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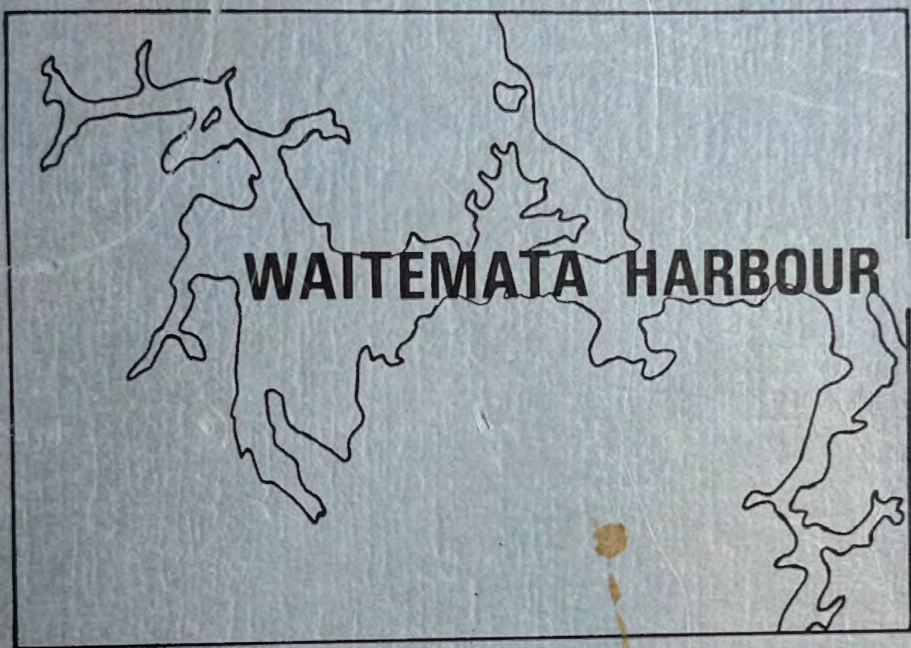

WAITEMATA HARBOUR STUDY

ECOLOGY

By M.F. Larcombe

JULY 1973

ECOLOGICAL REPORT
ON THE
WAITEMATA HARBOUR

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ECOLOGICAL REPORT ON THE WAITEMATA HARBOUR

INDEX

REPORT ON THE ECOLOGY OF THE WAITEMATA HARBOUR

INTRODUCTION

It is the aim of this study of the ecology of the Waitemata Harbour to :

1. Provide a record of the state of Harbour ecology at the present time.

2. Provide ecological information for consideration in determining the impact of proposed developments on the Waitemata Harbour ecosystem.

3. Describe the ecological impact of past and present developments within the Harbour Study Area.

4. Describe natural ecological changes that may be expected in the Harbour.

5. Indicate areas of particular ecological value for purposes of education, recreation and conservation.

To achieve these aims, the ecological report has been divided into several parts.

The Report on Intertidal Ecology describes the distribution and abundance of common fauna and flora and discusses several aspects of intertidal ecology for each of twenty-seven areas which together constitute the Harbour Study Area. Using information drawn from the reports on intertidal ecology, and additional data drawn from other sources and further research, a series of summary reports on various ecologically-orientated aspects of the Waitemata Harbour environ [illegible] have been written. These are listed in the index.

Generally, these reports do not present policies, but rather provide information which should be considered in the drafting of policies. It is intended that this ecological information be used in conjunction with information derived from other Harbour Study reports and to this end the ecological reports have been written in as concise a manner as possible in an attempt to make often complex ecological principles easily understood by the planners responsible for providing the final Harbour Plan.

It is also hoped that these reports are sufficient to provide a competent marine ecologist with the information required to make an assessment of the ecological impact of any particular proposed development without having to undertake any further research.

THE INTERTIDAL ECOLOGY OF THE WAITEMATA HARBOUR

INTRODUCTION

This report provides a record of the state of the intertidal ecology of the Waitemata Harbour Study Area at the present time.

The Study Area has been divided into twenty-seven parts, each of which is described separately, to facilitate reference to the ecology of any particular area.

The use of a series of headings enables easy reference to any particular aspect of the ecology of an area.

Descriptive Headings

1. Description of the Area.

   A general description of the surrounding land, foreshore and intertidal area.

2. Intertidal Substrates.

   Intertidal substrates are described along with some indication of the distribution and relative abundance of major types.

3. Intertidal Flora and Invertebrate Fauna

   Semi-quantitative descriptions of the common flora and invertebrate macrofauna are given, together with some indication of distribution within the area being described. To cover the Study Area with best effect in respect to the description of the flora and fauna, a system using an 'abundance index' was designed.

   Using this system comparisons can be made between the ecology of different areas within the Harbour with relative ease.

   Using past experience and data obtained during the course of this study a numerical index was determined for each invertebrate species consisting of categories of :

   abundant (a)
   common (c)
   occasional (o)
   rare (r)

This index has been designed solely for the Waitemata Harbour on the basis of the present range of numerical densities of the common fauna in that Harbour. It may, however, have a wider application in similar harbour situations, requiring only minor changes.

In a biological system where the distributions and numbers of animals are constantly changing the use of an abundance index is particularly valuable because it enables the detection of large changes without being confused by natural fluctuations in population density. No quantitative estimate of the abundance of the common algae has been attempted because of the large flucations shown by many of the intertidal species.

Appendix 1 gives the abundance index for each species.
Appendix 2 gives a brief description of the biology of each species.

4. Fish.

Common fish utilising the intertidal area are listed, with notes on the behaviour and abundance of each species.

5. Birds.

Common birds utilising the intertidal area are described.

6. Edible Invertebrates.

The edible invertebrates found in the intertidal area are listed along with an estimate of the degree of exploitation by Man, and the effect of such exploitation on the invertebrate populations.

Almost all the invertebrates taken from the Harbour area for food are shellfish, apart from small numbers of sea eggs (Evechinus chloroticus). Relevant information on changes in shellfish populations and recruitment are also given in this section.

7. Natural Changes.

Changes in the ecology of an area that might be expected to occur independently of man's influence are discussed.

8. Ecological Interference by Man.

The ecological impact of various human use of the Harbour foreshore and surrounding land are discussed.

9. Pollution.

The extent and ecological effect of any pollution occurring in the area is assessed.

10. Ecological Value.

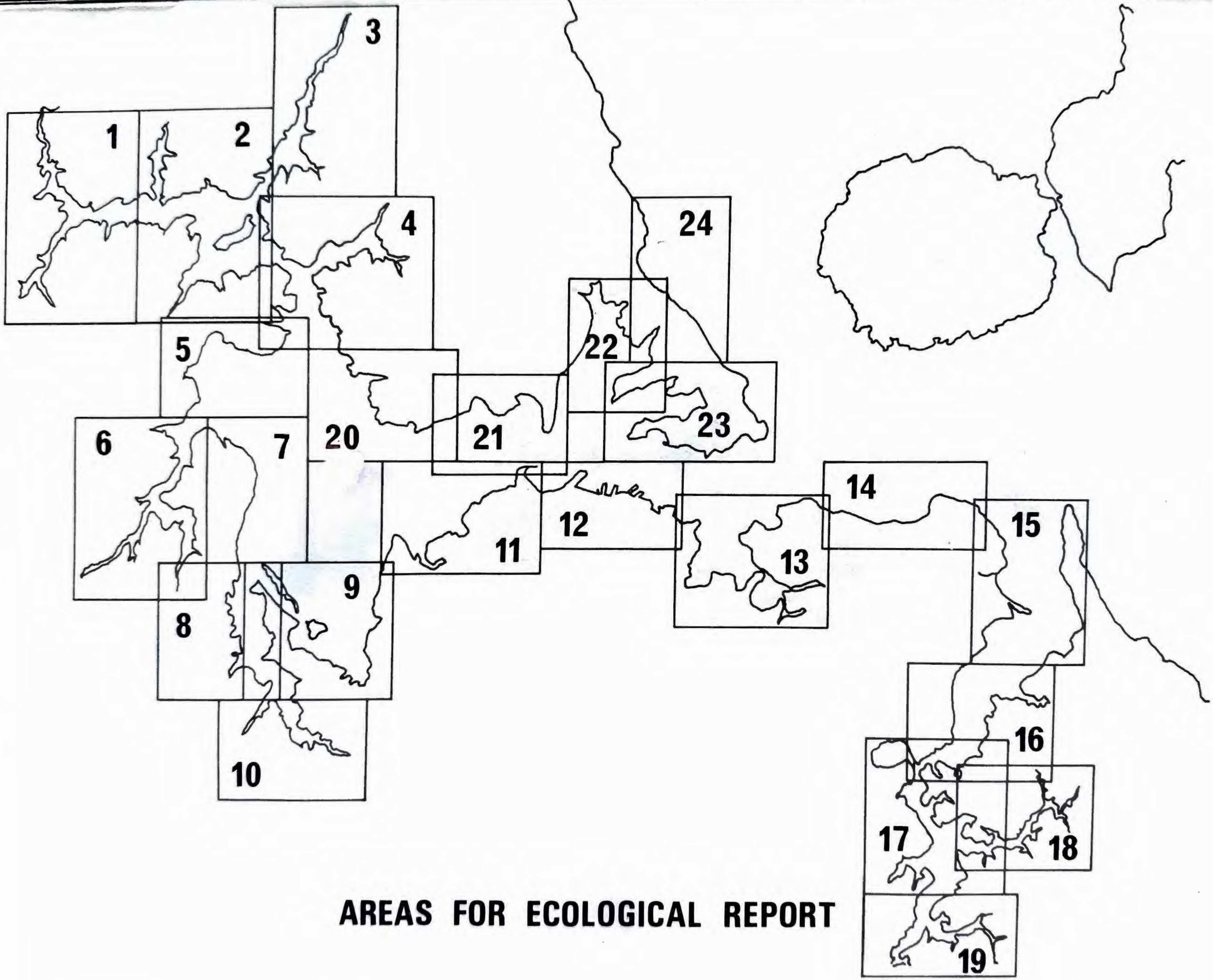
The ecological value of each area, or where the area is ecologically variable, the value of different parts of the area, is discussed.

11. Improvement and Protection of Ecological Assets.

Methods of improving the ecological 'condition' of the area - in terms of reversing polluting trends, reducing other interference, or altering the ecology to improve the aesthetic impact of the area are discussed.

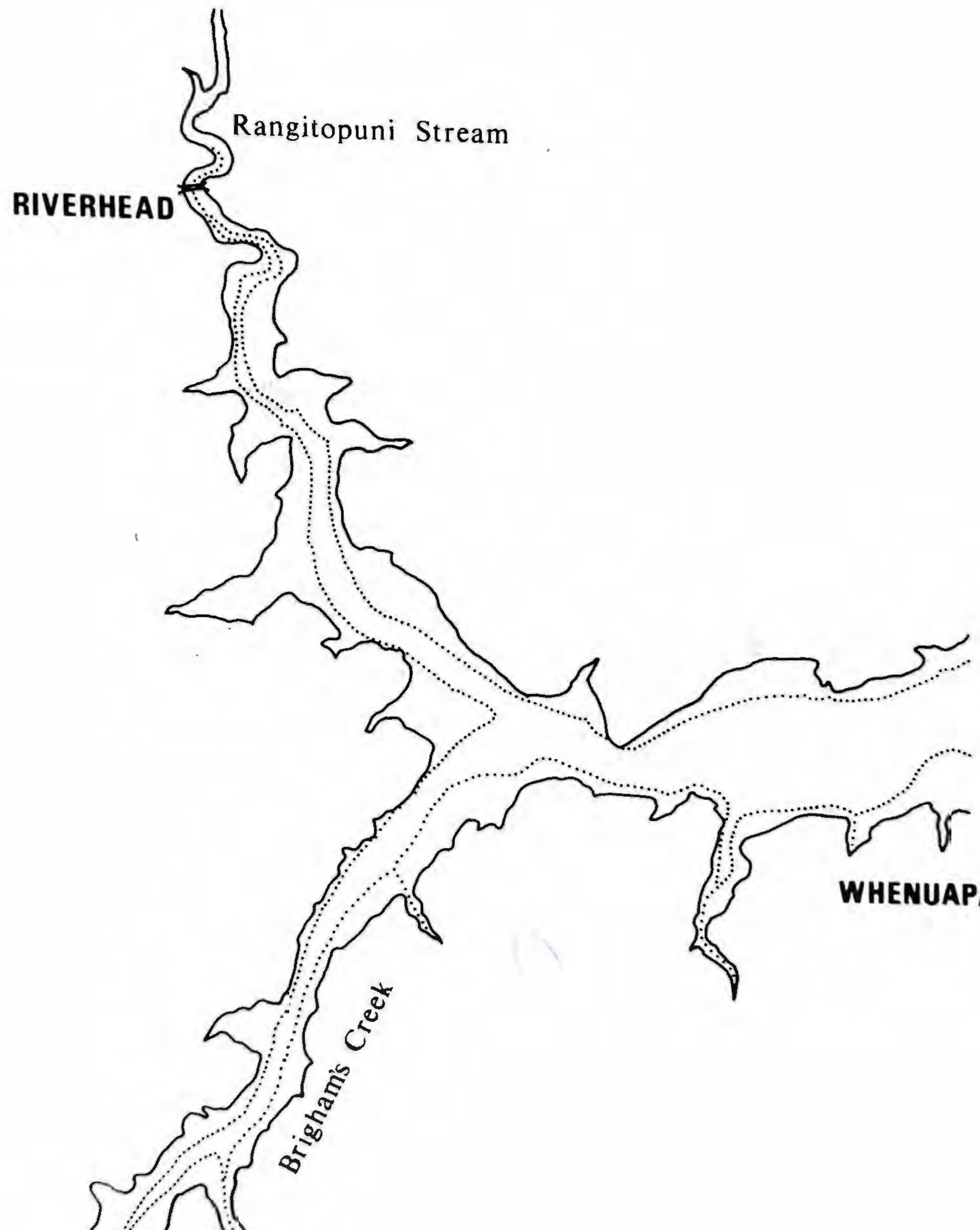
12. Potential Use of Ecological Assets.

Present direct use of ecological assets is described along with a discussion of any predictable changes in this use.



AREAS FOR ECOLOGICAL REPORT

AREA 1



RIVERHEAD AND BRIGHAM'S CREEK TO WHENUAPAI

AREA 1. RIVERHEAD AND BRIGHAMS CREEK TO WHENUAPAI

1.1 General Description

This upper region of the Harbour is characterised by wide intertidal mudflats with narrow low tidal channels. The shoreline is strongly indented with small bays and the entrances to creeks. The Rangitopuni Stream which enters the Harbour at Riverhead drains a large watershed and exerts considerable influence on the salinity of tidal waters in this region. (see Ecological Report on Harbour Waters.)

Most of the surrounding land is low-lying and has been developed for farming or market gardening. Generally, there are low banks of soft sandstone or clay falling to the upper intertidal. The vegetation on these banks and particularly on prominent headlands, adds considerably to the character of the region. Although the pohutukawa is not common this far up the Harbour, a variety of smaller natives such as kowhai, coprosmas, flax, pungas, and ferns combine with the more imposing pines in producing a pleasing association with the quiet waters and mudflats.

1.2 Intertidal Substrates

Most of the intertidal substrates of this region consist of soft sands and muds. Deposition of fine sediments derived from land runoff has modified the substrate in sheltered areas, (see 1.7 and 1.8 below) although there are still some relatively firm and sandy flats at high intertidal levels, particularly in Brigham's Creek.

Generally, the sediments are firmer and more coarse near low water level and in the channels, where they are continually graded by current action. Higher on the shore, they become progressively softer, particularly in sheltered areas and mangrove marshes. There is often a band of firm substrate at high tide level where sorting by wave action is most pronounced and there is little deposition of fine sediment.

Hard substrates are only exposed on a few points where the low tidal channel approaches the shoreline and there is sufficient current action to prevent the deposition of soft sediment. The rock is soft Waitemata sandstone, and is often covered with layers of fine silt.

