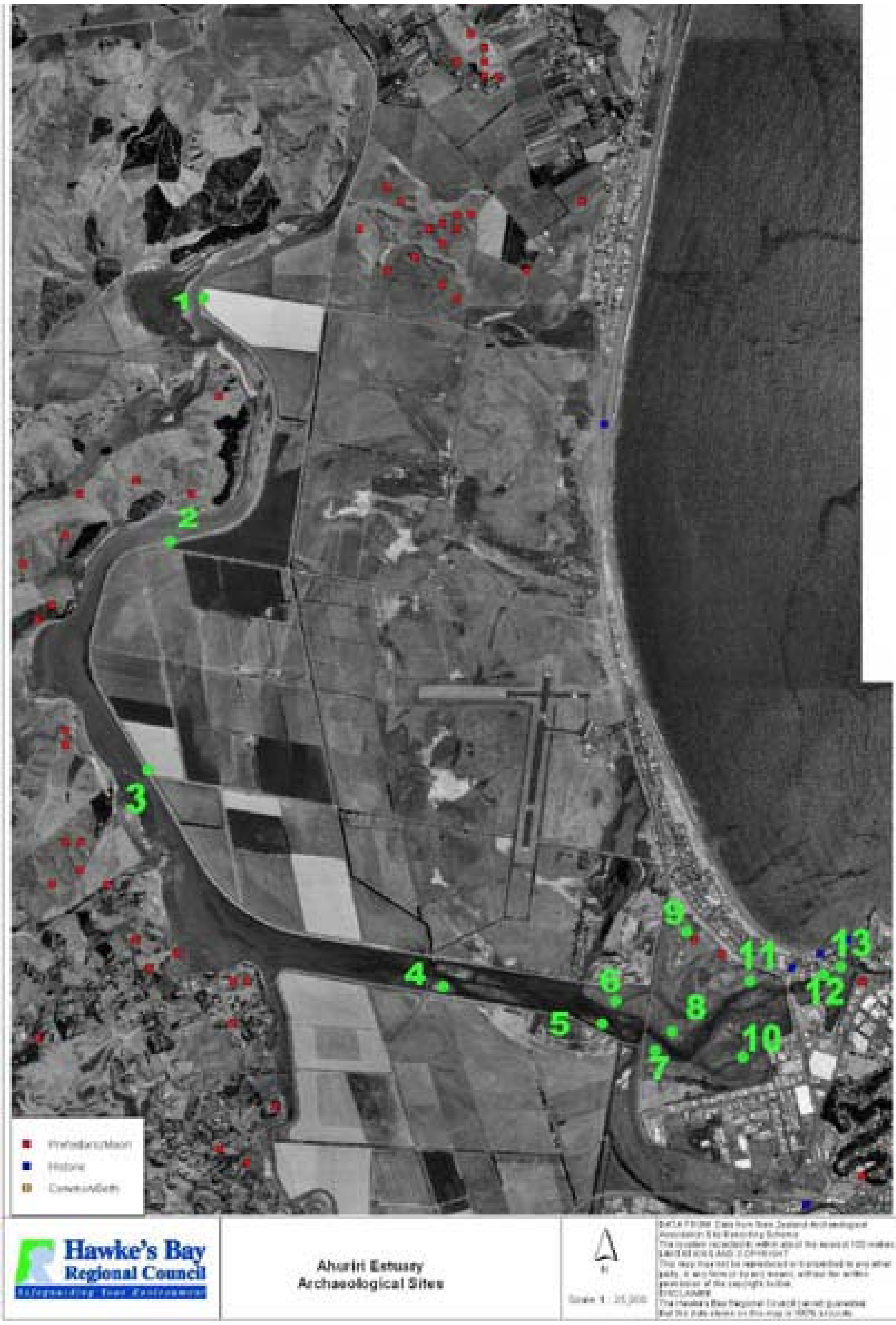


Figure 4.1: Location of Sediment Texture and Quality Sampling Sites

At Ahuriri 4, below the low level causeway, sediments had a very low proportion of gravels and a relatively high proportion of sands with muds. The sediments here are therefore described as muddy sands.

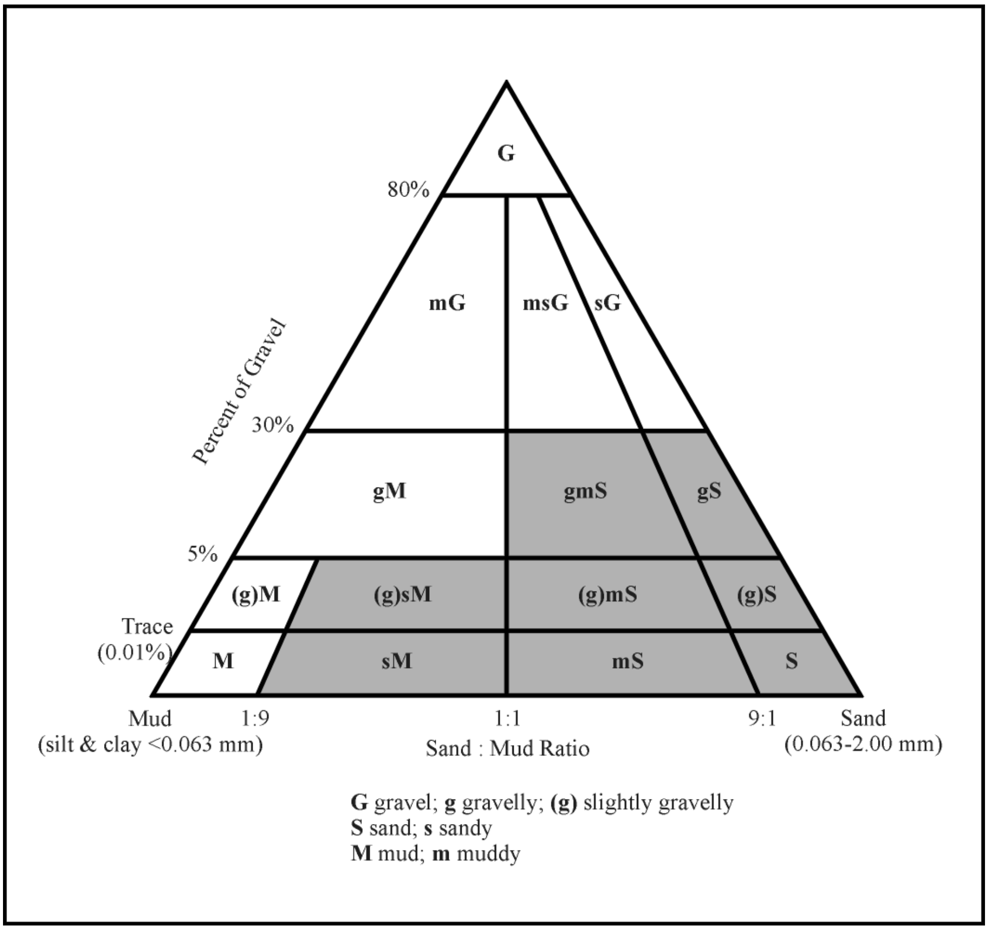


Figure 4.2: Sediment Texture Description Criteria

Sediments at sampling stations Ahuriri 5 and 6 showed distinctly different textural qualities despite being in close physical proximity within the estuary. Sediments at Ahuriri 5 were predominantly sands, while at Ahuriri 6 sediments had significant proportions of muds and some gravels and were therefore classified as slightly gravelly muddy sands.