1.3 Intertidal Flora and Invertebrate Fauna

There is a considerable reduction in both the numbers of species and the abundance of common species in this region, compared with areas further towards the mouth of the Harbour. This is a normal tendency and is to be expected in an area of considerable freshwater influence and reduced substrate variation. Other limiting factors are the quantity of suspended material in the water, and a possible reduction of water-carried food. (See Ecological Report on Harbour Waters.)

There are numerous small areas of mangrove in the upper intertidal, although a reduction in the abundance of mangrove is apparent towards the upper reaches at Riverhead.

Common flora and fauna of the region are:

Soft substrates

High tidal fringe

vegetation	Samolus repens Leptocarpus simplex Juncus maritimus var australiensis
fauna	Potamopyrgus antipodum (a) Ophicardelus costellaris (c) Ligia sp. (o) amphipods (c) Helice crassa (o)
Open high tidal flats	Amphibola crenata (c) Helice crassa (c)
Mid-tide soft areas	Helice crassa (o) Alpheus sp. (o) Mactra ovata (o) Hempolax hirtipes (r) spionid polychaetes (c) Nicon aestuariense (o)
Mangrove marsh	Amphibola crenata (c) Helice crassa (a) Potamopyrgus antipodum (c) Nicon aestuariense (o)
Firmer substrates near channels	Chione stutchburyi (c) Macomona liliana (o) Mactra ovata (c) Cominella adspersa (o) Cominella glandiformis (o) spionids polychaetes (a) Halicarcinus sp. (o)

Hard substrates

Although several of the common hard shore invertebrate species are present in this area they are considerably reduced in number. Bands of green and blue-green algae are conspicuous on damp rock surfaces in the winter, but disappear in summer.

High level

algae	Rhizoclonium hookeri Enteromorpha nana var minima
fauna	Sphaeroma quoyana (c) Onchidella Onigricans (o)

Mid tide level

algae	Gelidium sp. Sytosiphon lomentaria
fauna	Elminius modestus (c) Sphaeroma quoyana (c) spionid polychaetes (c) Anthopleura aureoradiata (o) Zeacumantus subcarinatus (o) Modiolus fluviatilus (c) Cominella glandiformis (o) Crassostrea glomerata (r)

Shelly areas adjacent to rock	Amphidesma australe (o) Zediloma subrostrata (o) Zeacumantus lutulentus (r) Hemigrapsus crenulatus (o)
Low tidal rock	Anthopleura aureoradiata (c) Mytilus fluviatilus (a) Balanus amphitrite (a)
Beneath boulders	emphipods (c) serpulid polychaete (o) polyzoan (c) Hemigrapsus crenulatus (c) Chitonopsis sp. (o) Melanopsis trifasciata (o)
Pools	Palaemon affinis (o)

Discussion

Most of the species described above are common over wide areas of the Harbour. In this region, the rigorous environmental conditions of variable salinity, high quantity of suspended material, and unsuitable substrate, have resulted in reductions in abundance, growth rates, and maximum sizes.

A small group of animals, however, is adapted to the salinity regime of this area, and is only found in regions with considerable freshwater influence. These include Melanopsis trifasciata which is found in both fresh and brackish water; the esturarine barnacle, Balanus amphitrite, and the mussel Mytilus fluviatilus. Various amphipods, polychaetes, and a species of polyzoan, may also fall into this category of truly estuarine animals.

1.4 Fish

Little is known of the utilisation of this area by fish species. Flatfish are common and at times there are large numbers of juveniles near the waters edge at low tide. Yellow-eyed mullet are also common in the channels. Eels and whitebait pass through the area.

Several other common species probably enter the area at times but there does not appear to be sufficiently rich in fauna to attract large resident populations.

1.5 Birds

A reduction in the abundance of common wading birds in this area is probably a result of the lower densities of invertebrate food. Small numbers of pied stilts, white-faced herons, red-billed gulls, and black-backed gulls are present. Kingfishers are the most common shore-feeding birds and there are small numbers of white-fronted shags and little black shags. Ducks occur at times in sheltered areas.

1.6 Edible Invertebrates

The only edible invertebrate that reaches edible size in this region is the bivalve Mactra ovata, although there are small numbers of Chione stutchburyi between 25 and 30 mm.

Although Mactra is common near the low tidal channels almost as far as Riverhead, the presence of this bivalve is probably not appreciated by the human population of the area, and there is little exploitation. Little change is to be expected in the abundance of these shellfish.

1.7 Natural Ecological Changes

The extensive soft flats of this upper area of the Harbour are important in providing suitable regions for the deposition of fine sediments carried from the land. In this way, water-bourne sediment is deposited in sheltered areas near the head of the Harbour, and the water moving to other parts of the Harbour is improved in quality.

Under natural conditions only small volumes of sediment would be carried into the Harbour and the removal of these from the water would be extremely effective with little ecological impact. A slow build-up of intertidal substrate level would result in a gradual transition from open mudflat to mangrove marsh to salt marsh to dry land.

1.8 Ecological Interference by Man

With the development of the watershed area from bush to farmland there has been an increase in the rate of sediment contribution to Harbour waters. The ecological impact of this rate increase is discussed in the Ecological Report on Harbour Waters.

With development of the watershed the volume of fresh water released into the Harbour will probably increase, and the pattern of freshwater flow will change. Ecological implications of such changes are discussed in the Ecological Report on Harbour Waters.

1.9 Pollution

Pollution of the intertidal region of this Area is slight, but there are some signs of organic pollution and eutrophication. On the surface of muddy areas below Riverhead there is a slime of micro-organisms - probably colonial diatoms or euglenoids - which is not normally found in such areas. In the built-up area of Riverhead there is some dumping of inorganic waste into the Creek, and there are substantial quantities of plastics caught on obstacles in the channel below the town.

The local timber mill is suspected of being a source of some pollution.

1.10 Ecological Value

The principal ecological value of this region lies in its function of protecting areas further down the Harbour from the deposition of fine sediments.

Although the intertidal area is not as rich, in terms of numbers of species and their abundance, as other regions towards the mouth of the Harbour, it is in a healthy state and of some value to food chains of the Harbour ecosystem.

Some types of animals and plants are only found in the estuarine conditions of this region.

1.11 Improvement and Protection of Ecological Assets

The reduction of sediment contribution to tidal areas would be of benefit to the ecosystem in terms of improving water quality, increasing the range of sediment types, and thus promoting biomass increase through improved growth rates and settlement.

The nature of the foreshore is important to the ecological stability of an area such as this. Fine substrates are the most prone to pollution through incorporation of organic material and the protection of the foreshore strip will reduce the contribution of organic matter to the intertidal area.

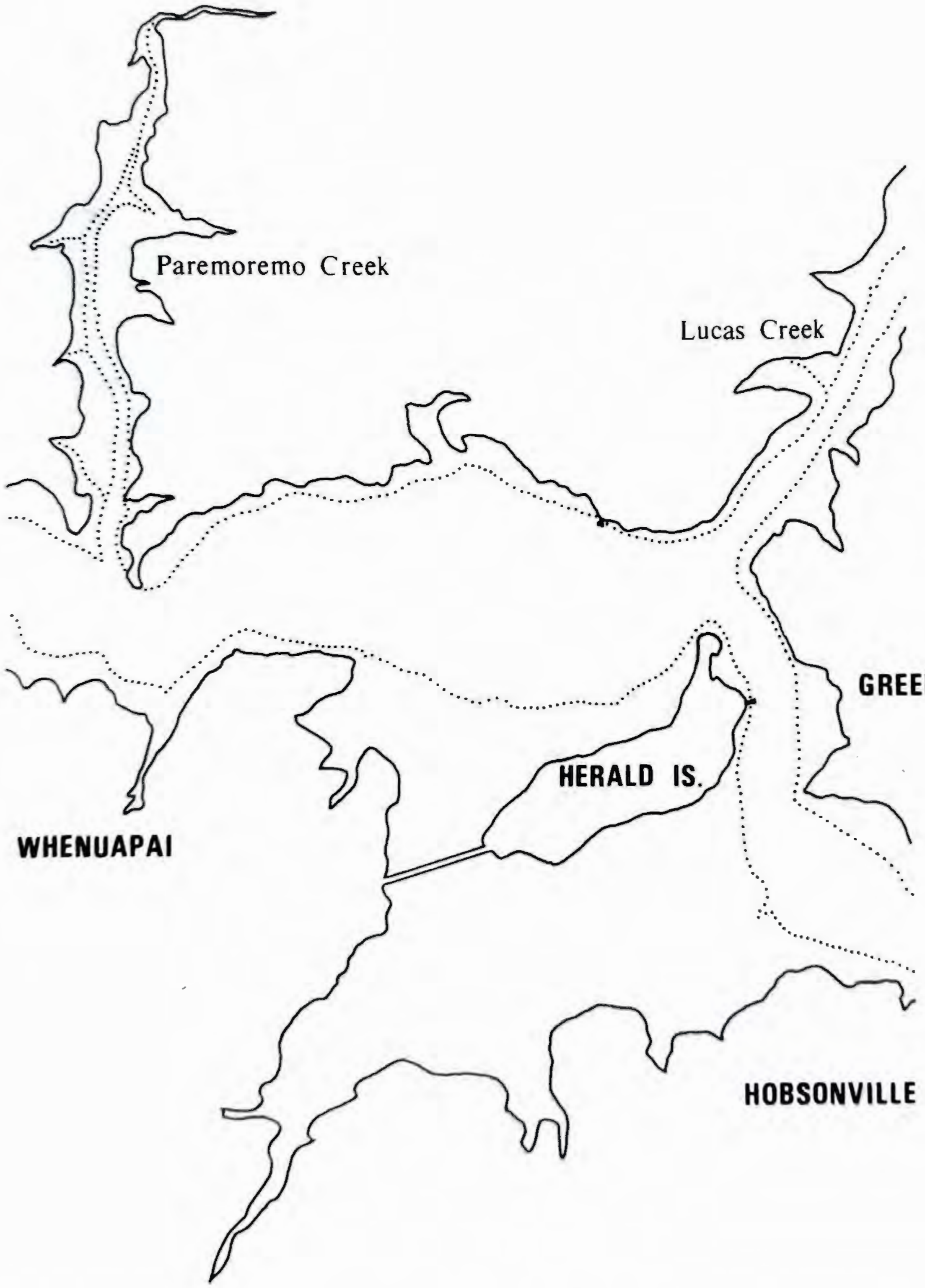
The retention of a foreshore 'buffer' zone of trees would also be of considerable value by enhancing the quiet character of the waters of this region.

1.12 Potential Use of Ecological Assets

At present this area is used for commercial flatfishing and probably for some casual flatfishing as well. Several studies have been undertaken at university level on aspects of the biology of estuarine animals in the Riverhead region.

Little increase in the use ecological assets can be foreseen, although with an increase in population in the region the educational use of intertidal ecology could increase.

AREA 2



PAREMOREMO CREEK, WHENUAPAI — HOBSONVILLE, GREENHITHE

AREA 2. PAREMOREMO CREEK - WHENUAPAI TO HOBSONVILLE - GREENHITHE

2.1 General Description

In this region of the Harbour there are extensive areas of shallow water with wide intertidal flats. The Paremoremo Creek and Lucas Creek, both with considerable tidal areas, branch off the main body of the Harbour. Shorelines are generally strongly indented with bays and small creeks, resulting in a shoreline of considerable length and variation.

Foreshores of this region are particularly striking, notably those of the northern side of the Harbour. To the east of the Paremoremo Creek entrance the land rises steeply from the water and covered in dense vegetation. This strip of rising land continues up the northern side of the Lucas Creek, (see Area 3) and a similar shore extends south from the Lucas Creek entrance to Greenhithe. Although pine is visually dominant over much of this foreshore, there is considerable regeneration of native trees.

On the south side of the Harbour, the Whenuapai to Hobsonville region is developed as farmland and market-garden. The land is gently rolling and low-lying compared with that to the north and east, and has low banks along most of the foreshore. Cliffs occur along the southern and eastern foreshores of Herald Island, while the remainder is low-lying with basalt block retaining walls along the causeway and in front of residential properties.

Towards the constriction in the Harbour between Herald Island and Greenhithe, the channel becomes gradually deeper. The large water volume which passes through this area, and also through the narrow region between Hobsonville and Beachhaven, results in strong tidal currents and considerable scouring in the channel region.

2.2 Intertidal Substrates

Most of the intertidal area of this region has a substrate of soft sediment, mainly mud. Mangrove has become established at suitable levels in sheltered situations and covers extensive areas. Lower down the shore there is a varying width of open mud flat.

In some areas there has been a buildup of shell and coarser sediments by wave and current action. Such areas occur at the end of Herald Island and on the northern side of Hobsonville Air Base where the intertidal zone rises relatively steeply from the low tidal channel. There are also minor aggregations of shell in the bay to the south of Herald Island and at Whenuapai. Generally, low tidal substrates are firmer than those higher on the shore. In low tidal channels sediments are often sandy.

Hard substrates are found in small areas on exposed points although there is often considerable silting. A relatively lengthy stretch of hard shore extends from the Paremoremo Wharf towards Greenhithe. In this region strong tidal currents keep the rock relatively clean and there is a comparatively rich fauna and flora.

2.3 Intertidal Flora and Invertebrate Fauna

Soft Shores: High tide level.

Generally, there is a narrow band of fairly firm substrate at this level, whether it be on an open shore, or inshore of a mangrove marsh.

plants	Samolus repens Selliera radicans Leptocarpus simplex Juncus maritimus var australiensis Stipa teretifolia
fauna	Ophicardelus costellaris (c) Potamopyrgus antipodum (a) Helice crassa (o)
Mangrove marsh	Helice crassa (a) Elminius modestus (c) (on roots) Crassastrea glomerata (r) Amphibola crenata (a)

Upper Intertidal - On fairly firm open shore - e.g. northern side of Herald Island

Chione stutchburyi (a)
Macomona liliana (c)
Zeacumantus lutulentus (c)
Zediloma subrostrata (c)
Cominella glandiformis (c)
Helice crassa (o)
Hemiplax hirtipes (o)
Elminius modestus (c)
Anthopleura aureoradiata (o)
spionid polychaetes (a)

Lower shore - Generally soft substrate

Alpheus sp. (c)
Hemiplax hirtipes (a)
Mactra ovata (o)
Chione stutchburyi (r)
Cominella glandiformis (o)
Cominella adspersa (o)
spionid polychaetes (c)
Scolelepis sp. (c)

- Firmer substrate: In areas where current action is strong and the shore usually fairly steep.

Chione stutchburyi (c)
Macomona liliana (a)
Nucula hartvigiana (c)
Soletellina nitida (a)
Mactra ovata (c)
Cominella glandiformis (c)
Cominella adspersa (c)
nemertean (c)
Glycera sp. (o)
Scolelepis sp. (c)
spionid polychaetes (a)

Hard Substrates

Most of the hard substrate in this region is very similar in nature, being broken and eroded and often covered in silt. A rich fauna and flora is supported in regions where there is strong current action, particularly on vertical surfaces and overhangs. Bands of green algae are conspicuous in winter especially on south-facing slopes which remain damp for long periods.

High tide level

algae	*Enteromorpha sp.* *Gelidium sp.*
fauna	*Sphaeroma quoyana* (a)
Under high tidal stones	*Ligia sp.* (c) amphipods (c) *Cyclograpsus lavauxi* (o)
Mid-tide level	*Sphaeroma quoyana* (c) *Elminius modestus* (o) *Melagraphia aethiops* (r) *Lepsiella scobina* (r)

	Zeacumantus subcarinatus (o)
	Onchidella nigricans (a)
	Crassostrea glomerata (o)
	Anchomasa similis (c) (may be dead)
	Anthopleura aureoradiata (c)
	Pomatoceros coeruleus (o)
	spionid polychaetes (c)
algae	*Hormosira banksii*
	Scytosiphon lomentaria
Under stones mid-tide level	*Petrolisthes elongatus* (c)
	Hemigrapsus crenulatus (o)
	Pilumnopeus serratifrons (c)
	Cominella glandiformis (o)
	Lepidonotus sp. (c)
	Nicon aestuariense (o)
	Eulalia sp. (o)
	Sypharochiton pelliserpentis (o)
Low tide level	*Ciona sp.* (c)
	Balanus amphitrite (c)
	Ostrea sp. (c)
	Microcosmus kura (c)

2.4 Fish

Many common species of fish may be found in this region of the Harbour. Intertidal flats are valuable in providing crustacean food for small schnapper and ideal areas for juvenile flounder to feed. The effect of *Parore* grazing is also obvious in places where these fish have been feeding on algae from the rock surfaces.

Commercial flatfishing is practised in this area, the main catch being yellow-bellied flounder with small numbers of dab.

2.5 Birds

The common shore-feeding birds are not abundant in this Area. Pied stilts, white-faced herons, red-billed gulls and black-backed gulls are present in small numbers. Kingfishers are the most common shore feeder, particularly in areas adjacent to flats inhabitated by large numbers of crabs.

Water-feeding birds consist of pied shag, little pied shag and little black shag, all of which are common. Little black shags occasionally occur in large flocks in the winter. Other water-feeding birds are the white-fronted terns of which small numbers are present throughout the year, and the occasional gannet.

2.6 Edible Invertebrates

Chione stutchburyi reaches a maximum length of about 30 mm in ideal conditions in this area. Beds of individuals of this size are not extensive, however, and are normally found at some distance from the shore adjacent to the low tidal channels. Chione is not taken for food to any great extent, probably because of the low numbers of edible individuals and their inaccessibility.

Mactra ovata occurs throughout the area, sometimes in dense beds of individuals of edible size. Apparently there are not many people aware of the existence of this bivalve or are not keen on gathering it because of the soft mud habitat.

2.7 Natural Ecological Changes

The major natural change one might expect in the ecology of this area would be the gradual accumulation of fine sediments with the resultant rise of intertidal level in sheltered areas and the consequent spread of mangrove marsh. This process is occurring at the present time, but the rate has been increased far above what one would consider natural by the contribution of large quantities of sediment to the Harbour as a result of Mans' activities.

2.8 Ecological Interference by Man

The principle effect of Man in this Area has been a speeding up of the rate of sediment deposition in tidal areas by the contribution of increased quantities of sediment from the watershed. As a result much of the mangrove marsh is expanding at a rapid rate; areas of previously coarse sediment are being covered by finer recently-deposited material and the natural communities of wide areas are being changed.

One obviously affected area is that around Herald Island particularly in the large bay immediately south of the Island. Recent deposition of fine sediments to a depth up to 15 cm has resulted in the destruction of a healthy Chione-type community, and its replacement with soft mud dwellers - Hemiplax hirtipes and Alpheus sp.

2.9 Pollution

There is some small scale dumping of inorganic rubbish on to Harbour foreshores in this Area. Although the ecological impact of such activity is small, the visual impact can be considerable.

Some intertidal mudflats have a crust of diatoms or flagellates on the surface - a sign of eutrophication. This is particularly noticeable in the Hobsonville region.

2.10 Ecological Value

Considerable ecological value may be attributed to the function of the extensive sheltered intertidal areas of this region in retaining large quantities of soft sediment derived from the watershed. Mangrove marshes are particularly valuable for this reason.

Although large intertidal areas have been affected by sedimentation, the fauna is still rich and is important to fish and birds as food.

The Areas are also of minor commercial value in providing a small flatfish fishery. It is also of considerable value as a nursery for juvenile flatfish and other species.

2.11 Improvement and Protection of Ecological Assets

A marked improvement of the intertidal ecology could be made by reducing the degree of sedimentation in this region. This can only be done by reducing the quantity of sediment entering the Harbour from the land. Protection of foreshores, where practicable, would help in this respect.

The steep, south-facing slopes to the east of Paremoremo deserve special consideration. These slopes are important to the character and environment of a large part of the Upper Waitemata. They are visible, and capable of being appreciated from a wide area. Development of such areas for residential purposes means, almost without exception, the removal of most of the vegetation. Such development would be a threat to intertidal ecology because of the almost unavoidable contribution of large quantities of sediment to the tidal area during the development process.

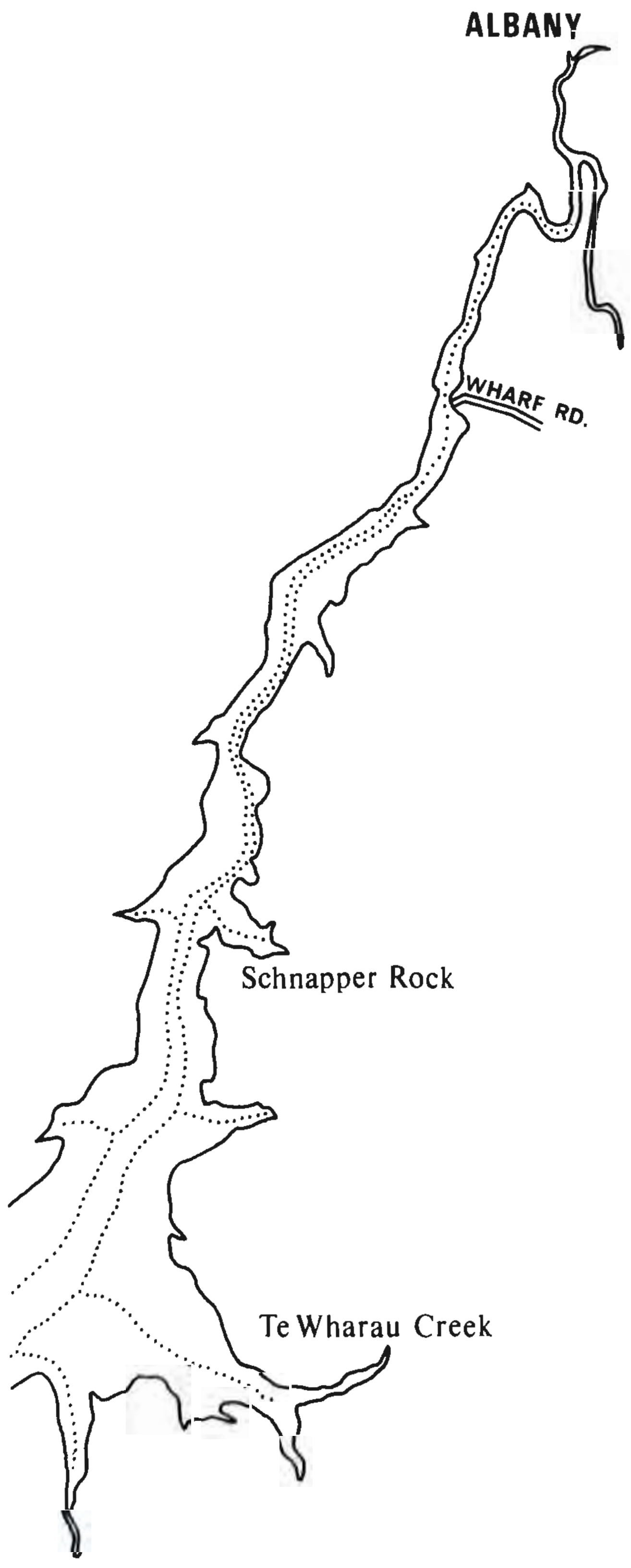
2.12 Potential Use of Ecological Assets

The present use of the ecological assets of this area is slight; major uses being commercial and recreational fishing. Shellfish gathering is only of a small scale.

Potential use of the Area will not vary significantly from that at present, although with increasing population in the region there will be an increasing demand on the Area for recreational purposes of fishing, boating and swimming. These activities require high standards of water quality.

There may also be some educational use of local shores. A good range of animals and plants is represented.

AREA 3



LUCAS CREEK

AREA 3. LUCAS CREEK

3.1 General Description

The Lucas Creek is a long narrow inlet extending from the Upper Harbour opposite Herald Island to the town of Albany. The watershed of this creek is largely farmland in the Albany Basin and to the south, with areas of bush on the steeper slopes. Small creeks enter the main waterway in the lower reaches, while two larger streams enter at the head of the tidal area at Albany.

The Lucas Creek has marked esturarine characteristics with considerable salinity variation throughout the area and particularly towards the upper reaches. On low spring tides practically all tidal water leaves the creek above Snapper Rock, and after heavy rain the low tidal channel is almost fresh at this point. After dry spells highly saline water penetrates right to Albany with the rising tide and low tidal water is also of higher salinity. General salinity patterns for this type of area are discussed in the Ecological Report on Harbour Waters.

The tidal part of the Lucas Creek is situated in an extensive valley, with rolling farmland to the south and sharply rising land along the northern bank. Vegetation on this steep northern side of the creek consists of patches of regenerating native bush and areas of mature pine. The character this gives to the area close to the water is particularly attractive and well worth preserving. The southern side of the creek seems destined for development as residential suburbs, being ideally suited for this purpose.

3.2 Intertidal substrates

Intertidal substrates in this Area are composed principally of soft sediments, although there are isolated outcrops of rock on some points on the northern side of the creek entrance and particularly towards Albany.

Towards the mouth of the creek there are extensive intertidal mud flats on either side of the low tidal channel. A band of mangrove occupies the upper intertidal and large areas in the mouths of subsidiary creeks. Near low water and in the low tidal channel there are areas of firmer sandy substrate where current action removes fine sediment particles. Rock outcrops in the area are similar in nature to those in other areas of the Upper Harbour, being of soft Waitemata Sandstone, and heavily silted except in current or wave exposed areas.

In the middle region of the creek, the tidal area narrows. There are still extensive high level mudflats with mangrove fringing the shoreline. Often there is a sharp drop from the mudflat into the low tidal channel.

With further narrowing of the tidal area in the vicinity of Wharf Road the mangrove becomes less abundant and is restricted to small patches near the shoreline. There are small areas of open mudflat with banks falling steeply to the low tidal channel. At low tide the water in the channel flows swiftly over benches of rock in the stream bed, while there are accumulations of boulders in calmer areas, and patches of coarser sediment.

Towards Albany the tidal area becomes progressively narrowed, with steep banks and overhanging vegetation. Faster water movement means little accumulation of fine sediment. The mangrove disappears and the low tidal channel flows over rock benches with areas of boulders and coarse sediment. The limit of tidal penetration is a small waterfall about 100 metres above the road bridge carrying Highway 1 at Albany.

3.3 Intertidal flora and invertebrate fauna

Because of the considerable variation in hydrological properties along the Lucas Creek this Area has been described in three parts:

A. Entrance Area

B. Middle Creek

C. Upper Creek

3.3.A. Entrance Area

Three major ecological habitats may be recognised in this region.

(i) Mangrove marsh

(ii) Midtidal mud flat

(iii) Low tidal mud flat.

3.3.A. (i) Mangrove marsh

There are extensive areas of mangrove in this region, both lining the shoreline and particularly in the entrance to the Te Wharau Creek. At present the mangrove marsh is both healthy and attractive.

High tidal fringe

flora
Leptocarpus simplex
Stipa teretifolia
Juncus maritimus var *australiensis*
Selliera redicans
Samolus repens

fauna
Potamopyrgus antipodum (a)
Ophicardelus costellaris (c)
Helice crassa (c)

Mangrove marsh
Amphibola crenata (c)
spionids (c)
Alpheus sp. (c) (wet areas)

on pneumatophores, roots and branches
Elminius modestus (c)
Crassastrea glomerata (o)

Caloglossa leprierrii
Catenella nipae
Rhizoclonium hookeri

3.3.A. (ii) Mid-Tidal Mud Flat

In the mid-tidal region there are extensive areas of variable softness. Sediments are predominantly fine muds.

Amphibola crenata (c)
Chione stutchburyi (r)
Helice crassa (c)
Hemiplax hirtipes (c)
Alpheus sp. (c)
Nicon aestuariense (o)
spionid polychaetes (a)

3.3.A. (iii) Low tidal flats

In some regions the low tidal flats are soft and support a similar fauna to that described above for the mid-tidal mud flat. However, in areas of strong current action there are more sandy stable sediments which support a different group of animals. These include:

Chione stutchburyi (c)
Mactra ovata (c)
Cominella glandiformis (o)
Cominella adspersa (o)
Macomona liliana (o)

The fauna and flora of rock outcrops in this region are similar to that described in Area 2.

3.3.B. Middle Creek

The same three regions described for the entrance area can be recognised here, although the extent of low tidal flats with sandy substrate is limited to the low tidal channel.

Principal differences are in the abundance of the common species. Hemiplax hirtipes is virtually absent, and there are reductions in the densities of Chione stutchburyi and Alpheus sp. The reduction of Chione is due to the small area of suitable substrate, while the reduction of Alpheus and Hemiplax is probably due to increasing freshwater influence.

On Snapper Rock itself are found:

algae	Enteromorpha sp. - common in winter
fauna	Elminius modestus (c) Sphaeroma quoyana (a) Crassostrea glomerata (r)

3.3.C. Upper Creek

In the narrow part of the Creek above Wharf Road, mangrove is all but absent. Intertidal banks are steep, being largely mud in the Wharf Road region with increasing amounts of sandstone further towards Albany. At low tide the water flows rapidly over benches of rock and accumulations of stones and pebbles.

on mud banks	Amphibola crenata (a) Chione stutchburyi (o) Mactra ovata (c) Helice crassa (o)

attached to stones in the channel

Mytilus fluviatilus (c)
spionid polychaetes (a)
Balanus amphitrite (c)
polyzoan (c)

Amphibola is also found in the low tidal channel, and there are small numbers of *Chione* in the sediment between stones.

With the further narrowing of the Crrek towards Albany, and the exposure of more hard substrate, *Sphaeroma* becomes abundant over most of the tidal range. The burrowings of this animal are particularly conspicuous in the rock in the vicinity of the road bridge at Albany. *Mytilus fluviatilus* is found to the limit of tidal penetration above Albany, as is *Helice crassa* which burrows amongst vegetation, often some distance above high tide mark. *Potamopyrgus* is also abundant.

Albany	*Sphaeroma quoyana* (a) *Mytilus fluviatilus* (c) *Potamopyrgus antipodum* (a) *Zemelanopsuis trifasciata* (o) stonefly larvae (o) *Helice crassa* (o)

3.4 Fish

Many of the common Harbour fish probably enter the waters of this region at times. Of those dependant on the area for food, juvenile schnapper and flatfish are the most important.

3.5 Birds

Of the shore feeding birds kingfishers are the most numerous, being common in all mangrove areas and near open flats inhabited by crab species. Small numbers of pied stilts, white-faced herons, red-billed gulls and black-backed gulls are also present.

Three species of shags are found; pied shags being common with small numbers of little pied shags, and occasional large groups of little black shags in the winter.

White-fronted terns often feed in the waters near the entrance to the Creek, as does the occasional Caspian tern and gannet.

3.6 Edible Invertebrates

Two species of edible shellfish are found in this area, the mud snail, *Amphibola crenata*, and *Mactra ovata*.

The mud snail is probably not taken for food, and few people seem to be aware of the presence of Mactra and it is not exploited.

Small numbers of Crassostrea glomerata occur on mangrove roots and pneumatophores but these are not often taken.

3.7 Natural Ecological Changes

The most significant natural ecological change in progress in the Lucas Creek is the slow accumulation of fine sediments resulting in a rise of intertidal substrate level and a slow spread of mangrove marsh. Unlike other parts of the Upper Harbour, (Areas 1 and 2) there appears to have been little acceleration of the rate of sediment deposition in the intertidal part of the Lucas Creek.

3.8 Ecological Interference by Man

Man has had little effect on the ecology of this region. Care must be taken during development of the surrounding land to avoid undue contribution of sediment to the tidal area, and to protect the foreshore particularly where there are steep slopes above the water.

3.9 Pollution

There is little sign of pollution over much of this area. Isolated cases of dumping of rubbish into the tidal area occur where roads approach the foreshore and adjacent to private residences.

The untidy nature of the foreshore in the vicinity of the boat yards at the entrance to the Creek is noticeable, with a variety of plastics, metals and concrete waste littering the shore.