Sediments at Ahuriri 7, below the railway embankment, had a very high proportion of sands with some muds and are therefore described as muddy sands. At Ahuriri 8 sediments had a more significant proportion of gravels and muds present, however, sands were still the predominant textural category. Sediments in this area of the estuary are described as gravelly muddy sands. Sediments from the Ahuriri 9 and 10 sampling stations are described as muddy sands due to the high proportion of sands, moderate proportion of muds and trace proportions of gravel. Ahuriri 11, the sampling station in the lower estuary closest to the sea, had sediments with a small proportion of gravel and high proportions of both sand and mud, however, the mud fractions were slightly higher than the sand fractions and the sediments here are therefore described as slightly gravelly sandy muds.

Sediments at Ahuriri 12 in the Inner Harbour area were almost completely within the 0.063mm to 2 mm size class. The sediments at this sampling station are described as sands. While sediments at this sampling station had the lowest silt fractions, it is interesting to note that sufficient silt fractions were apparently present for sediment quality analyses. At Ahuriri 13, there were trace amounts of gravel found in the sediments, which resulted in a description of slightly gravelly sands for this sampling station. Insufficient silt fractions were present in samples from this station to allow sediment quality analyses to be conducted on the <0.063 mm grain size fraction.

4.2 Sediment Quality

Sediment quality analyses were conducted on the <0.063 mm grain size fraction of samples collected from the sampling stations indicated in Figure 4.1. The mean results of the sediment quality analyses, as supplied by Hawke's Bay Regional Council, are presented and compared against Australian and New Zealand Environment and Conservation Council (ANZECC) interim sediment quality guidelines in Table 4.2.

The *Water Quality Guidelines for Fresh and Marine Waters* (ANZECC, 2000) provide a framework for managing receiving environment quality. Many approaches have been adopted internationally to derive sediment guidelines, however, there are few reliable data on sediment toxicity for either Australian or New Zealand samples from which independent sediment quality guidelines might be derived. Because of this, and as has been done by many other countries, the option selected for the sediment quality guidelines is the use of the best available overseas data refined on the basis of knowledge of existing baseline concentrations as well as local effects data.

The ANZECC guidelines have provided New Zealand and Australia with recommended guideline values called interim sediment quality guideline (ISQG) values with low and high limits. This approach provides trigger values with which to compare monitoring data. These are not pass/fail numbers, but a spur for further investigation usually an assessment of benthic invertebrate community health.

Table 4.2: Mean Results of the Sediment Quality Analyses (mg/kg dry weight)

Site		Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
Upper Estuary									
Ahuriri 1		2.5	0.13	18	14	12	<0.10	12	52
Ahuriri 2		2.8	0.12	23	24	16	<0.10	13	74
Ahuriri 3		3.3	0.10	23	23	16	<0.10	13	85
Middle Estuary									
Ahuriri 4		2.4	<0.10	20	20	14	<0.10	11	85
Ahuriri 5		2.2	<0.10	18	9	9	<0.10	8	62
Ahuriri 6		3.7	<0.10	24	17	16	<0.10	12	105
Lower Estuary									
Ahuriri 7		2.6	<0.10	19	10	11	<0.10	9	67
Ahuriri 8		4.9	<0.10	27	21	20	<0.10	13	122
Ahuriri 9		4.4	<0.10	21	13	15	0.10	11	82
Ahuriri 10		4.5	0.10	54	25	27	<0.10	10	146
Ahuriri 11		4.6	<0.10	32	31	23	<0.10	14	138
Inner Harbour									
Ahuriri 12		4.5	<0.10	21	24	26	<0.10	10	83
Ahuriri 13 *		1.8	<0.10	8	5	5	<0.10	4	23
ANZECC	**ISQG-Low**	**20**	**1.5**	**80**	**65**	**50**	**0.15**	**21**	**200**
	ISQG-High	**70**	**10**	**370**	**270**	**220**	**1**	**52**	**410**

* Analysis was conducted on the <0.200 mm grain size fraction as very little sediment <0.063 mm was available at this station.

The ANZECC Interim Sediment Quality Guideline (ISQG) low and ISQG high values have been derived from the effects range low (ERL) and median (ERM) described in US National Oceanic and Atmospheric Administration, NOAA (Morgan and Long, 1991) and updated in 1995 (Long *et al*, 1995). The expected occurrence of adverse biological effects can be attributed to contaminants depending on their relationship to the guidelines. Contaminants in sediments are anticipated to result in adverse biological effects:

(1) rarely when concentrations are less than the ISQG-Low,
(2) occasionally when concentrations are between the ISQG-Low and the ISQG-High, or
(3) frequently when concentrations are greater than the ISQG-High guideline.

Arsenic concentrations at all sampling stations were less than the ANZECC ISQG-Low guideline and adverse biological effects are therefore not anticipated at any of these sampling stations due to sediment arsenic concentrations. There is an apparent trend of increasing arsenic concentrations toward the lower end of the Ahuriri Estuary with sampling stations in the lower estuary having generally the highest sediment arsenic concentrations. The notable exception is the Ahuriri 13 sampling station, which had the lowest arsenic concentration, however, this may be related to the sediment grain size structure at this station.

The highest sediment cadmium concentrations were recorded from the Upper Ahuriri Estuary with evidence of some attenuation of cadmium concentration with distance from Maori Head. Sediment cadmium was found at sampling station Ahuriri 10 at the method minimum detection limit of 0.10 mg/kg dry weight, however, cadmium concentrations at all other sampling stations were less than the method minimum detection limit. All mean sediment cadmium concentrations were less than the ANZECC ISQG-Low guideline.

The lowest mean sediment chromium concentration was recorded from sampling station Ahuriri 13 in the inner harbour. This may be related to the relative lack of fine sediment particles at that sampling station. The highest mean chromium concentration (54 mg/kg dry weight) was recorded at Ahuriri 10 in the lower estuary. This sampling station is the closest to the industrial area of Pandora. All mean sediment chromium concentrations recorded were well below the ANZECC ISQG-Low guideline.

The lowest mean sediment copper concentration was recorded from sampling station Ahuriri 13 in the inner harbour. This may be related to the relative lack of fine sediment particles at that sampling station. The highest mean copper concentration (31 mg/kg dry weight) was recorded at Ahuriri 11 in the lower estuary. This sampling station was in the Westshore area. All mean sediment copper concentrations recorded were well below the ANZECC ISQG-Low guideline.

The lowest mean sediment lead concentration was recorded from sampling station Ahuriri 13 in the inner harbour. This may be related to the relative lack of fine sediment particles at that sampling station. The highest mean lead concentration (27 mg/kg dry weight) was recorded at Ahuriri 10 in the lower estuary. This sampling station is the closest to the industrial area of Pandora. All mean sediment lead concentrations recorded were well below the ANZECC ISQG-Low guideline.

Mean sediment mercury concentrations recorded from all sampling stations were less than the method minimum detection limit of 0.10 mg/kg dry weight with the exception of sampling station Ahuriri 9. The mean sediment mercury concentration at Ahuriri 9 was at the method minimum detection limit of 0.10 mg/kg dry weight. Mean mercury concentrations were all less than the ANZECC ISQG-Low guideline.

Mean sediment nickel concentrations recorded from all sites were less than the ANZECC ISQG-Low guideline. Mean sediment nickel concentrations were highest at Ahuriri 11 and lowest at Ahuriri 13, however, the low mean concentration at Ahuriri 13 may be related to the sediment grain sizes available for analysis.

The highest mean sediment zinc concentration recorded was from Ahuriri 10. All mean sediment zinc concentrations recorded were less than the ANZECC ISQG-Low guideline. The lowest mean sediment zinc concentration was recorded at Ahuriri 13, however, this may be related to the sediment grain sizes available for analysis at this station.