3.10 Ecological Value

The ecological value of a large shallow area such as the Lucas Creek lies in its functions of retaining sediment derived from land runoff; providing large surfaces for oxygenation and purification of tidal waters; providing sheltered feeding areas for juvenile fish; and possessing a natural and healthy fauna and flora which is important to food chains throughout the Harbour ecosystem.

3.11 Improvement and Protection of Ecological Assets

At present, the tidal area of the Lucas Creek is ecologically clean and healthy. Because of the large volume of fine sediments, however, it is an area that will be extremely susceptible to change by sedimentation or the introduction of organic waste material. The planning of development of the land surrounding this area will be of considerable importance to intertidal ecology. The retention of natural foreshores is important, along with careful development to minimise the contribution of sediment to the tidal area.

An important asset of this area is the steep, tree-covered slope immediately north of the creek. This sharply-rising slope extends much of the way to Albany and is visible from large areas of land to the south. The retention of this slope as a 'green belt' would preserve much of the character of the tidal areas and be a real asset for the residential areas planned for the south side of the creek. Preservation of this area would also help protect the tidal area from the almost unavoidable contribution of large quantities of sediment if the land were developed.

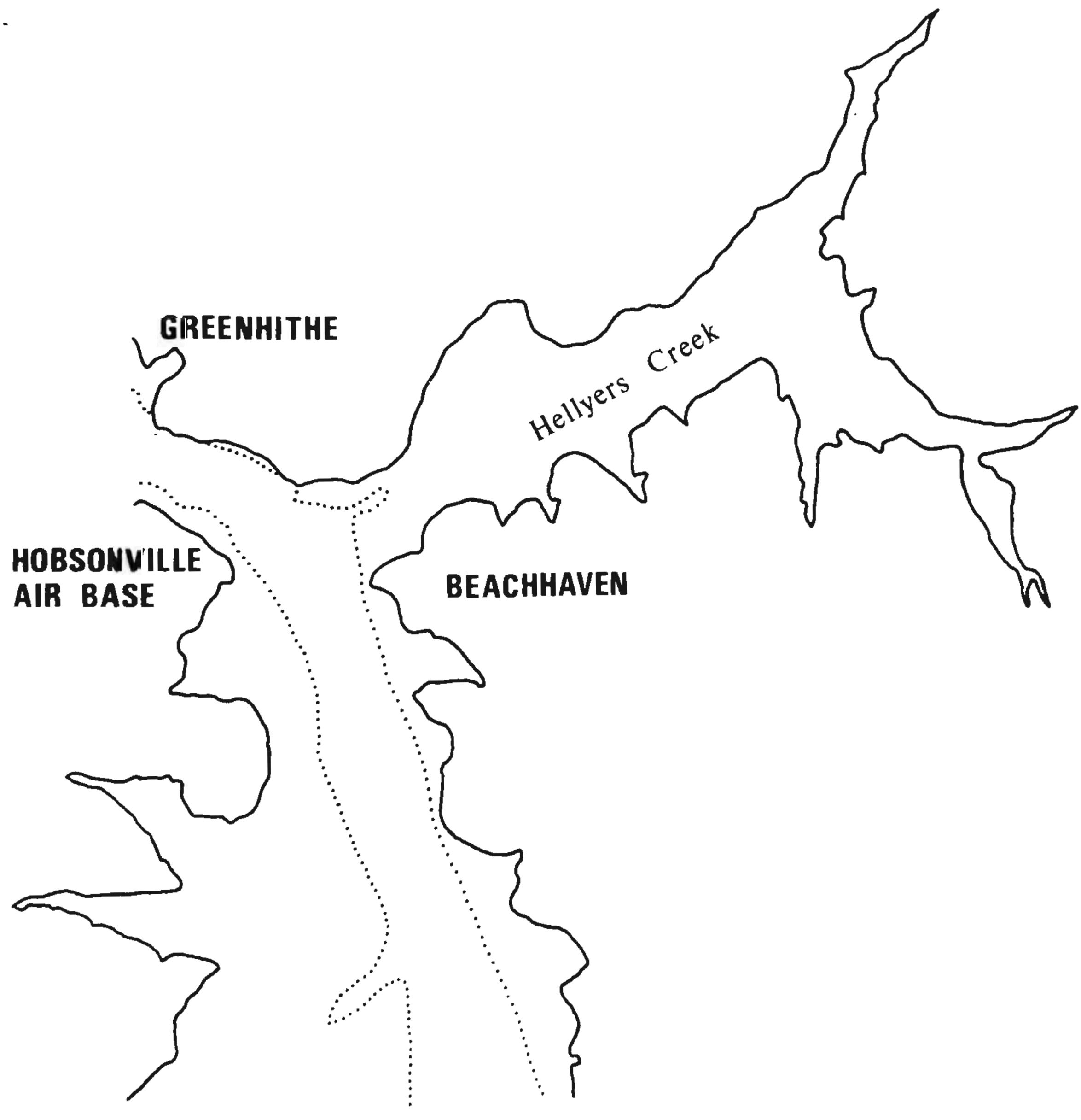
3.12 Potential Use of Ecological Assets

There is some potential use of the ecological assets of this area for educational purposes, especially when the southern shore is developed for housing and the university is built in the Albany Basin.

Small-scale commercial fishing occurs at present, and it is probable that recreational flatfishing and line fishing will become important with increased population.

Tree-covered slopes to the north of the creek would be well suited for development of walking tracks.

AREA 4



HELLYERS CREEK, BEACHHAVEN, GREENHITHE

AREA 4. GREENHITHE TO BEACHHAVEN INCLUDING HELLYERS CREEK AND HOBSONVILLE

4.1 General Description

In this region the Harbour is constricted and there is a deeply-scoured main channel. Shores are protected from wave action and there is considerable silt deposition in areas protected from strong currents.

South of Greenhithe the foreshore is fairly steep with cliff in some places. Much of this is tree-clad with many regenerating native species amongst mature pines.

The northern side of the entrance to Hellyer's Creek is particularly prominent with a vegetation covered steep slope falling to the water's edge. Almost all of the block of land to the south of View Road on the northern side of Hellyer's Creek is covered with trees. This steep, south-facing slope supports large areas of regenerating native bush with kauris becoming prominent in some places. Around the head of Hellyer's Creek development is encroaching into the bush and scrub, although much of the steep land close to the water is still tree-clad, right to the southern extremity of the tidal area.

The low-lying southern side of Hellyer's Creek is largely residential with some foreshore reserves and mature trees remaining. South of the Beachhaven Wharf there are a series of small points with low cliffs and bays between. Some of the steeply-rising slopes have been subdivided and much of the tree cover removed. However, there are many small prominent areas close to the water in which a few trees remain and add greatly to the attraction of the area.

The land on the western side of the Harbour in this region is included in the Hobsonville Air Base. Most is developed as farmland, aerodrome, and servicing facilities for the Air Base. Much of the foreshore is in fairly natural state with low cliffs and steep banks covered with scrub and trees.

4.2 Intertidal Substrates

In areas protected from the strong current action of the main channel sediments are fine and soft. Near the channel there are some areas of firm sandy sediment, particularly on protruding points such as at Greenhithe.

Some sandstone reefs are exposed intertidally - notably in the area to the north of the entrance to Hellyers Creek and on the points to the south of Beachhaven Wharf.

4.3 Intertidal flora and invertebrate fauna

Soft shores - Much of the intertidal region of this area is relatively homogeneous with respect to soft shore fauna. Away from the localised patches of firm sandy substrate, the sediments are uniformly soft and fine. Mangrove occupies large areas of the upper shore, particularly in sheltered places such as Hellyer's Creek.

Shore fringe	vegetation	Stipa teretifolia Salicornia australis Leptocarpus simplex Juncus maritimus var australiensis
	fauna	Potamopyrgus antipodum (c) Ophicardelus costellaris (c) Ligia sp. (o) Helice crassa (c) amphipods (c)
Mangrove marsh		Crassostrea glomerata (o) Helice crassa (c) Amphibola crenata (c) Elminius modestus (c)
High level soft flats		Helice crassa (a) Amphibola crenata (a)
High level firm flats		Chione stutchburyi (a) Macomona liliana (a) Zeacumantus lutulentus (c) Anthopleura aureoradiata (c) Cominella glandiformis (c) Notoacmea helmsi (c) Zediloma subrostrata (o) Elminius modestus (o)
Low tidal soft flats		Alpheus sp. (a) Hemiplax hirtipes (a) Mactra ovata (c) Cominella adspersa (o)

Hard Shores - The hard shores of this region consist of cliffs and reefs of Waitemata sandstone. In winter there is a conspicuous band of green algae about the high water mark, particularly well developed where there is fresh water seepage. This band disappears in summer but there is still a zone of less-conspicuous blue-green algae above the high water mark.

Boulder accumulations at high levels		Ligia sp. (a) Cyclograpsus lavauxi (c) Hemigrapsus edwardsi (o) amphipods (c)
High tidal reefs	algae	Enteromorpha sp. Hormosira banksii Gelidium cavlacantheum
	fauna	Sphaeroma quoyana (a) Melagraphia aethiops (o) Zeacumantus subcarinatus (o) Lepsiella scobina (o) Cominella glandiformis (o) Cominella maculosa (r) Onchidella nigricans (a) Crassostrea glomerata (o) Petrolisthes elongatus (o) Anthopleura aureoradiata (c) Pomatoceros coeruleus (o)
Lower intertidal levels		Ostrea sp. (c) Perna canaliculus (r) Sigapatella novaezelandiae (r) Ciona sp. (c) Watersipora cucullata (c) Other polyzoa (c) Lunella smargda (r) pholad holes (c) microcosmur kura (a)
Beneath bounders - mid-low tide level		Amaurochiton glaucus (o) Sypharochiton pelliserpentis (o) Petrolisthes elongatus (c) Onchidella nigricans (a) Isactinia olivacea (o) Hemigrapsus crenulatus (o) Pilumnopeus serratifrons (o) Lepidonotus sp. (o)
	fish	Acanthoclinus quadridactylus (o) Forsterygion nigripenne (o)

Discussion

The fauna and flora of this region is as varied and healthy as would be expected. Noticeably limiting to some species is the high rate of sediment deposition on both hard and soft substrates.

4.4 Fish

The only intertidal fish are the 'Tommy' cod Acanthoclinus quadridactylus and the small Trypterigion nigripenne which are found in pools beneath stones.

Particularly noticeable in the high tidal band of green algae are the teeth marks left by feeding parore.

Flatfish are often seen in the shallow waters. There also appear to be considerable numbers of small surface fish which attract feeding terns - particularly in the main channel region.

Intertidal populations of crabs - Helice crassa and Hemiplax hirtipes are of considerable food value for schnapper.

4.5 Birds

The most common birds feeding intertidally are the kingfishers. Particularly abundant amongst the mangroves they are also common perched on any hard object protruding from the high tidal muds, where they feed on crabs.

White-faced herons occur in small numbers over the whole area of soft shore as do the pied stilts. Pied shags are fairly common, and at times large feeding flocks of little black shags are present.

Two species of terns - white-fronted, and caspian, feed in the channels as does the occasional gannet.

Pukekos and rails may be present particularly in the Hellyer's Creek area.

4.6 Edible Invertebrates

Although there are several species of edible shellfish in this area they do not occur in any substantial quantities and are not often taken for food.

Species present are : <u>Chione</u> <u>stutchburyi</u> (too small)
<u>Crassostrea</u> <u>glomerata</u> (few only)
<u>Perna</u> <u>canaliuclus</u> (few only)
<u>Mactra</u> <u>ovata</u> - common but not generally taken because of very muddy habitat.
<u>Lunella</u> <u>smaragda</u> - few only on reefs, but reach a very large size in this area.

Exploitation for food at present levels is unlikely to affect the abundance of these species.

4.7 Natural Ecological Changes

Natural changes that can be expected in this region are a slow buildup of intertidal sediment levels due to siltation in sheltered areas. Such a change will not have any great effect on the intertidal fauna because most of the area already has a very soft intertidal substrate.

4.8 Ecological Interference by Man

Man appears to have had little effect on the intertidal ecology of this region. Sediment buildup appears to have been at a very slow rate, probably increased only slightly by man (compare with Whenuapai area and Shoal Bay).

There has been some alteration of the foreshore - particularly at Hobsonville where facilities for servicing flying boats were constructed. However, this has had no adverse ecological impact.

4.9 Pollution

There is little pollution in this area. The worst examples are to be found on areas of the shore adjacent to residential properties, particularly in the Beachhaven-Hellyer's Creek region. Mangrove marshes are often maltreated by rubbish dumping, particularly where a road approaches the shore.

Another example of rubbish dumping occurs at the head of Hellyer's Creek where a pipeline crosses the intertidal creek. A considerable quantity of rubbish of different types has been carried to the middle of the viaduct and dumped on the tidal mud flats.

There are small areas of mudflat in the Hobsonville region which periodically show a 'bloom' of green micro-organisms on the surface. This may be an indication of enrichment of the mud by deposition of organic material.

4.10 Ecological Value

The low tidal zone of this area is rich in crustacean fauna which is an important component of the diet of schnapper populations in the Harbour. Small crustacea and polychaetes of low tidal muds are also important to flatfish.

Generally, this area has a higher biomass than areas further towards the head of the Harbour. Further down the Harbour there are considerable changes in species distributions and several of the abundant species in this area become reduced in density.

4.11 Improvement and Protection of Ecological Assets

Little can be done to improve the ecological state of the area, other than tidying up the foreshores, and preventing the dumping of rubbish in the intertidal zone.

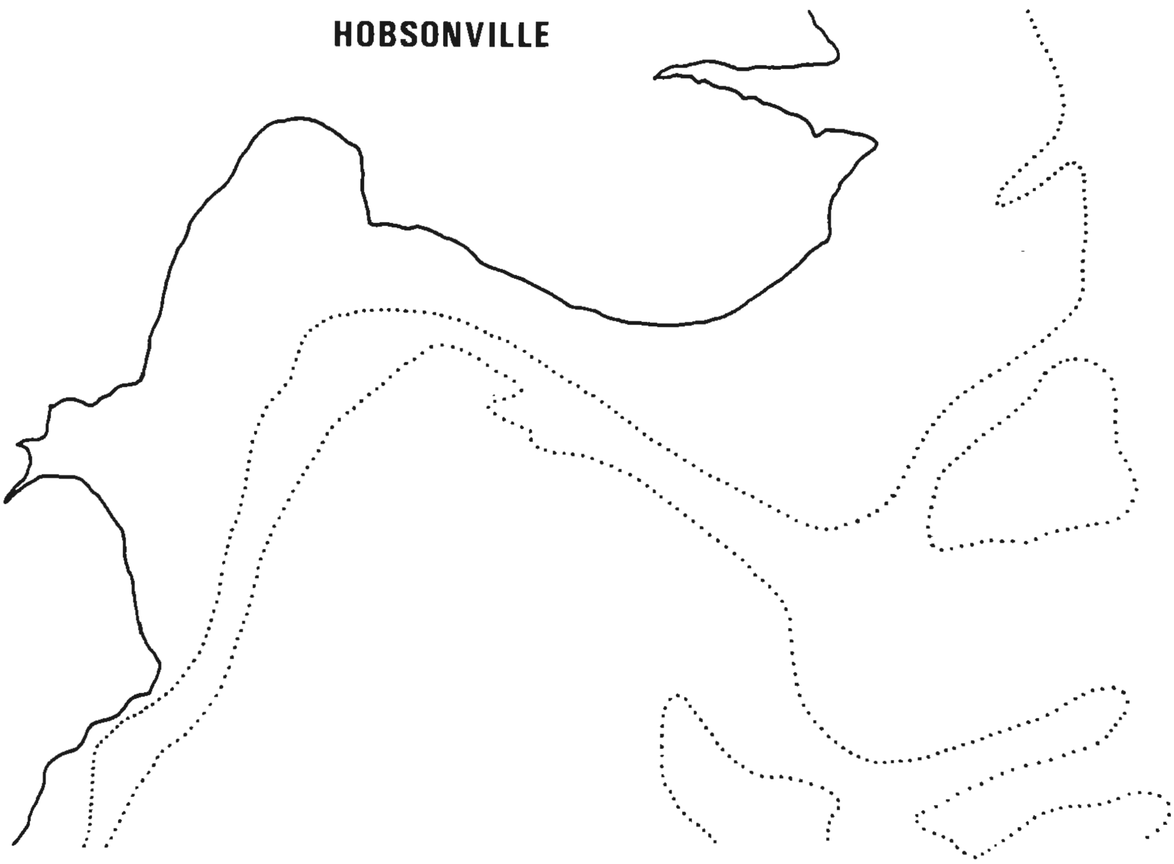
Protection of the present ecological conditions of this area will require careful development procedure, in the watershed, particularly on the steep slopes overlooking the tidal region. The best protection in some of these areas particularly the northern side of Hellyer's Creek would be to leave the steep foreshore in its natural state and encourage the growth of native trees.