The mean sediment metals concentrations analysed for in the samples collected from each of the sediment quality sampling stations suggests that adverse biological effects should occur only rarely as a result of the mean concentrations of contaminants in Ahuriri Estuary sediments.

A comparison of the Ahuriri Estuary sediment quality with other estuaries around New Zealand is presented in Table 4.3.

Of the sediment quality parameters in common with the Ministry for the Environment National Protocol, cadmium, chromium and nickel concentrations in the Ahuriri Estuary were less than the average concentrations calculated from data from the other New Zealand estuaries. The mean copper, lead and zinc concentrations recorded within the Ahuriri Estuary were mostly higher than the average copper, lead and zinc concentrations calculated from data from the other New Zealand estuaries.

Table 4.3: Comparison of Mean Sediment Quality in Ahuriri Estuary with Other New Zealand Sites (mg/kg dry weight)

Site	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
Ahuriri 1	2.5	0.13	18	14	12	<0.10	12	52
Ahuriri 2	2.8	0.12	23	24	16	<0.10	13	74
Ahuriri 3	3.3	0.10	23	23	16	<0.10	13	85
Ahuriri 4	2.4	<0.10	20	20	14	<0.10	11	85
Ahuriri 5	2.2	<0.10	18	9	9	<0.10	8	62
Ahuriri 6	3.7	<0.10	24	17	16	<0.10	12	105
Ahuriri 7	2.6	<0.10	19	10	11	<0.10	9	67
Ahuriri 8	4.9	<0.10	27	21	20	<0.10	13	122
Ahuriri 9	4.4	<0.10	21	13	15	0.10	11	82
Ahuriri 10	4.5	0.10	54	25	27	<0.10	10	146
Ahuriri 11	4.6	<0.10	32	31	23	<0.10	14	138
Ahuriri 12	4.5	<0.10	21	24	26	<0.10	10	83
Ahuriri 13 *	1.8	<0.10	8	5	5	<0.10	4	23
Other NZ Sites (from MfE, 2002)								
Otamatea Arm	-	0.4	20.5	13.8	11.4	-	9.4	54.5
Ohiwa	-	0.1	7.4	4	3.4	-	3.9	27.7
Ruataniwha	-	0.1	24	7.1	4.7	-	13.7	37.5
Waimea	-	0.3	67.6	9.6	7.4	-	72.5	41.8
Havelock	-	0.3	48.8	10.7	5.6	-	26.5	43
Avon-Heathcote	-	0.1	15.6	3.2	6.3	-	6.6	38.3
Kaikorai	-	0.1	48.4	16.8	45.3	-	15.6	184.2
New River	-	0.1	11.1	3.8	0.7	-	5	17.1
Aparima Estuary	-	0.067	15	12	11	-	10	49
Mataura Estuary	-	0.024	7.1	6.6	6.2	-	6	27
Waitemata Harbour	-	<0.5	52	60	65	-	28	161
Average of NZ Sites	**-**	**0.19**	**28.9**	**13.4**	**15.2**	**-**	**17.9**	**61.9**
ANZECC ISQG-Low	**20**	**1.5**	**80**	**65**	**50**	**0.15**	**21**	**200**
ANZECC ISQG-High	**70**	**10**	**370**	**270**	**220**	**1**	**52**	**410**

* Analysis was conducted on the <0.200 mm grain size fraction as very little sediment <0.063 mm was available at this station.

5 WATER QUALITY

A single grab sample of surface water was collected from the channel nearest to each benthic biota and sediment quality sampling station. Each sample was chilled before being couriered in a chilly bin to Hill Laboratories Limited for analysis. Samples were analysed for nutrient concentrations, salinity, pH, suspended solids, turbidity, clarity and colour, organic carbon, and chlorophyll *a* concentrations. At the time of sampling, the surface water salinity, temperature and dissolved oxygen concentration and dissolved oxygen percent saturation were measured using a calibrated YSI Model 85 dissolved oxygen field meter.

Results of the water quality field measurements are presented in Table 5.1.

Table 5.1: Results of Water Quality Field Measurements

	Site 1	Site 2	Site 3	Site 4	Site 5
Temperature (°C)	16.2	18.1	16.4	15.9	15.1
Dissolved Oygen (g/m^3)	8.5	8.5	8.2	8.1	8.1
DO Saturation (%)	104.2	101.6	98.8	97.6	87.0
Salinity	32.5	22.4	29.1	29.3	16.1

The field measurements suggest that the water within the Ahuriri Estuary is generally of reduced salinity compared with open coastal water (salinity around 34-36) and that salinity tends to be lower further up the estuary away from the sea. This shows the greater relative influence of the freshwater inputs to the estuary further from the sea. Water temperatures were generally warm and normal for early spring. Dissolved oxygen saturations were high at all stations, particularly at Stations 1 and 2. This may be due to algal productivity in the water.

The results of the laboratory analyses of water samples are presented in Table 5.2 and a certificate of analysis is included as Appendix 11.4.

The pH results show a relatively consistent pH at all sampling stations and shows the influence of saline waters. The salinity results confirm the influence of saline coastal water within the estuary and agree with the field measurement of salinity reasonably well. Turbidity results show that the water near the sampling stations at low tide was generally moderately turbid, however, the water at the Poraiti sampling station was very turbid at the time of sampling.

Table 5.2: Results of Laboratory Analyses of Water Quality

Constituent	Units	Site 1	Site 2	Site 3	Site 4	Site 5
pH	pH units	8.2	8.5	8.2	8.2	8.3
Salinity		32.9	22.1	29.0	29.2	16.3
Turbidity	NTU	20.7	29.3	15.5	29.3	99.1
True Hazen Colour	Hazen units	8	100	5	10	30
Total Suspended Solids	g/m^3	42	112	28	48	137
Total Ammoniacal Nitrogen	g/m^3	0.12	0.21	0.10	0.09	0.10
Total Nitrogen	g/m^3	0.2	0.7	0.3	0.4	1.5
Total Kjeldahl Nitrogen	g/m^3	0.2	0.5	0.2	0.3	1.4
Nitrate-N + Nitrite-N	g/m^3	0.025	0.188	0.065	0.043	0.076
Nitrate Nitrogen	g/m^3	0.021	0.169	0.07	0.039	0.071
Nitrite Nitrogen	g/m^3	0.005	0.020	0.008	0.004	0.005
Dissolved reactive phosphorus	g/m^3	0.065	0.129	0.124	0.085	0.118
Total phosphorus	g/m^3	0.100	0.500	0.175	0.131	0.310
Total organic carbon	g/m^3	3.8	9.8	4.7	6.3	17.6
Chlorophyll *a*	g/m^3	<0.003	0.003	0.013	0.003	0.012

Total suspended solids concentrations were moderately elevated at Sites 1, 3 and 4 and were high at Sites 2 and 5 at the time of sampling.

The total nitrogen concentration was highest at Site 5 at the time of sampling. The majority of this nitrogen was in the organic form (as evidenced by the total kjeldahl nitrogen concentration). This was the highest concentration of organic nitrogen recorded in estuary waters during this survey. The total oxidised nitrogen concentration (nitrate nitrogen + nitrite nitrogen) at Site 5 was moderate. Total oxidised nitrogen concentration at Site 2 was the highest recorded during this survey and this was due to a high concentration of nitrate nitrogen at this location at the time of sampling.