4.12 Potential Use of Ecological Assets

At present there is a small amount of recreational and commercial fishing taking place in this region. This will probably increase with the growing population. Recreational use of the area will also increase requiring consistently high standards of water quality.

The area might well be used for educational purposes, particularly if bush and natural shore areas were in close proximity.

AREA 5



HOBSONVILLE

AREA 5. HOBSONVILLE TO TE ATATU INCLUDING ENTRANCE TO HENDERSON CREEK

5.1 General Description

This area is very shallow with extensive intertidal flats. The Henderson Creek enters the region in the south western corner and at low tide the channel extends in a curve to the north and east.

Surrounding land is developed for farming and is generally low-lying and sloping gently towards the water. Foreshores are mainly low banks of clay or sandstone with some cliffed areas on the south-western shore outside the entrance to the Henderson Creek.

5.2 Intertidal Substrates

There is a considerable range of intertidal substrates in this area. Off the end of the Te Atatu Peninsula there is an extensive mangrove marsh with shell bars built up along the perimeter. A high level shell bar extends to the north outside the mangrove area and shelters the region to the west. Outside the entrance to the Henderson Creek the shores are sheltered by the mangrove and shell barriers to the east. The upper shore is fringed with mangrove with deep soft muds in the mid-tidal region. Low tidal substrates are also very soft, apart from a few areas in the channel where banks of sandy substrate are exposed. Occasional outcrops of soft sandstone occur in the low tidal region on the western side but these are heavily silted, except where they are directly exposed to strong current action. Shell barriers have formed across the entrances to the bays in the northern part of this area sheltering extensive mangrove marsh. Substrates outside the barriers are soft and muddy.

In the northernmost part of the low tidal Henderson Creek there is a constriction in the channel with sandy substrates on either side. To the east of the large shell bar substrates are generally fine and sandy with local accumulations of shell. This region joins on to Area 7.

On the Hobsonville side there are small patches of peaty material exposed opposite the end of the shell bar with accumulations of shell inshore. Substrates are fine sand near the main Harbour channel leading towards Beachhaven but become progressively muddy towards the north with high tidal shelly areas inshore and mangrove in sheltered regions.

5.3 Intertidal Flora and Invertebrate Fauna

Soft shores - The considerable variation in substrate nature in this area has resulted in colonisation by a wide range of invertebrates.

Outside the Henderson Creek Entrance - There are small patches of sedge about high water level and generally there is a fringe of mangrove on the western side, with extensive mangrove marsh to the east.

Mangrove areas	Helice crassa (a) Amphibola crenata (c)
Mid-shore - Substrates outside the mangrove marsh are very soft and muddy.	Helice crassa (c) Alpheus sp. (c)
Low water level - muddy areas	Alpheus sp. (a) Hemiplax hirtipes (o)
More sandy areas near the channel	Chione stutchburyi (c) Amphidesma australe (o) Mactra ovata (o) Nucula hartvigiana (o) Leptomya retiaria (r) Cominella glandiformis (c) Cominella adspersa (o) Alpheus sp. (o) spionid polychaetes (a)
Clean low tidal sand near the end of the shell bar	Baryspira australia (c) Cominella adspersa (c) Cominella glandiformis (c) Soletellina nitida (c) Macomona liliana (c) ASYCHIS THEODORI (o) Aglaophamus macroura (o) Callianassa filholi

Shelly mid-tidal areas

Chione stutchburyi (c)
Amphidesma australe (c)

Clean sand adjacent to the main Harbour Channel (opposite Island Bay)

Baryspira australia (c)
Baryspira novaezelandiae cystallina (a)
Cominella glandiformis (c)
Cominella adspersa (o)
Calianassa filholi (c)
Lysiosquilla spinosa (c)
Pontophilus australis (c)
Soletellina nitida (a)
Macomona liliana (o)
Atrina zelandica (r)
Offadesma angasi (o)
Marphysa sp. (c)
Asychis theordori (a)
Orbinia (c)
spionids (a)
Trochodota dendyi (o)
Balanoglossus australiensis (c)
Aglaophamus macroura (c)
Phoronis ovalis (a)

South of Hobsonville - There is a zone of soft mud on a fairly steep bank dropping towards low water. Substrates on top of the bank and on a high tidal flat are generally firmer and sandy.

Low water

Alpheus sp. (a)
Hemiplax hirtipes (a)
Cominella adspersa (c)

Mid-tide flats

Chione stutchburyi (a)
Amphidesma australe (c)
Macomona lilina (a)
Nucula hartvigiana (c)
Zediloma subrostrata (c)
Zeacumantus lutulentus (c)
Cominella glandiformis (c)
Notoacmea helmsi (c)
Magelona sp. (c)
Orbinia (a)
spionid polychaetes (a)
Elminius modestus (c)
Anthopleura aureoradiata (c)

Hard shores - There is very little hard shore in this region. Small areas of Waitemata sandstone are exposed near the entrance of the

Henderson Creek, mainly at a high intertidal level. There are a few outcrops of rock near low water level. About high water mark there is a zone of blue-green algae throughout the year in damp places and a band of green algae in the winter.

High levels	Sphaeroma quoyana (a) Zeacumantus lutulentus (o)
Middle levels	Anthopleura aureoradiata (c) Elminius modestus (o) Zediloma subrostrata (o)
Low levels	Balamus amphitrite (c) Ostrea sp. (c) Microciona sp. (c)

5.4 Fish

The extensive intertidal flats of this region support a rich fauna which is potentially valuable as food for fish. Large numbers of small flatfish are found in the sheltered region outside the Henderson Creek entrance, and it is probable that most species of common Harbour fish enter this area at times.

5.5 Birds

Pied stilts, red-billed gulls, and black-backed gulls are found in small numbers in the sheltered soft-sediment areas outside the Henderson Creek entrance. Kingfishers are common in the mangrove marsh and pukekos are occasionally seen.

On the extensive shell bar to the north of the Te Atatu Peninsula large numbers of white-faced herons feed. This is the highest concentration of these birds in the Waitemata. Caspian terns rest on the shell bars, along with s ıll numbers of gulls.

Of the fish feeders pied shag occur in small numbers throughout the area and white-fronted terns and caspian tern often feed at high tide.

5.6 Edible Invertebrates

The edible invertebrates of this region are all shellfish. Chione stutchburyi of edible size is found in small numbers in the shell bar region to the north of the Te Atatu Peninsula along with localised patches of edible Amphidesma australe. It is unlikely that these beds are exploited because of their distance from the shore.

Mactra ovata occurs in small numbers in the sheltered region outside the Henderson Creek entrance. This species is not often sought for food. Large numbers of mud snails, Amphibola crenata, are found in the mangrove marsh, but these are not often taken.

Present rates of exploitation will not affect the shellfish concentrations in this area. There is a possibility, however, that there will be an increase in the numbers of Chione and Amphidesma of edible size in the region to the east of the shell bars off the end of the Te Atatu Peninsula. There are large areas of apparently suitable substrate which could be colonised by these species.

5.7 Natural Ecological Changes

The most significant natural ecological changes occurring in this area are the deposition of fine sediments in the area outside the Henderson Creek entrance, and the movement of shell bars to the north and east of the Te Atatu Peninsula.

Deposition of fine sediments is to be expected in a sheltered area such as that outside the Henderson Creek entrance, although there appears to have been a considerable acceleration of this process. Under natural conditions a slow buildup of intertidal substrate level would occur, resulting eventually in a spread of mangrove marsh and the formation of deep soft substrates.

The accumulation of dead bivalve shells in the region to the north of the Te Atatu Peninsula has resulted in the formation of a series of shell bars. Some of these bars have become stable and support a typical shell barrier vegetation; others are moving slowly shorewards or towards the stabilised bars. A chain of shell bars protects the mangrove marsh off the end of the Peninsula.

As accumulations of shell and coarse sand move slowly shorewards they destroy the fauna of the region they move over. In some places accumulations of shell become fairly stable in intertidal areas and support a fauna dependant on shelly substrates.

The slow formation and movement of shell bars is expected to continue in this region.

5.8 Ecological Interference by Man

Man has had a considerable impact on the ecology of the sheltered region outside the entrance to the Henderson Creek by permitting the contribution of considerable quantities of soft sediment to the waters of the Henderson Creek. The effects of rapid sediment deposition are obvious in mid and low tidal areas where previous faunas have been destroyed. In less sheltered areas natural faunas have been reduced in density and growth rates appear to have been adversely affected.

There appears to have been little impact on the more exposed regions to the east of this area, or within the stable mangrove marsh off the end of the Te Atatu Peninsula.

5.9 Pollution

There is no obvious pollution of this area at present.

5.10 Ecological Value

This is an area of considerable variation, both in terms of the prevailing physical conditions and in terms of the diversity of the fauna. Whereas the fauna of the sheltered region to the west has been adversely affected by sedimentation and the diversity reduced, the fauna of the more exposed eastern area, particularly on the extensive low tidal flats, is rich and healthy. The eastern area is capable of entering into a greater number of interactions with other areas of the Harbour ecosystem and is thus more valuable.

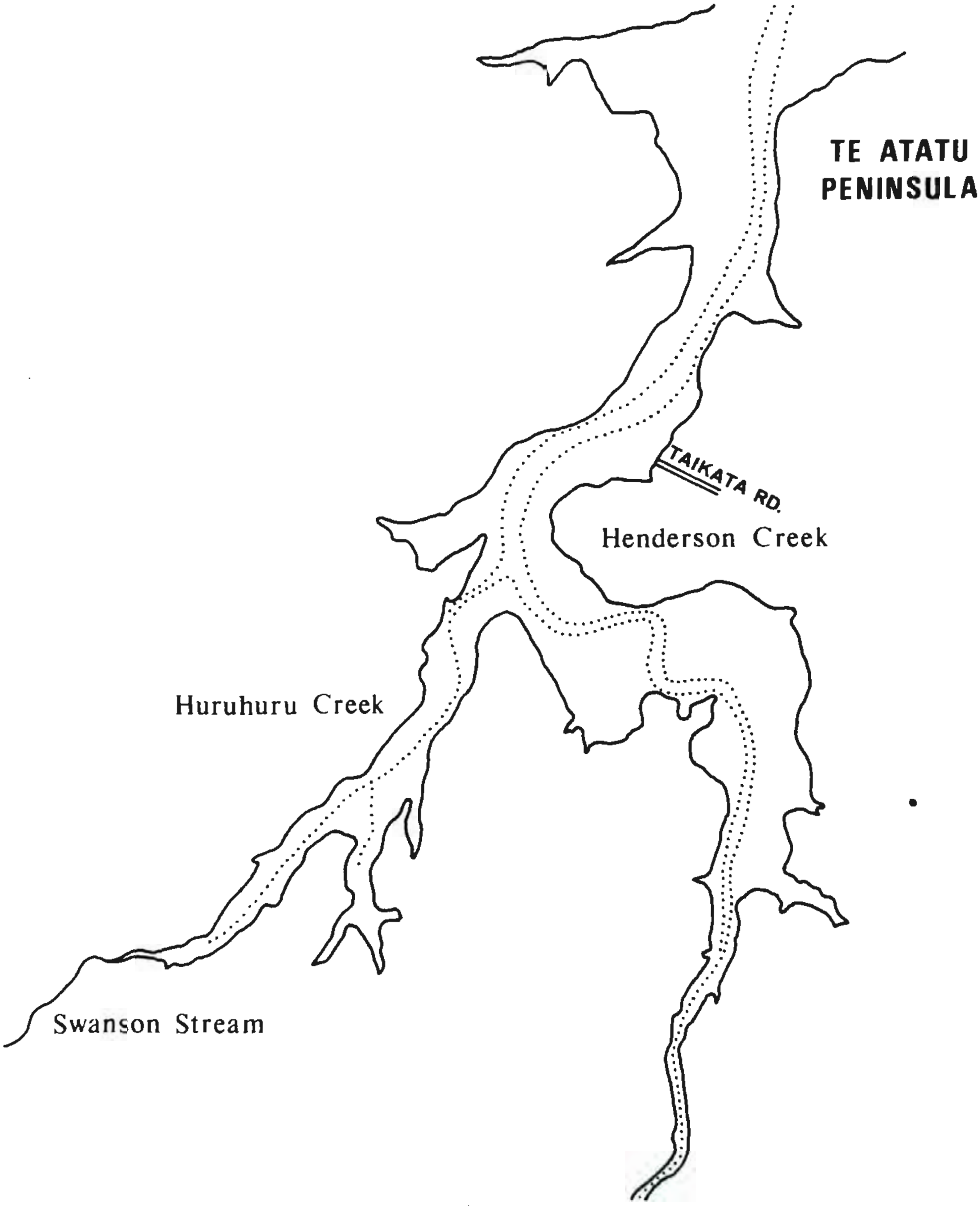
5.11 Improvement and Protection of Ecological Assets

There is little improvement that could be made to the ecological condition of this area. Considerable protection could be afforded by preventing the contribution of sediments to the tidal areas of the Henderson Creek, and by careful development of the foreshore when the land to the west and north is subdivided.

5.12 Potential use of Ecological Assets

There is little direct use of the ecological assets of this region at present, although a small amount of flatfishing is practised. It is unlikely that this situation will change in the future, although there will be a considerable increase in appreciation of the natural condition of this area when overlooking land to the west and north is developed for housing.

AREA 6



HENDERSON CREEK

AREA 6. HENDERSON CREEK

6.1 General Description

The Henderson Creek is a narrow tidal creek extending to the south-west from the Upper Harbour Basin. Its main tributaries are the Oratia and Opanuku Streams which join just below the upper tidal limit in Henderson Borough, and the Swanson Stream which drains into the tidal Huruhuru Creek.

Henderson Creek enters the main body of the Harbour west of the end of the Te Atatu Peninsula where there is an abrupt narrowing of the tidal area. Practically all surrounding land on the eastern side of the Creek is developed for residential purposes whereas that on the western side is largely farmland with some residential areas and small patches of bush. Apart from some steeply-rising land near the entrance to the Creek on the western side, most of the country is gently rolling with low banks dropping to the intertidal. Much of the foreshore reserve on the eastern side is in an unkempt state with scrub and gorse dominant, although in the upper tidal part of the Creek small reserves such as Falls Park are particularly attractive. Towards the entrance area on the western side there are prominent areas of bush, notably to the east of Colwill Road.

The Creek is used for barge transport of sand and shingle to Selwood Road and the Waitemata County has an organic refuse tip at the end of Taikata Road.

6.2 Intertidal Substrates

In the narrow upper reaches of the Creek intertidal substrates consist largely of soft sands and muds. The strong tidal and freshwater currents grade the bottom sediments which are mainly fine mobile sand.

Where the Creek widens in the vicinity of the north-western motorway bridge there are areas of mangrove on the upper shore with soft muddy substrates. Some high tidal areas are firm and sandy. Outside the mangrove marsh there is a band of very soft substrate above low water but in the channel sediments are often sandy.

Towards the Creek entrance there are also considerable areas of high tidal mangrove with soft sediments. Extensive muddy areas are found outside these with some firmer sand banks near low water and in the low tidal channel. Low tidal substrates are continually sorted by strong currents.

There are occasional outcrops of soft sandstone intertidally, particularly near the entrance of the Creek. The sandstone is generally heavily silted except where exposed to the current.