Ammonia can be toxic to aquatic life and for this reason the USEPA lists water quality criteria for continuous exposure and for maximum exposure to ammonia concentrations in surface waters. Ammonia toxicity varies with temperature, salinity and pH and the USEPA criteria take this into account by listing criteria varying according to these parameters. Portions of these criteria are presented in Tables 5.3 and 5.4.

Table 5.3: USEPA Continuous Exposure Total Ammonia Criteria (g/m^3)

Salinity = 10			
pH	**Temperature** (°C)		
	10	**15**	**20**
8.0	2.0	1.40	0.97
8.2	1.3	0.87	0.62
8.4	0.81	0.56	0.41
8.6	0.53	0.37	0.27
Salinity = 20			
pH	**Temperature** (°C)		
	10	**15**	**20**
8.0	2.1	1.5	1.0
8.2	1.3	0.94	0.66
8.4	0.84	0.59	0.44
8.6	0.56	0.41	0.28
Salinity = 30			
pH	**Temperature** (°C)		
	10	**15**	**20**
8.0	2.2	1.6	1.1
8.2	1.4	1.0	0.69
8.4	0.90	0.62	0.44
8.6	0.59	0.41	0.30

Table 5.4: USEPA Maximum Exposure Total Ammonia Criteria (g/m^3)

Salinity = 10			
pH	**Temperature** (°C)		
	10	**15**	**20**
8.0	13	9.4	6.4
8.2	8.5	5.8	4.2
8.4	5.4	3.7	2.7
8.6	3.5	2.5	1.8
Salinity = 20			
pH	**Temperature** (°C)		
	10	**15**	**20**
8.0	14	9.8	6.7
8.2	8.9	6.2	4.4
8.4	5.6	4.0	2.9
8.6	3.7	2.7	1.9
Salinity = 30			
pH	**Temperature** (°C)		
	10	**15**	**20**
8.0	15	10	7.3
8.2	9.6	6.7	4.6
8.4	6.0	4.2	2.9
8.6	4.0	2.7	2.0

The highest total ammoniacal nitrogen concentration recorded during this survey (Site 2) was less than the continuous exposure criteria for the water quality conditions encountered. Ammonia concentrations at all other stations were all well below the continuous exposure criteria for the water quality conditions encountered.

The highest total phosphorus concentration recorded was at Site 2. This sample contained the highest dissolved reactive phosphorus concentration, however, the dissolved reactive phosphorus concentrations at Sites 3 and 5 were also elevated.

The highest total organic carbon concentration was recorded at Site 5.

Chlorophyll *a* concentrations were low at Sites 1, 2 and 4. The highest chlorophyll *a* concentration of 0.013 g/m^3 was recorded at Site 3.

The two sets of water quality results with the lowest salinity also had elevated phosphorus, dissolved reactive phosphorus, total organic carbon, total suspended solids, and organic nitrogen concentrations. The water quality at these two sampling stations may have been significantly influenced by the quality of the freshwater inputs to the estuary.

The results of the water quality sampling give a 'snapshot' view of the character of the water quality of the estuary. These results suggest that ammonia toxicity is unlikely to be a problem within the estuary under the water quality conditions likely to be encountered. The water quality results also suggest that on occasion turbidity and suspended solids concentrations are elevated and that the suspended solids are likely to be organic material. When estuarine water quality is influenced by the freshwater inputs to the estuary, nutrient concentrations and turbidity tend to be higher.

6 SIGNIFICANT HABITATS

During the investigation of the Ahuriri Estuary significant habitats for wildlife, specifically birds, were identified in the following areas:

Westshore Pond

This area is valuable as a bird feeding, roosting and nesting habitat. Its importance as a wildlife habitat is recognised by its status as a wildlife refuge.

Northern Pond

This area is valuable as a bird feeding, roosting and nesting habitat. Its importance as a wildlife habitat is recognised by its status as a wildlife refuge.

Southern Marsh

This area is potentially valuable as a bird feeding, roosting and nesting habitat, however, its value is compromised by stock access.

Western Shore Above Taipo Stream

Most of this area was not investigated on foot, however, as viewed from several places along the stopbank on the eastern shore there are large embayments within which there appeared to be areas of sea-rush present. These areas may be significant as fish breeding habitat, particularly for galaxiid fishes (whitebait species). The habitat value of these areas, however, is potentially compromised by stock access.

Eastern Shore Above Taipo Stream

Areas of sea-rush along the eastern shore above the Taipo Stream are potentially significant areas for fish breeding, particularly for galaxiid fishes (whitebait species).

7 RECREATIONAL USE OF THE ESTUARY

The Ahuriri Estuary is a locally important area for recreational use. While the recreational significance of the estuary is probably better understood by local authorities, the following recreational pursuits were observed in progress or infrastructure to facilitate these recreational activities were observed.

Fishing

Fishing was observed in the Inner Harbour area. While this is not strictly within the estuarine area, the water quality in the Inner Harbour is at least partly influenced by the estuary itself.

Kayaking

Kayaking was observed in the Pandora Pond area.

Sailing

Sailing of small dinghys was not observed during the course of the investigation, however, dinghy sailing in the Pandora Pond area has been observed in the recent past.

Walking

Various boardwalks, footpaths and pedestrian accessways exist around the estuary, particularly in the lower estuary area. A number of people were observed walking with and without dogs around the lower estuary area.

Shooting/Hunting

Several maimais were observed in the main channel of the upper estuary around and above the mouth of the Taipo Stream. In addition, spent shotgun shells were observed on the shoreline and in the flotsam around the sea-rush near the mouth of the Taipo Stream.

8 CONCLUSIONS

The native shoreline communities of the lower estuary are of only moderate botanical interest but are in a generally healthy state. These communities are reasonably free from weeds but both boxthorn and boneseed are present and ought to be eliminated as far as possible. There is incomplete control of tamarisk on the northern shore of the lower estuary. Hybridisation of the "Australian ngaio" with the "true ngaio" may be occurring in the lower estuary area.

The native plant communities of the Westshore Pond, Northern Pond and adjacent areas are of only moderate botanical interest, except for the abundance of the aquatic plant *Ruppia polycarpa*. Two adjoining areas have conservation values due to the native herbfield and the uncommon habitat represented by the saline arm extending west from Westshore Pond.

The aquatic infauna sampling within the estuary showed a relatively low diversity and abundance of organisms at most sampling stations. Differences in the infaunal communities appeared to be most strongly influenced by the position of the sampling station within the estuary with the highest and lowest sampling stations showing very different infaunal communities. Overall the infaunal communities within the Ahuriri Estuary suggest that it is similar to, but different from, the eight reference estuaries within the national estuarine monitoring protocol.

While cockles were a significant component of the aquatic fauna in the Westshore area of the estuary, shellfish were not particularly common elsewhere. Numbers of mudsnails were higher at the sampling stations higher within the estuary. Benthic macroalgae was not a significant feature of any of the sampling stations, nor of the Ahuriri Estuary as a whole at the time of sampling. Benthic microalgal communities appeared to differ depending upon the position of the sampling station within the estuary, however, the dominant benthic microalgal taxa appear to be different to those found during national estuary monitoring.

Sediment texture analysis showed higher proportions of mud from the upper estuary while sediments lower in the estuary tended to have higher proportions of sands. Sediment quality within the Ahuriri Estuary appeared to be relatively good when compared to guidelines for the protection of aquatic organisms. When compared against recent data from other New Zealand estuaries, the Ahuriri Estuary sediment contaminant concentrations were less than the average, except for zinc.

Water quality sampling within the estuary showed that ammonia was unlikely to cause toxicity problems for aquatic organisms under water quality conditions observed during the time of sampling. Nutrient concentrations were variable and elevated at times. The water within the estuary was, at times, turbid with elevated suspended solids. This was hypothesised as being principally organic material.

9 RECOMMENDATIONS

Genetic contamination of local ngaio may be occurring in the lower estuary due to naturalisation of the "Australian ngaio" (*Myoporum insulare*) hybridisation of *M. insulare* with *Myoporum laetum*. It is not know how deleterious this local genetic contamination may be, however, removing wild plants as they appear would be a possible partial remedy.

Cessation of quarrying in and occasional mowing of the herbfield extending into the airport from the Northern Pond.

Fencing at least the lower 100 metres of the saline pan extending west from Westshore Pond to prevent free access of farm animals.

Protection of the Southern Marsh from degradation by farm animals by fencing the southern side. Consideration of the effects on the use of the site by birdlife should be undertaken prior to fencing.

It is suggested that an in-depth botanical survey of the entire Ahuriri Estuary be undertaken using the latest aerial photographs at appropriate scales. This survey should include those areas not physically visited during this brief botanical investigation. Once this detailed botanical survey has been conducted it may be appropriate to repeat this level of sampling effort every 5 years or so to track changes in vegetation.

Repeat sampling of the infaunal communities throughout the estuary on a regular basis would allow assessment of adverse biological effects within the estuary. The frequency of that sampling is debatable, however, sampling every two years at the same time of year may be appropriate.

Collection of cockles from the Westshore area for shellfish flesh quality analysis would provide the Hawkes Bay Regional Council with information on the risks to human health from recreational or cultural harvest of cockles from this potentially attractive seafood resource. Sampling should follow Ministry of Health protocols and the results should be compared against relevant food standards. It is suggested that microbiological parameters (suggest faecal coliform, *E. coli* and enterococci bacteria) as well as metallic contaminants (with copper, lead and zinc as an absolute minimum) should be analysed for by an accredited analytical laboratory.

It is recommended that subsequent sediment grain size analysis differentiate between more classes of sediment. Ideally, sediments should be differentiated into the following categories with optional further differentiation of silts and clays.

>3.35 mm	gravel
2.0 - 3.35 mm	granules
1.18 - 2.0 mm	very coarse sand
0.6 - 1.18 mm	coarse sand
0.3 - 0.6 mm	medium sand
0.15 - 0.3 mm	fine sand
0.063 - 0.15 mm	very fine sand
< 0.063 mm	silt and clay

This allows a more detailed assessment of sediments throughout the estuary and the potential for affecting biological communities and observed contaminant distributions.

It is recommended that subsequent sediment quality analyses should include total nitrogen, total phosphorus, ash free dry weight, sediment phaeophytin and sediment chlorophyll *a* concentrations. This would bring sampling results into line with the national estuarine monitoring protocol and allow comparison of sediments from Ahuriri Estuary with other New Zealand estuaries. Provision of a full data set for sediment quality sampling results, rather than just mean contaminant concentrations, would allow statistical analysis of sediment quality and robust comparison of sites within the estuarine system.

It is recommended that sediment quality and textural analysis of Ahuriri sediments should be repeated on a regular basis. The frequency of that repeated sampling is debatable, however, sampling every two years at the same time of year may be appropriate.

A once-off set of water quality samples provides little information about the general status of the estuary's water quality. A more intensive water quality monitoring programme should be developed which is independent of the aquatic biology and sediment sampling programmes and this water quality programme should include major inputs to the estuary, e.g. Taipo

Stream, under a variety of conditions and tidal heights at a variety of locations throughout the estuary to determine the relative influence of freshwater inputs and seawater infiltration on the general water quality of the estuary. Water quality monitoring of the estuary should perhaps focus on the suitability of the estuary for full contact recreation over the bathing season.

While compliance with the national estuary monitoring protocol potentially allows comparison of Ahuriri Estuary with other estuaries around New Zealand, the value of these comparisons are limited. It is not unexpected that Ahuriri Estuary should be different than other estuaries due to differing catchments, climate, geology, etc. The major benefit of compliance with the national protocol is ensuring that the assessment of the estuary is scientifically robust, thorough and defensible. It is recommended that further sampling of the Ahuriri Estuary should comply with the national protocol, particularly in terms of sediment quality sampling. If, however, comparison with historical data held on Ahuriri Estuary were required, i.e. an evaluation of change through time, a sampling programme that seeks to gather comparable information using similar methods would be necessary.