6.3 Intertidal flora and invertebrate fauna

The flora and fauna are described for three areas:

A. Entrance area.
B. Middle Creek.
C. Upper Creek.

6.3.A Entrance area

High tide level - most of the upper intertidal of this region is occupied by mangrove marsh, although large areas have been reclaimed - particularly in the vicinity of Taikata Road. On the shoreward side of the mangrove there is generally a band of sedge and other vegetation on fairly firm substrate.

	flora	Leptocarpus simplex Salicornia australis
	fauna	Ophicardelus costellaris Potamopyrgus antipodum Helice crassa
Mangrove marsh		Amphibola crenata (a) Helice crassa (a) Alpheus sp. (c) wet areas spionids (c) wet areas
		Crassostrea glomerata (o) Onchidella nigricans (o) Elminius modestus

Mid tidal mud flats - are mainly soft with occasional stable areas of coarser substrate

Hemiplax hirtipes (a)
Alpheus sp. (c)
Helice crassa (o)
Mactra ovata (o)
Cominella glandiformis (o)

Low tidal flats - normally firmer than the higher flats because of sorting action of stronger currents.

Alpheus sp. (c)
Hemiplax hirtipes (o)
Chione stutchburyi (o)
Mactra ovata (o)
Amphidesma australe (o)
Cominella glandiformis (c)
Cominella adspersa (o)
Zeacumantus lutulentus (o)
Anthopleura aureoradiata (c)
Elminius modestus (c)

Rock outcrops

High tide level — blue-green algae
Enteromorpha sp.

fauna — *Sphaeroma quoyana*

Mid low tide — *Zediloma subrostrata* (o)
Onchidella nigricans (o)
Modiolus fluviatilus (c)
Elminius modestus (c)
Balanus amphitrite (a)
Anthopleura aureoradiata (c)

6.3.B Middle Creek

Sedge communities are well developed in some of the higher intertidal areas notably in the basin to the north of Rutherford High School. High level mangrove marsh with trees restricted in height also occurs in the basin.

The fauna and flora of mangrove marshes are similar to that of marshes in the entrance area of the Creek.

Low tidal flats are generally soft and muddy

Alpheus sp. (c)

Firm patches — *Chione stutchburyi* (o)
Mactra ovata (o)
Cominella glandiformis (o)

Of some interest is the presence of small patches of *Zostera* amongst high tidal mangroves.

6.3.C *Upper Creek*

Towards the upper limits of the Creek the banks are steep and the tidal area narrow. Sediments are mobile in the Creek bed with some banks of soft mud in places. Small pockets of sedge occur about the high tide marks with the burrows of *Helice crassa* high amongst the vegetation. Large numbers of *Potamopyrgus antipodum* are also present.

6.4 *Fish*

Little is known of the fish in this area. Flatfish, and yellow-eyed mullet are probably present most of the year, and other common species probably enter the Creek at times. Mangrove areas near the entrance to the Creek may be important to Parore as a source of algal food.

6.5 *Birds*

Very few birds are found in the upper reaches of the Creek, except for the kingfisher which is common throughout the area. Where the intertidal area increases and there are open mudflats small numbers of shore feeders are found; Pied stilts, white-faced herons, red-billed gulls and black-backed gulls. Generally these become more numerous towards the mouth of the Creek. Pied shags are common in the lower part of the Creek and are also found in the upper reaches at high tide. Little black shags occasionally fish in the lower reaches, and larger black shags are sometimes seen in the entrance area. Little pied shags also occur in the area.

The refuse tip at Taikata Road attracts large numbers of black-backed gulls which are mainly concentrated in that area or resting on inter-tidal flats nearby.

Pukekos are found in the mangrove fringes of the Creek, and occasionally Caspian terns and white-fronted terns feed in the lower reaches at high tide. Ducks occur in small numbers throughout the area.

6.9.A Pollution of freshwater streams leading into the area

Pollution of streams in this area is derived both from industrial sources and the local population. The Oratia Stream is occasionally badly polluted by waste products, although this was being remedied in 1972.

In the creeks passing through Henderson Borough there are considerable quantities of inorganic waste - mainly plastic and paper. These litter the banks in both the tidal and freshwater portions of the creek.

6.9.B Pollution as a result of development of tidal areas

Pollution arising from the development of foreshore areas is usually caused by an inconsidered approach on the part of developers, and later, a careless attitude on the part of residents.

The foreshore reserves of large areas of the eastern shore of the Henderson Creek are sadly neglected. These weed-covered areas are often used as dumping grounds for rubbish from households in the vicinity.

Strip reclamation in the vicinity of Taikata Road has left untidy foreshores outside the reclamation. Facing walls are ineffective in many places and considerable quantities of sediment have been contributed to the remaining tidal areas.

The reclamation made by the Taikata Sailing Club near the entrance to the creek is also very untidy. Eroding walls have resulted in demolition material being spread over the intertidal and metals, clay and garden refuse make this an unsightly mess.

6.9.C Pollution as a result of reclamation of tidal land by refuse tipping

Present practice at the Taikata Road tip is to place organic refuse directly into tidal areas of mangrove marsh. There is no protective wall or other means of preventing salt water incursion into the dumped refuse. Besides a general spread of wind and water carried rubbish beyond the area of the reclamation there is the formation of a black tip liquor which escapes into the surrounding tidal area. The nature and volume of this liquor are discussed further in the Water Quality Report (A.R.A.).

Ecological effects of the tip liquor are not evident, although there is a real danger of some as yet unnoticed cumulative effect if this continues to be released into the tidal area. Of considerably greater ecological impact is the alteration of current patterns caused by the reclamation and the consequent deposition of considerable quantities of soft sediment outside the reclaimed area.

There may be a slight eutrophication of Henderson Creek waters although this is not necessarily caused by the Taikata Road tip. Scums of green colonial diatoms or flagellates occur intertidally in the lower creek at times.

6.10 Ecological Value

As with the other shallow creeks of the Upper Waitemata the most valuable ecological function of the Henderson Creek is as an area in which deposition of land derived sediments occurs before they can be carried further down the Harbour. The extensive, sheltered inter-tidal flats and mangrove marsh of this Area are well suited for this purpose.

The use of natural tidal areas for educational purposes particularly in the central part of the Creek near Rutherford high school would provide a valuable asset to local schools.

Rich flats near the entrance to the Creek, and the extensive mangrove marsh in the central area are valuable to food chains of the Harbour ecosystem in providing food for juvenile fish and organic material for deposit feeders and scavengers.

6.11 Improvement of the Area

The foreshores of much of this area, particularly the eastern side of the Creek, are capable of considerable improvement. The planting of native shrubs in place of the present weeds and scrub would do much to improve the creek side environment.

If the foreshore was cleaned up this would probably deter the local householders from depositing rubbish. The cumulative effect of small lots of dumped rubbish makes the foreshore appear untidy.

6.12 Potential Use of the Area

The lower part of the Henderson Creek is used for mooring larger craft, and recreational sailing, boating, water-skiing and swimming. Local residents express some concern over changes to the Creek in this area - principally the presence of rubbish in the water, and the accumulation of mud in the intertidal area. Enjoyment of this area has probably been reduced by this environmental deterioration.

The intertidal areas of the Henderson Creek, and in particular the high tidal mangrove swamps and salt marsh provide good examples of natural communities for educational purposes. The report on Intertidal Reserves suggests the development of an area near Gloria Park for this reason.

6.6 Edible Shellfish

There are few edible shellfish in this Area. Chione stutchburyi and Amphidesma australe do not reach a large enough size, and Mactra ovata occurs only sporadically. There is unlikely to be any change in the abundance or growth rates of these species.

6.7 Natural Changes

Natural changes to be expected in an area such as the Henderson Creek would be a slow accumulation of sediment in intertidal areas resulting in a rise of substrate level and eventual change from mud flat to mangrove marsh to salt marsh. This process is well illustrated by the communities in the large basin to the north of Rutherford High School where high tidal mangrove is prevented from growing larger by high substrate levels, and there are patches or 'islands' of sedge and other vegetation appearing at the higher levels.

6.8 Effects of Man

The principle effect of man's development of this area has been to increase the quantity of sediment contributed to the intertidal region. Sediment deposition has been particularly noticeable on the lower areas where substrates are now extremely soft.

The effects of rapid sediment deposition can be seen in the vicinity of the reclamations in the Taikata Road area. Some sediment has been contributed directly from the reclamation but far greater quantities have deposited from the water in what was previously a current swept portion of the Creek. This example illustrates two important aspects of development that may interfere with intertidal ecology. First the poor design of reclamations which may alter current patterns; and second, the large quantities of silt that are entering tidal waters/

6.9 Pollution

Pollution of this Area may be described in three parts.

A. Pollution of freshwater streams leading into the area.
B. Pollution as a result of development of the tidal areas of the Creek.
C. Pollution by rubbish disposal in tidal areas.

AREA 7

TE ATATU

AREA 7. TE ATATU PENINSULA

7.1 General Description

Several hundred acres of flat shore lie between the tide marks in this area which includes the region to the north of the low tidal channel of the Whau River as far as the end of the Te Atatu Peninsula.

Land immediately behind the coast is developed for farming purposes being mainly open fields and pasture. There is a small residential area near the end of the Te Atatu Peninsula. Foreshores are generally low clay banks which in some areas are being rapidly eroded. To the south of Harbour View Road there is an extensive marsh at high water level. There is a strip of scrub with some mature trees in the foreshore area.

7.2 Intertidal Substrates

Substrates over much of this area are similar in nature being fine and sandy. There is, however, considerable substrate variation in the southern part of the area in the vicinity of the Whau River Channel.

Substrates in the low tidal Whau River channel are soft with coarse sand on the banks and surrounding flats. The shell barrier to the north of the river channel shelters an area in which soft muds have accumulated and mangrove marsh developed. High tidal sand flats inside the mangrove area are firm and well-drained, with salt marsh developed inshore. At the base of the low tidal sand spit to the north of the Whau River Channel there are patches of soft mud and accumulations of dead shell with most of the area being a firm sandy mud. Towards low water substrates become clean and sandy.

Over the extensive flats to the north substrates are firm and sandy with patches of semi-consolidated sandstone protruding over a wide area. Embedded in the soft sandstone are the remains of trees of considerable size. An area of boulders near the low water mark (Fig. 7.1) is puzzling as these appear to be of volcanic origin.

To the north of Harbour View Road high tidal substrates consist of accumulations of shell and sand with some localised deposition of soft clays where the foreshore is eroding.

To the north of the end of the Te Atatu Peninsula there are accumulations of shell in the upper intertidal and extensive shell barriers outside a large mangrove marsh.

7.3 Intertidal flora and Invertebrate Fauna

Areas of soft muddy substrate in the upper intertidal near the Whau River entrance support

Helice crassa (a)
Alpheus sp. (o)
Hemiplax hirtipes (o)

In slightly firmer areas there are dense populations of Zeacumantus lutulentus and Amphibola crenata.

The roots and pneumatophores of the larger mangroves fringing the shell barrier support

Crassostrea glomerata (c)
Modiolus neozelanicus (c)
Zeacumantus subcarinatus (a)
Zediloma subrostrata (c)
Lunella smaragda (c)
Elminius modestus (a)
Anthopleura aureoradiata (c)

High level mangrove marsh behind the shell barrier supports dense populations of Helice crassa and Amphibola crenata.

An extensive salt marsh area fringes the shore to the south of Harbour View Road. In this region are found healthy sedge and rush communities and meadows of the glass wort Salicornia australis and other small succulents.

The stable part of the high tidal shell barrier supports a variety of plants adapted to such areas (See Area 22.C, for common species associated with shell barriers).

Over much of the mid-tidal areas a typical assemblage of animals of soft sand flats is found.

Chione stutchburyi (a)
Amphidesma australe (o)
Macomona liliana (a)
Nucula hartvigiana (c)
Micrelenchus huttoni (o)
Zediloma subrostrata (c)
Zeacumantus lutulentus (a)
Xymene plebeius (o)

Cominella glandiformis (c)
Notoacmea helmsi (c)
Amaurochiton glaucus (c)
Anthopleura aureoradiata (c)
Elminius modestus (o)
Hemigrapsus crenulatus (c)
Lysiosquilla spinosa (o)
Callianassa filholi (o)

In clean sand towards low tide mark at the end of the sand spit to the north of the low tidal Whau River Channel.

Baryspira australis (c)
Aglaja cylindrica (r)
Cominella adspersa (o)
Soletellina nitida (a)
Callianassa filholi (o)
Lysiosquilla spinosa (o)
Notamastus zeylanicus (o)
Asychis theordori (c)
Phoronis ovalis (c)

Low tidal clean sand to the north

Baryspira australis (r)
Haminoea zelandica (c)
Cominella adspersa (o)
Soletellina nitida (o)
Lysiosquilla spinosa (o)
Callianassa filholi (c)
Pectinaria australis (c)
Asychis theordori (c)

The area of low tidal boulders (Fig 7.1) supports

Elminius modestus (a)
Pomatoceros caeruleus (c)
Lunella smaragda (c)
Zediloma subrostrata (c)
Lepsiella scobina (c)

Beneath boulders

Acanthochiton zelandicus (c)
Sypharochiton pelliserpentis (c)
Amaurochiton glaucus (c)
Pilumnopeus serratifrons (c)
Petrolisthes elongatus (a)
Alpheus sp. (o)
Elminius modestus (c)
Lepidonotus sp. (a)
Microcosmus kura (c)
flatworks (2 spp) (c)

Inshore from the boulder patch there is a generally shelly substrate with small beds of Amphidesma australe occurring on the flanks of shell bars.

7.4 Fish

Small numbers of flatfish are often to be seen about the low water mark in this area and schnapper are caught by boat fishermen. Low tidal flats support a rich fauna which is potentially important as a food source for demersal species.

7.5 Birds

Common shore-feeding species utilise the low tidal flats of this area in some numbers. Common are red-billed gull, pied stilt, black-backed gull and white-faced heron. Kingfishers feed in the mangrove marsh inshore. Fish feeders in this area include Caspian terns, white-fronted terns and the occasional gannet, with pied shags in the Whau River Channel. Caspian terns roost intertidally in groups of up to 30, and there is a black-backed gull roost on high tidal flats to the south of Harbour View Road.

7.6 Edible Invertebrates

Of the shellfish which reach edible size in this area Chione stutchburyi is found in low density beds near the low water mark, and Amphidesma australe occurs in small dense beds in shelly areas. Neither of these species appear to be taken for food in any quantity. It is possible, however, that the density and extent of beds of Chione of edible size will increase in the low tidal areas, in which case exploitation would be expected to increase.

The mud snail, Amphibola crenata is found in the mangrove marsh and small numbers of Lunella smaragda are found on the larger mangroves and on the boulder patch. It is unlikely that these species are taken for food.

It is also unlikely that the oysters attached to mangrove trunks and pneumatophores near the shell barrier are taken.

7.7 Natural Ecological Changes

Slight ecological changes will be associated with slow sediment deposition near the low tidal Whau River, and in the shell barrier region. The mangrove marsh will increase in area slowly as substrates become suitable for colonisation. The shell barrier will probably move very slowly to the north.

Minor changes can also be expected in high tidal regions to the north of Harbour View Road where soft banks are being eroded and clay deposited on the intertidal substrates.

7.8 Ecological Interference by Man

There has been little interference with the natural ecology of this area. A small reclamation has been made at the end of Harbour View Road.

7.9 Pollution

There is no obvious pollutions of this area.

7.10 Ecological Value

The rich and healthy faunas of this area are of considerable value to the Harbour ecosystem, both because of the large intertidal area, and because of the interactions with fish and bird populations.

The variation of habitat types in the region to the south of Harbour View Road makes this area of considerable educational interest. The shell barrier and extensive high tidal salt marsh are natural habitats under considerable threat in the Waitemata.

7.11 Improvement and Protection of Ecological Assets

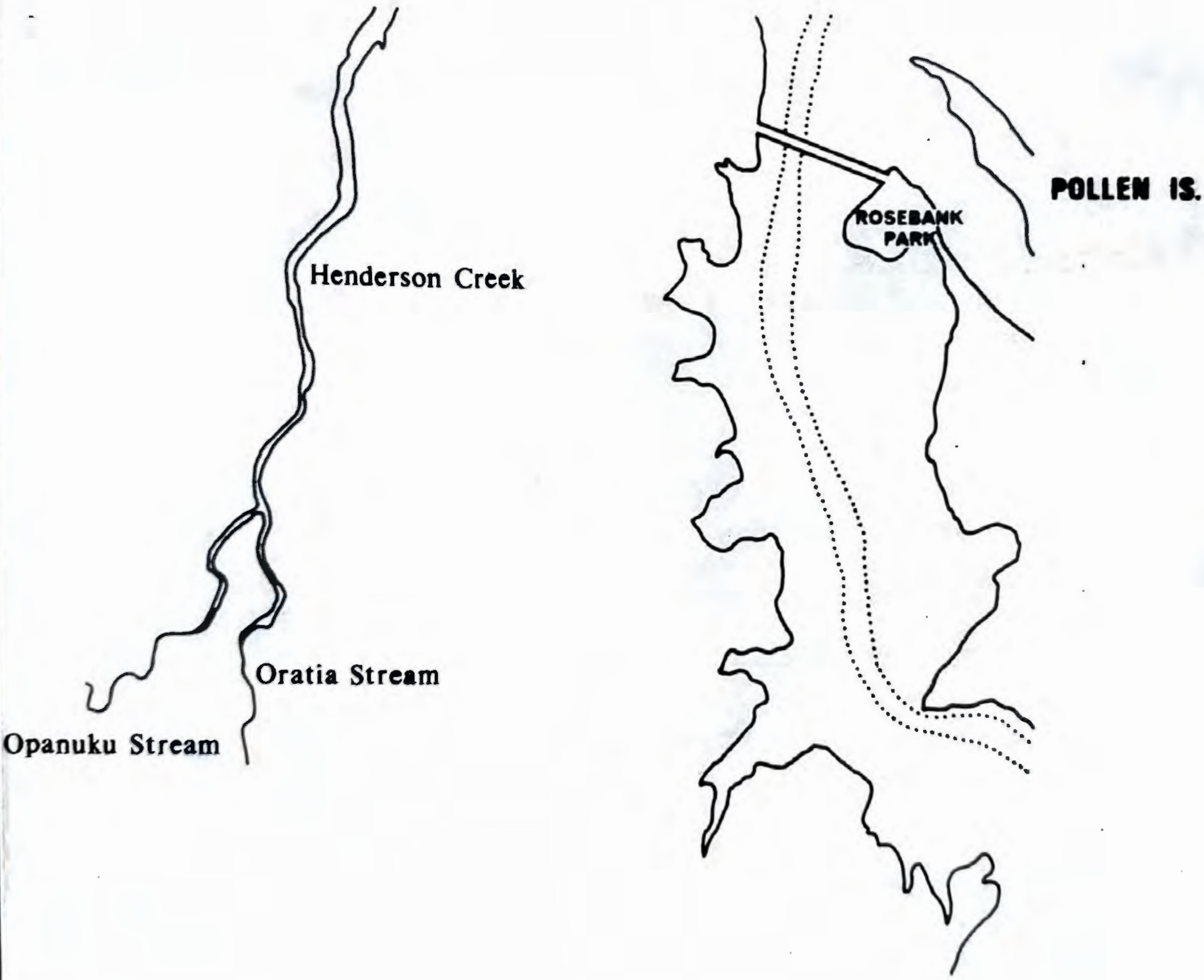
Minor improvement could be made to the high tidal area to the north of Harbour View Road by halting erosion of the soft foreshore.

Protection of the intertidal environment will be required if the foreshores of this region are further developed. The washing of silts and clays from neighbouring land is a potential problem.

7.12 Potential Use of Ecological Assets

At present a considerable part of this area is designated for reclamation if the development of a container port off the Te Atatu Peninsula is approved. If the port development does not eventuate, the high tidal salt marsh, mangrove marsh and shell barrier region to the south of Harbour View Road would make an excellent wildlife and educational reserve. (See Report on Intertidal Reserves)

AREA 8



LOWER WHAU RIVER

AREA 8. LOWER WHAU RIVER

8.1 General Description

In the lower Whau the tidal area becomes wider than further up the river, but the shoreline remains strongly indented with bays and the entrances to small creeks. Large areas of mangrove lie adjacent to the banks, while there are expanses of open mud on both sides of the low tidal channel.

Land on the western side of the river is largely residential with large numbers of properties looking down on the water. The end of the Rosebank peninsula is largely industrial with residential properties beginning in the vicinity of Avondale Road.

Foreshores generally consist of a low steep bank with scrubby vegetation, although there are patches of mature pines on the Rosebank Peninsula, and pohutukawa trees in places.

8.2 Intertidal Substrates

There are some high tidal sandy flats, near the entrance to the Creek on the eastern side, which support salt marsh vegetation. In the mangrove marshes there is a gradation of substrate nature from relatively firm high-tidal marsh to deep soft sediments further down the shore. Outside the mangrove there are extensive areas of open mud which is also very soft. Towards the level of the low tidal channel there are patches of firmer sands, particularly where current action is accentuated by the curving channel.

8.3 Intertidal Flora and Invertebrate Fauna

Three main habitats can be described for the plants and animals of this Area.

A. Fringing marsh.

B. Mangrove marsh.

C. Open mud flat.

8.3.A. Fringing Marsh

There is normally a band of variable width about the mean high water mark which has a relatively firm substrate and supports a variety of sedges and salt marsh plants. High tidal flats outside the Rosebank Domain have developed a typical salt marsh vegetation.

Common plants	Salicornia australis Selliera radicans Samolus repens Leptocarpus simplex Juncus maritimus var australiensis
fauna	Ophicardelus costellaris (c) Potomopyrgus antipodum (c) Helice crassa (c) Amphibola crenata (o)

8.3.B Mangrove areas

In high intertidal regions, mangrove growth is restricted and there are extensive areas of small mangrove trees. In such areas the substrate is relatively firm and there is obviously a slow evolution towards salt marsh.

fauna	Amphibola crenata (a) Helice crassa (a)

In lower intertidal areas mangroves grow to a greater size and the substrate is generally soft and muddy.

Amphibola crenata (c)
Helice crassa (c)
Alpheus sp. (c)
Elminius modestus (a)
Crassostrea glomerata (o)

8.3.C Open mud flats

Mudflats outside the mangrove are usually very soft.

Alpheus sp. (a)
Helice crassa (o)
Hemiplax hirtipes (a)

In more sandy areas towards low water several other species may be found

Cominella glandiformis (c)
Cominella adspersa (o)
Chione stutchburyi (o)
Mactra ovata (o)

8.4 Fish

Little is known of the importance of this area to fish populations, although it is probable that several common species enter the region at times. Permanent residents include flatfish - principally yellow-bellied founder, yellow-eyed mullet, and parore.

8.5 Birds

Shore feeding birds are not abundant in this Area. The most common are pied stilts, white-faced herons, red-billed gulls and black-backed gulls. Fish-feeders are well represented with large numbers of pied shag, little pied shag, and little black shags. Kingfishers are the most numerous birds being common throughout the area. Mallard ducks are seen occasionally but are more common in the Upper Whau (see Area 10). Occasionally white-fronted terns and caspian terns feed in the area.

8.6 Edible Invertebrates

Quantities of edible shellfish in this Area are small. Mactra ovata occurs in some soft areas but few people seem to exploit it. Crassostrea glomerata is found on the roots and pneumatophores of mangroves but there is only a small amount of exploitation. It is unlikely that there will be any change in the abundance of edible species in the Area.

8.7 Natural Ecological Changes

As with other shallow, Upper Harbour areas the most significant changes to be expected in the Lower Whau River would be associated with gradual accumulation of sediment and the evolution of tidal areas from mud flat to mangrove marsh to salt marsh to dry land. This process is admirably illustrated in the lower reaches of the Whau particularly on the eastern side adjacent to the end of the Rosebank Peninsula.

Other natural changes to be expected will be alterations of current flow patterns with constant movement of sediments particularly in the low tidal region.

8.8 Ecological Interference by Man

Development of the land surrounding this area has left the foreshore untidy, with waste materials from industries, householders, and local bodies contributing. Some reclamations are particularly untidy with a variety of waste materials being used for fill and insufficient covering and inadequate sealing of the faces which come into contact with tidal water.

The increase in sedimentation rates caused by development of the watershed is also evident in this area. A rapid accumulation of soft sediments in some areas has resulted in a rapid spread of mangrove.

8.9 Pollution

Apart from the sedimentation problem, pollution of this area is largely due to the untidy nature of the foreshore. There has been a deterioration of high tidal areas into which rubbish is dumped. The cumulative effect of many small pollutant contributions is evident here, particularly in soft sediment areas where there is little tidal flushing.

8.10 Ecological Value

The principle ecological value of this Area lies in its function of retaining fine sedimented material and preventing this from being carried further down the Harbour.

This area also has considerable value as a visual amenity to the overlooking residential areas to the west and south.

The entrance area of the River on the eastern side may well assume considerable importance as an educational area, providing examples of different natural mangrove and salt marsh communities (See Report of development of Intertidal Reserves).

8.11 Improvement of the Area

Major improvements can be made to the state of the foreshore in this Area. If the foreshore is kept in a natural state as far as possible this will go a long way towards protecting the intertidal area.

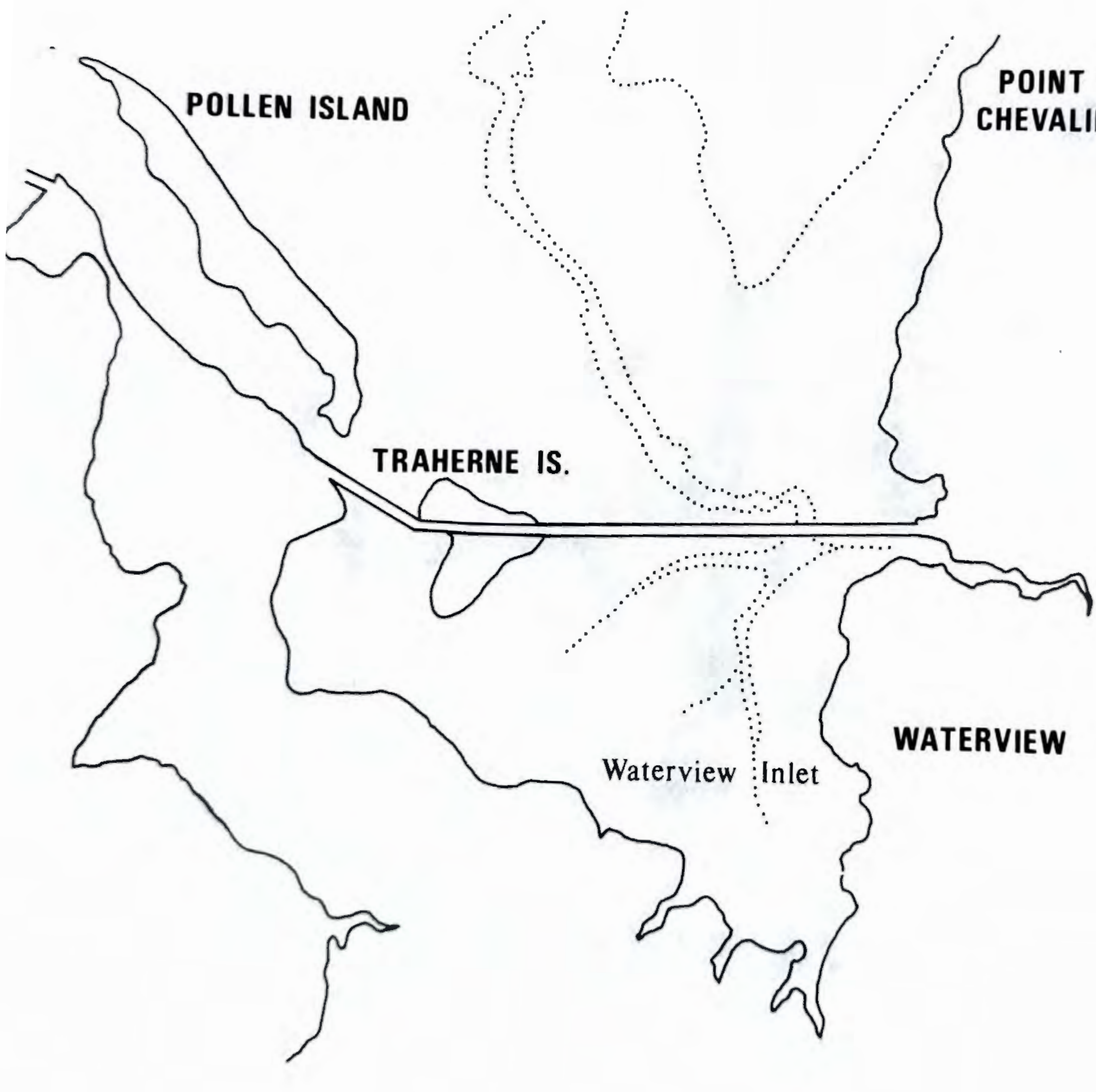
Other improvements can be made in educating the local population as to the potential damage that can be caused by the dumping of material into tidal areas.

8.12 Potential Use of the Area

At present this Area is used by the local population for mooring boats, and in small numbers for recreational boating and fishing. Commercial flatfishermen may operate in the area occasionally.

Potential use of ecological assets of the Area will not be great, although the development of the area adjacent to the Rosebank Domain could well result in considerable educational use. (See Report on Intertidal Reserves.)

AREA 9



POINT CHEVALIER TO POLLEN ISLAND

AREA 9. POINT CHEVALIER TO POLLEN ISLAND, INCLUDING WATERVIEW INLET

9.1 General Description

This area consists of a large shallow bay, the head of which is crossed by the north-western motorway enclosing the Waterview Inlet. On the western side of the bay are the low-lying Pollen and Traherne Islands. Large intertidal areas of the south-western part of the bay have been designated for reclamation for the development of railway marshalling and storage facilities in association with the planned container port to be situated off the Te Atatu Peninsula.

The land surrounding this region is largely residential on the eastern side and in the southern part of the Waterview inlet. To the west there is industrial land along the Rosebank peninsula. Pollen and Traherne Islands are low-lying with extensive accumulations of shell and surrounding mangrove marsh.

Foreshores to the south of Point Chevalier consist of low cliffs of sandstone with fringing pohutukawa and prominent pines and macrocarpa. Towards the south the foreshore is not as steep and there is generally a strip of green close to the high tide level with mature trees in places. Along the western side there is some developed land right to the waters edge, but generally there is a band of scrub with occasional prominent pines along the foreshores.

9.2 Intertidal Substrates

There is considerable variation in the nature of intertidal substrates in this region. At Point Chevalier there are reefs of Waitemata sandstone on the point with a shelly beach along part of the western side. To the south the sandstone is largely covered by soft sediments with only occasional outcrops.

Outside the motorway reclamation the substrate is generally firm with a considerable buildup of raised shell bars. A small shell barrier partially blocks a small inlet containing mangrove adjacent to the Walker Road Reserve. Firm shelly substrate extends right across the head of the bay outside the motorway and outside Pollen Island. There are occasional patches of muddy sand about mid-tide level and expanses of sand towards low water.

Within the Waterview Inlet, which is enclosed by the northwestern motorway reclamation, there are areas of firm shelly substrate near the channel, but otherwise much of the substrate is soft mud. High level areas around Traherne Island support extensive mangrove marsh while on firm high tidal sands and muds there is considerable development of salt marsh.

Behind the main shell barrier of Pollen Island there is an extensive area of high tidal mangrove marsh with trees restricted in size because of the high level. The transition of mangrove to salt marsh is well illustrated in this area.

9.3 Intertidal Flora and Invertebrate Fauna

Soft shores; sandy areas to the south of Point Chevalier.