10 REFERENCES

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9 APPENDICES

Appendix 11.1: Photographs of Benthic Quadrats

Plate 1: Station 1 (Westshore) quadrats a-f, 30 September 2003

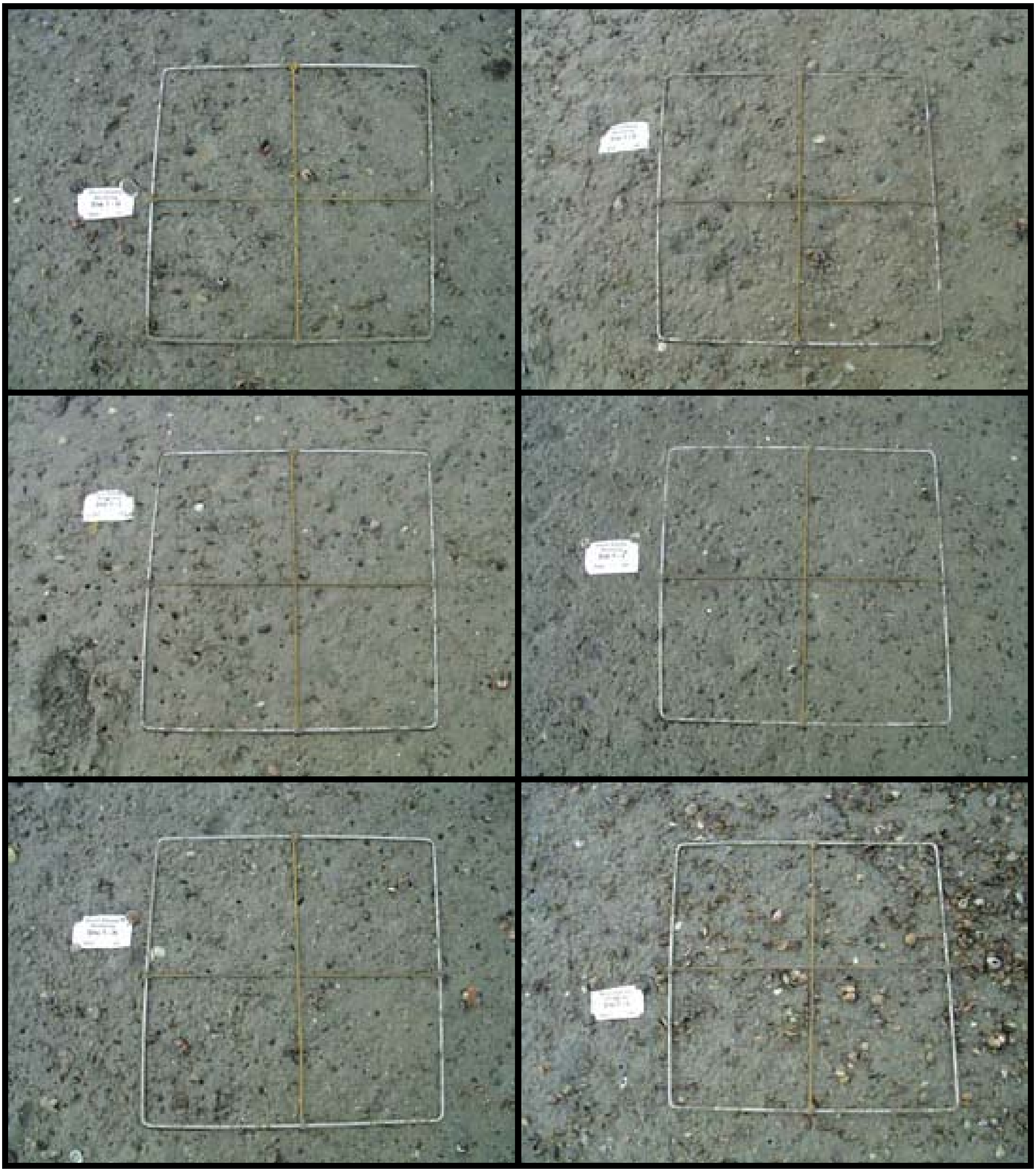

Plate 2: Station 1 (Westshore) quadrats g-l, 30 September 2003

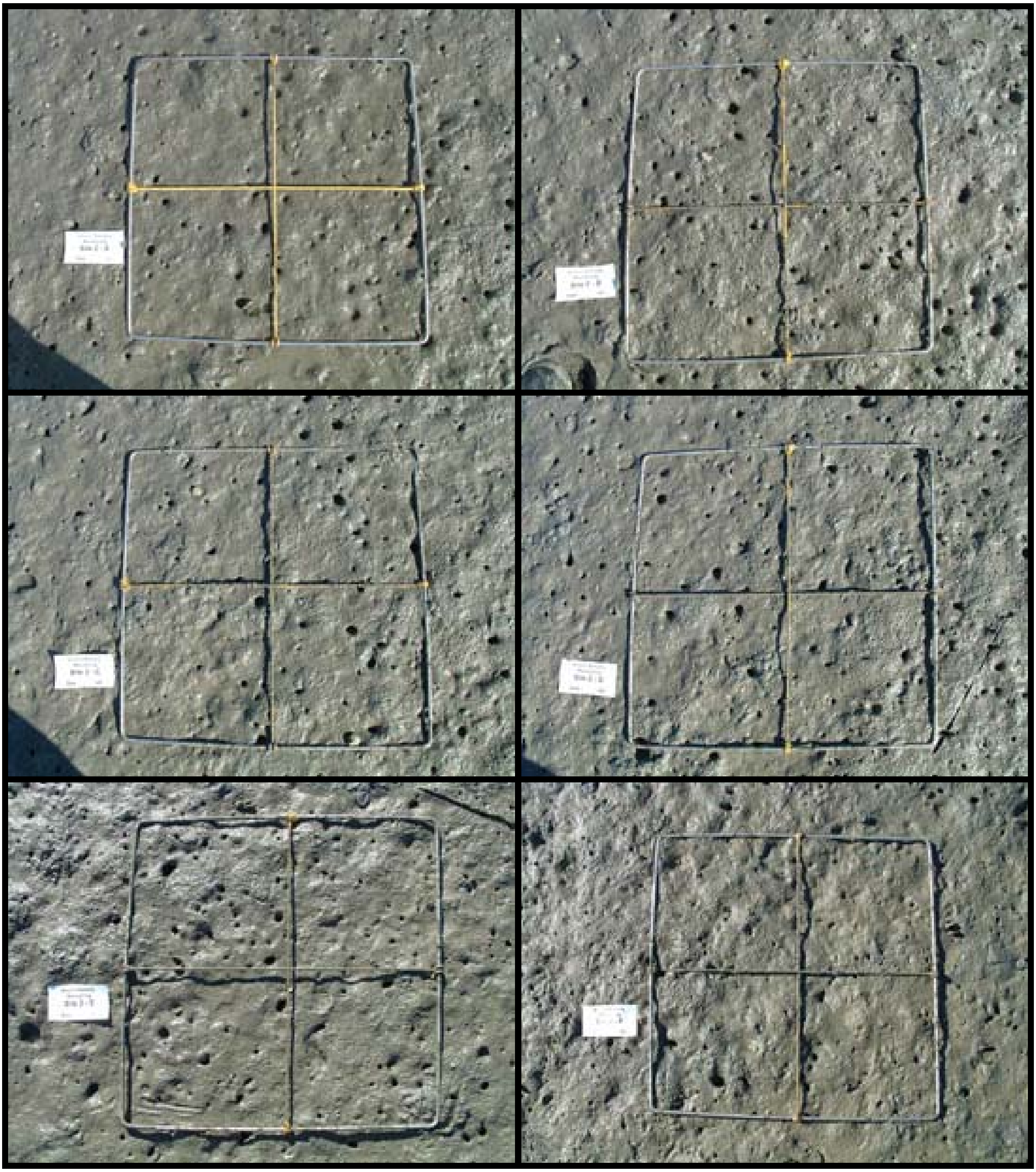

Plate 3: Station 2 (Pandora) quadrats a-f, 29 September 2003

Plate 4: Station 2 (Pandora) quadrats g-l, 29 September 2003

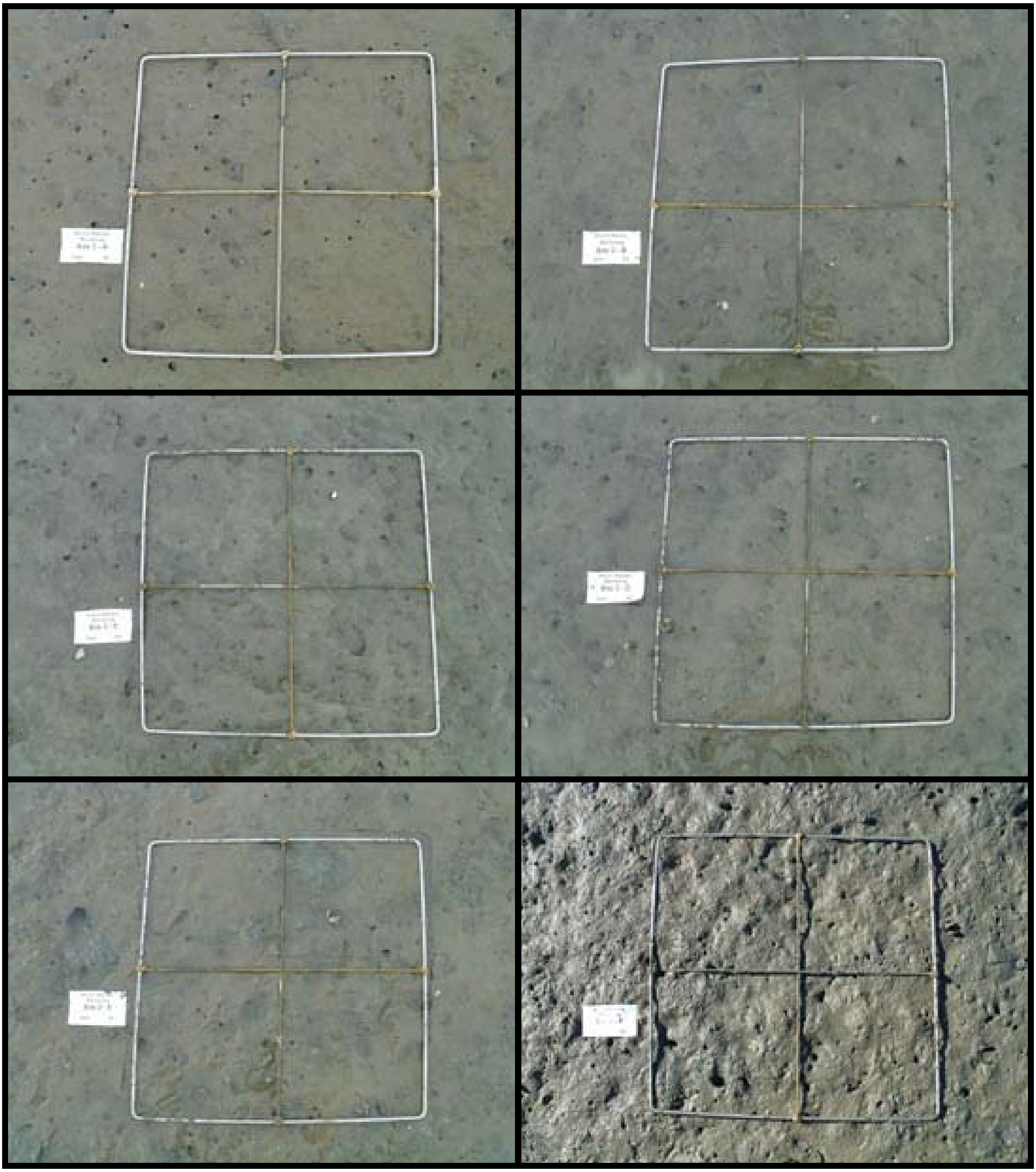

Plate 5: Station 3 (Railway Bridge) quadrats a-f, 30 September 2003

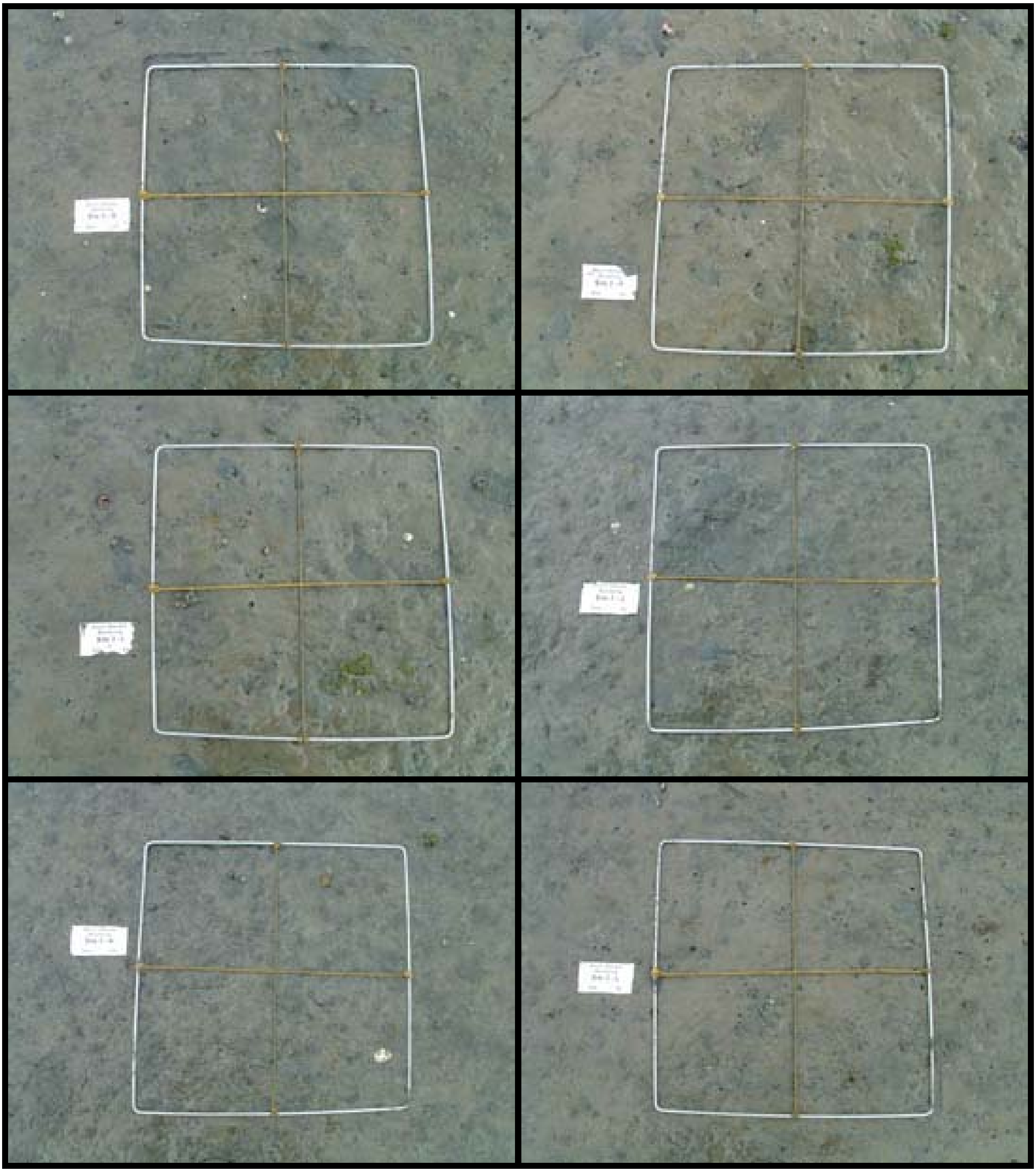

Plate 6: Station 3 (Railway Bridge) quadrats g-l, 30 September 2003

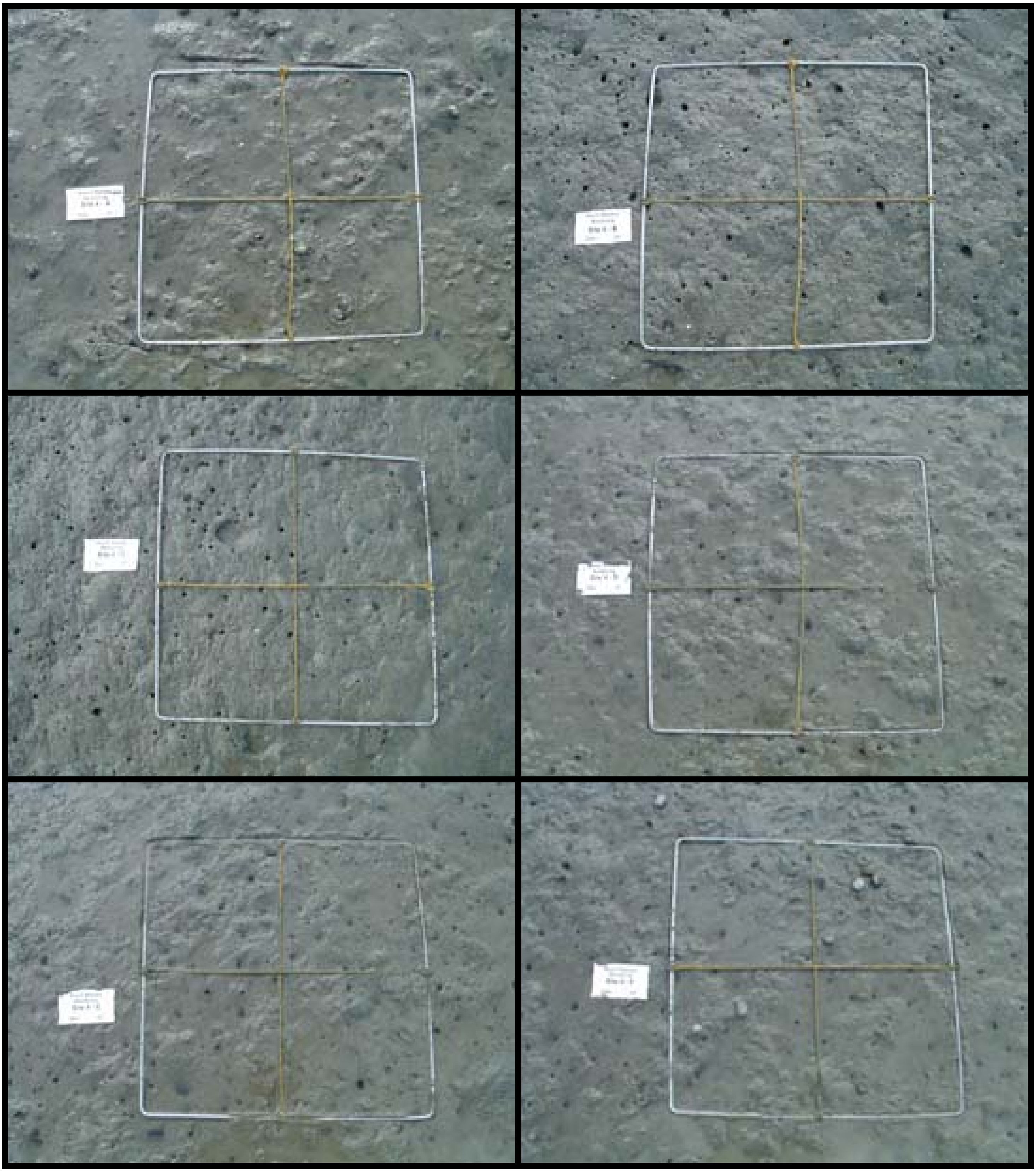

Plate 7: Station 4 (Low-level Bridge) quadrats a-f, 31 September 2003

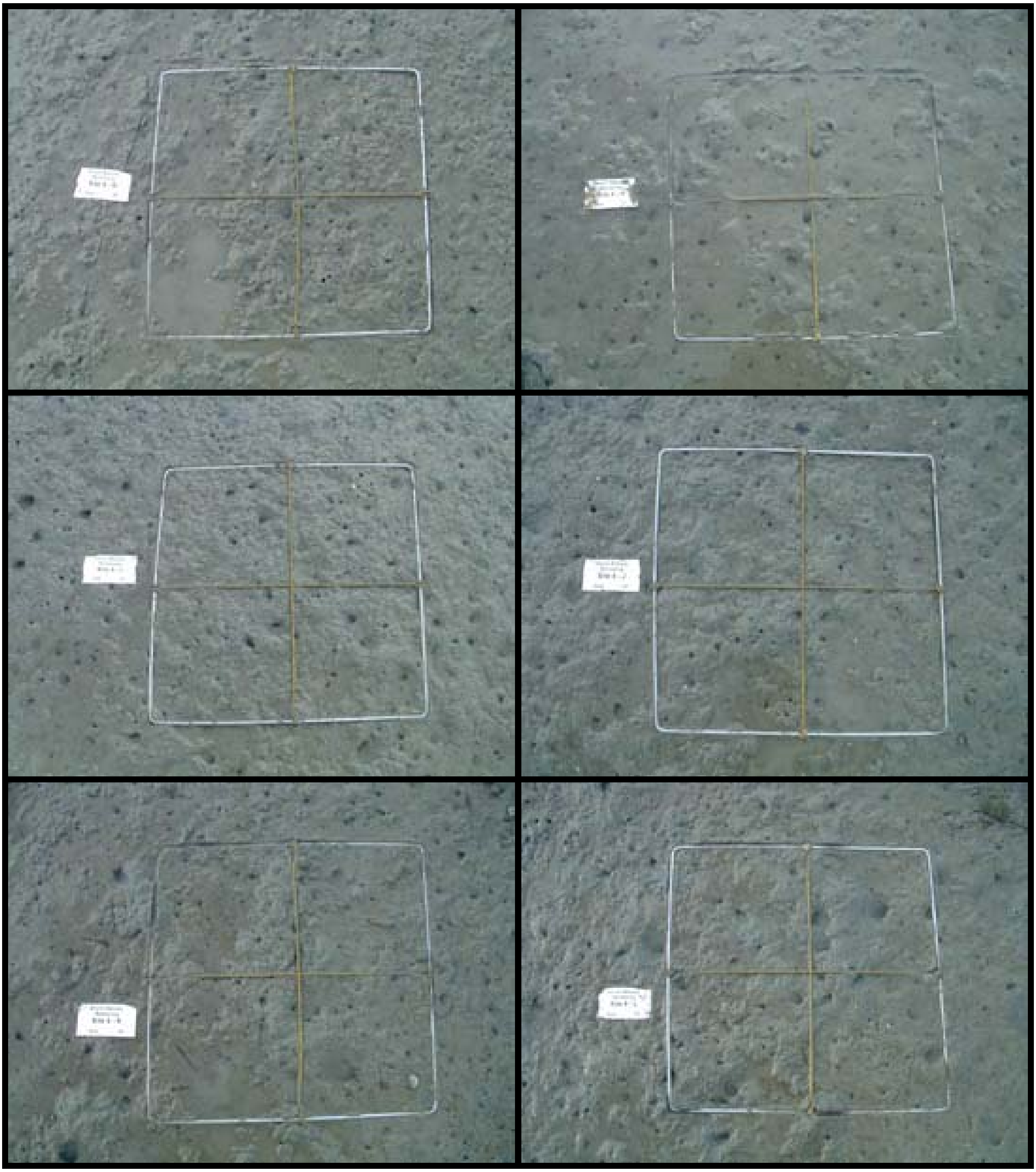

Plate 8: Station 4 (Low-level Bridge) quadrats g-l, 31 September 2003

Appendix 11.2: Shellfish Size Frequency Data

Appendix 11.3: Results of Benthic Microalgal Identification

Appendix 11.4: Water Quality Certificate of Analysis

Appendix 11.5: Positions of Sampling Stations

Infauna, Epifauna, Macroalgae, Microalgae and Water Quality Sampling Stations

Sampling Station	Position	Nominal Error	Date Sampled
Site 1	E 2844280 N 6184094	±4.4 m	30/9/2003
Site 2	E 2844176 N 6183525	± 5.1 m	29/9/2003
Site 3	E 2843489 N 6183624	±5.0 m	30/9/2003
Site 4	E 2840538 N 6184246	± 4.9 m	2/10/2003
Site 5	E 2841895 N 6184073	± 5.5 m	1/10/2003

Positions fixed using Geodetic Datum 49 (NZ Map Grid)

Sediment Quality and Texture Sampling Stations

Site	Latitude	Longitude
Ahuriri 1	39^{0}263.44S	176^{0}502.86E
Ahuriri 2	39^{0}273.81S	176^{0}504.61E
Ahuriri 3	39^{0}288.38S	176^{0}509.01E
Ahuriri 4	39^{0}289.45S	176^{0}519.38E
Ahuriri 5	39^{0}291.53S	176^{0}524.48E
Ahuriri 6	39^{0}291.71S	176^{0}527.34E
Ahuriri 7	39^{0}291.84S	176^{0}526.82E
Ahuriri 8	39^{0}291.72S	176^{0}527.33E
Ahuriri 9	39^{0}288.42S	176^{0}528.81E
Ahuriri 10	39^{0}356.70S	176^{0}551.06E
Ahuriri 11	39^{0}289.46S	176^{0}532.07E
Ahuriri 12	39^{0}288.98S	176^{0}535.51E
Ahuriri 13	39^{0}288.15S	176^{0}536.24E

Position data as supplied by Hawkes Bay Regional Council