High tide level	Talorchestia sp. (c)
Mid tide level	Chione stutchburyi (a) Macomona liliana (c) Zeacumantus lutulentus (a) Zediloma subrostrata (c) Cominella glandiformis (c) Marphysa sp. (o) Axiothella quadrimaculata (o) spionid polychaetes (a) Anthopleura aureoradiata (c)
Low tide, clean sands	Notoacmea helmsi (c) Haminoea zelandica (o) Baryspira australis (c) Cominella adspersa (c) Cominella glandiformis (c) Chione stutchburyi (a) Nucula hartvigiana (a) Macomona liliana (a) Mactra ovata (o) Axiothella quadrimaculata (o) Aglaophamus macroura (o) Glycera sp. (c) spionid polychaetes (a) Anthopleura aureoradiata (c)

Shelly areas outside motorway from Walker Road to Pollen Island.

Chione stutchburyi (c)
Amphidesma australe (c)
Macomona liliana (c)
Nucula hartvigiana (c)
Mactra ovata (o)

Cominella glandiformis (a)
Zeacumantus lutulentus (c)
Notoacmea helmsi (c)
Zediloma subrostrata (a)
Amaurochiton glaucus (c)
Helice crassa (o)
Hemigrapsus crenulatus (c)
Elminius modestus (c)
Anthopleura aureoradiata (a)
flatworms (c)

Mangrove marsh

The small area of mangrove adjacent to the reserve at Walker Road retains permanent water in some areas which has permitted the growth of large quantities of green algae - mainly Enteromorpha sp.

Within the Waterview Inlet there is a fringe of mangrove around the entire shoreline. On the eastern side there are quite large trees at lower tidal levels, while towards the western side and in the vicinity of Traherne Island the size of the trees is limited by the high intertidal levels. At present the whole area is ecologically healthy.

Helice crassa (a)
Amphibola crenata (a)
Potamopyrgus antipodum (c)
Ophicardelus costellaris (c)

Salt marsh

There are extensive areas of high tidal salt marsh adjacent to Pollen and Traherne Islands. Mangrove occupies lower ground than Salicornia, while Juncus and Leptocarpus occupy the highest marsh. In the area behind Pollen Island three types of marsh are easily recognisable.

Mangrove
Salicornia
Sedge

Amongst the Leptocarpus - Juncus marsh may also be found

Stipa teretiforia
Plagianthus divaricatus
Selliera radicans
Samolus repens

On the higher levels of the stabilised shell bank there has been considerable growth of flax (Phormium) with the shrubs

	Plagianthus Cassinia retorta Leptospermum scoparium
Grasses	Festuca arundinacea Arundo conspicua
on top of the shell	Aster subulatus Rumex sp. Anagallis arvensis Plantago lanceolata Plantago coronopus

The marshes of this area are probably rising slowly with the consequent spread of the above communities over what was previously open sand flat in the sheltered area.

Hard shores

The hard shores of this area are restricted to the vicinity of Point Chevalier where there is a sandstone cliff and reefs extending over most of the tidal range. To the south soft sediment covers the eroded sandstone and there are only occasional protruding ledges and boulders.

There is a distinct band of blue-green algae on the cliff face above high water mark. In winter there is also a band of bright green algae below this, particularly in areas with fresh water seepage.

High level	algae	Enteromorpha sp. Gelidium
	fauna	Sypharochiton pelliserpentis (o) Melagraphia aethiops (c) Zeacumantus subcarinatus (c) Zediloma subrostrata (c) Sphaeroma quoyana (c)
	algae	Hormosira banksii Corallina officinalis
Mid-tide level		Pomatoceros caeruleus (c) Onchidella nigricans (c) Crassostrea glomerata (o) Cominella maculosa (o) Isactinia olivacea (o) Anthopleura aureoradiata (c)

Beneath Boulders

Petrolisthes elongatus (c)
Pilumnopeus serratifrons (o)
Watersipora cucullata (c)
Lunella smaragda (o)
Lepsiella scobina (o)
Amaurochiton glaucus (c)
Ostrea sp. (o)

Discussion

The fauna and flora of this region is naturally rich and varied. Over most of the area populations are stable, although there will be some changes in the region outside the motorway, and in central area of the Waterview Inlet (see 9.8).

9.4 Fish

The rich fauna of the low tidal flats of the area outside the motorway is probably an important food source for fish populations. Excavations made by schnapper in search of bivalve food are common in this region. At times there is a dense population of juvenile flatfish in the shallow areas at low tide, and it is probable that the extensive area of the Waterview Inlet is also an important source of food for flatfish.

The small, light-brown goby, *Acentrogobius lentiginosus* is abundant in shallow waters and pools, and yellow-eyed mullet occur throughout the area.

9.5 Birds

The open sand flats to the south of Point Chevalier support small numbers of the common shore-feeding birds: pied stilts, red-billed gulls, black-backed gulls, and white-faced herons.

In the softer regions of the Waterview Inlet there are larger concentrations of pied stilts and white-faced herons, and a single white heron fed in this area for a period during 1972. Shags are common in the vicinity of the channel which drains the Waterview Inlet, and include pied shag, and little black shag. In winter a flock of more than 120 little black shags was observed feeding in this area, although it is probable that they moved around the Harbour and did not rely on this area alone. Kingfishers are common in the mangrove areas, while ducks and pukekos are found in secluded areas.

At high tide small numbers of white-faced terns and Caspian terns feed in the area, and during rough weather gannets are occasionally seen.

Pollen and Traherne Islands are of considerable value to the bird populations of this region, and also to populations of shore-feeding birds which spread over a wide area of the Upper Harbour. These two areas are used for roosting both at high water and at night and are two of the few areas that remain sufficiently secluded for this purpose.

9.6 Edible Invertebrates

Although several species of edible shellfish occur in this area, there are only small areas in which these reach an edible size.

Crassostrea glomerata is restricted to the hard shore in the vicinity of Point Chevalier. It does not occur in large numbers because of the soft nature of the rock.

Chione stutchburyi is abundant over much of the area but only reaches an edible size near low water level to the south of Point Chevalier. Densities are not high.

Although Amphidesma australe occurs in small beds of edible size adjacent to the shell banks towards the head of the bay outside the motorway there are not many people aware of the presence of this species.

Amphibola crenata is abundant in the Waterview Inlet but very few people take this species for food.

Exploitation of shellfish is not high in this area because of their patchy distribution and the small numbers of edible size. There is a possibility that extensive beds of Chione and Amphidesma might form and reach edible size, but this depends largely on the changes that are occuring in sediment movement in the area.

9.7 Natural Ecological Changes

The most important ecological changes that are occuring in this area are due to sediment movement. It is difficult to estimate to what extent these changes are due to the formation of the motorway reclamation and to what extent they are natural.

Before the construction of the motorway there was considerable movement of coarse shelly material in the vicinity of Pollen Island. This resulted in the formation of the shell barrier which forms the crest of the Island. The shell barrier moved gradually towards the shore, and after its passage peaty material was exposed to seawards. Incipient shell barriers were also formed in the region.

Natural sedimentation in the lee of the shell barrier resulted in a rise of the substrate level and the consequent colonisation by mangrove and salt marsh plants. The same process occurred in the area surrounding Traherne Island and towards the head of the Waterview Inlet.

9.8 Ecological Interference by Man

The construction of the motorway viaduct has had a considerable impact on the ecology of this area. The accumulation of shell in bars along the outside of the motorway has been spectacular. Some of these bars show considerable mobility and are moving steadily shorewards.

Inside the motorway there has been a rapid accumulation of fine sediments in the central basin. This has resulted in a rise in substrate level and the mangrove is moving steadily outwards from the shore. With the deposition of soft sediments there has been a change in the natural faunal communities from the sandy Chione-Macomona type to a muddy Alpheus-Hemiplax type.

9.9 Pollution

There is little apparent pollution of this area, although the casual dumping of refuse by householders in the Waterview area is causing a deterioration of the local mangrove environment in places.

9.10 Ecological Value

The high tidal marsh areas surrounding Traherne Island and inshore of Pollen Island are of considerable ecological value, both because of their stage of development and the rarity of this type of environment in the Waitemata ecosystem, and also because of their value to bird populations as roosting areas.

Generally the intertidal areas are in a healthy state, and some of the tidal areas are particularly rich in faunal variety and density.

The Waterview Inlet has a healthy intertidal environment which is a source of considerable pleasure to the local residents. The large surface area of this region could have an important effect in purifying tidal waters.

9.11 <u>Improvement and Protection of Ecological Assets</u>

Considerable improvement could be made to the foreshores of this region - particularly those of the Waterview Inlet. Planting of trees and shrubs adjacent to the high tide level will protect the intertidal region.

Care should be taken with development of new subdivisions near the base of the Rosebank Peninsula to minimise sediment contribtions to the area.

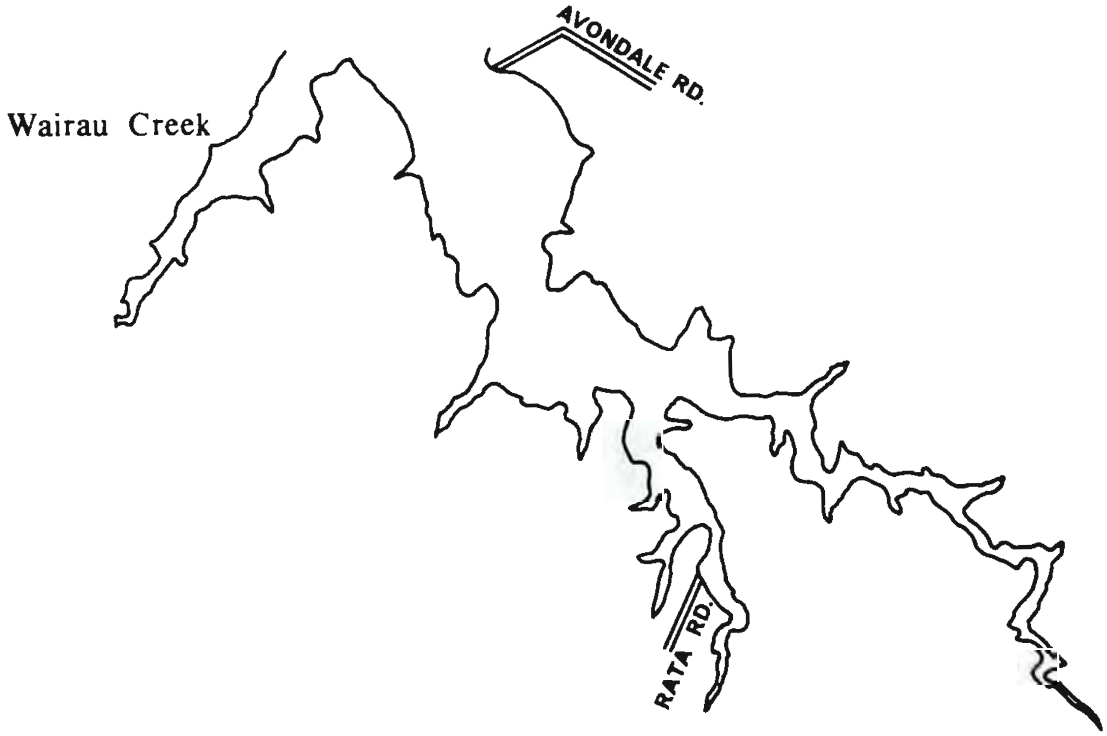
9.12 <u>Potential Use of Ecological Assets</u>

A considerable area in the south-western part of the Waterview Inlet and behind Pollen Island is designated for reclamation if a container port is to be developed on the Te Atatu Peninsula. If this development proceeds, particular attention should be paid to the possibility of retaining part of Traherne Island and the surrounding flats in a natural state. There is little of this type of area remaining in the Waitemata, and it assumes considerable value for educational purposes and as a wildlife refuge.

The Walker Road area should also be examined with a view to preserving the shell barrier to the south and a part of the enclosed mangrove marsh. This could also be of considerable educational value.

At present the principle use of ecological assets of this region is by fishing. Most fishing is done outside the motorway and towards the centre of the bay, although net fishing for flatfish is practised in the Waterview Inlet. This use of the area is unlikely to change.

AREA 10



UPPER WHAU RIVER

AREA 10 UPPER WHAU CREEK

10.1 General Description

This area consists of the head of the Whau Creek, to the south of, and including, the Wairau Creek. Most of the surrounding land is residential with small light industrial areas near New Lynn.

Foreshores generally consist of steep banks, often covered with rough vegetation. Extensive reclamation has been made at the end of Archibald Road and the foreshore has been faced with basalt. There is an inorganic rubbish dump near the end of Canal Road.

This upper part of the Whau River is almost completely tidal with only narrow low tidal channels. Minor freshwater flows enter the River in this region.

10.2 Intertidal Substrates

In the upper extremities of the tidal areas of the Whau and its tributaries, the intertidal area usually falls quite steeply to the low tidal channel. Substrates in such areas are soft muds.

Where the intertidal region widens mangroves occur in a fringe near the shore and there are extensive areas of open mud flat below the mangrove level. Mud is generally very soft although there may be firmer areas in the low tidal channels. Sedges and salt marsh plants are found in some high tidal areas where substrates are relatively firm.

Hard substrates are almost non-existent in this area with only occasional small outcrops of sandstone which is generally heavily silted. The roots, trunks and pneumatophores of mangrove trees provide a suitable surface for colonisation by some common hard shore animals and plants.

10.3 Intertidal Flora and Invertebrate Fauna

Fringing salt marsh and sedge	*Leptocarpus simplex* *Juncus maritimus var australiensis* *Salicornia australis* *Selliera radicans* *Samolus repens*

fauna	*Ophicardelus costellaris* (c) *Potamopyrgus antipodum* (a) *Amphibola crenata* (o) *Helice crassa* (c) amphipods (c)
Mangrove marsh	*Amphibola crenata* (a) *Potamopyrgus antipodum* (c) *Helice crassa* (a) *Crassostrea glomerata* (r) *Elminius modestus* (c)
Low tidal soft muds	*Helice crassa* (o) *Alpheus sp.* (o) amphipods (c) spionid polychaetes (a)

10.4 Fish

Little is known of the fish populations in this area. Several Harbour species such as parore, yellow-eyed mullet, and flat fish use areas such as this for feeding.

10.5 Birds

Shore feeding birds are found in small numbers throughout this area, but more often in the more open regions towards the mouth of the river. White-faced herons, pied stilt, and red-billed gulls are common. Ducks are often seen in mangrove regions. Fish feeding species include pied shags, little pied shags, and little black shags.

10.6 Edible Invertebrates

There are no edible invertebrates in this area.

10.7 Natural Ecological Changes

Natural Ecological changes to be expected in an area such as this are the slow rise in intertidal sediment level in protected regions, and a gradual change in the fauna to adapt to soft sediments and the rising substrate level. The most conspicuous natural changes will be an expansion of the area occupied by mangrove marsh in regions of rapid accretion.

10.8 Ecological Interference by Man

The most noticeable impact of man in this area has been through reclamation of shore areas, and the contribution of quantities of fine inorganic silts and clays to the tidal area.

Strip reclamations along the shore may have caused local changes in sedimentation patterns but this is not apparent. Interference with the region outside the reclaimed areas seems neglibible.

The accumulation of soft sediments is a widespread problem in the Whau River. In some sheltered regions sediment accumulation appears to be processing at a rapid rate, although in most cases the organisms of soft muds are able to cope with sediment buildup.

10.9 Pollution

This area of the upper Whau River is one of the most maltreated in the Waitemata Harbour. Large numbers of private residences border the narrow tidal waterways and many residents appear to regard the creeks as a receptacle for all types of refuse. Wherever a road or public accessway approaches the intertidal area there are dumps of rubbish. Council workmen and P & T crews are also responsible for depositing rubbish in tidal areas.

The collective effect of many small pollutant contributions is detrimental to the natural environment of this region. The soft muds are particularly sensitive to the introduction of foreign material. The deterioration of the intertidal environment results in the production of obnoxious odours which are in turn unpleasant to the human community.

10.10 Ecological Value

Extensive intertidal areas of soft substrate such as the upper Whau Creek have considerable ecological value in providing large surface areas for interactions important in maintaining high water quality.

The natural fauna and flora is also important in providing organic detritus which is utilised by communities further towards the mouth of the Harbour. Larger invertebrates are the food of fish and birds.

10.11 Improvement and Protection of Ecological Assets

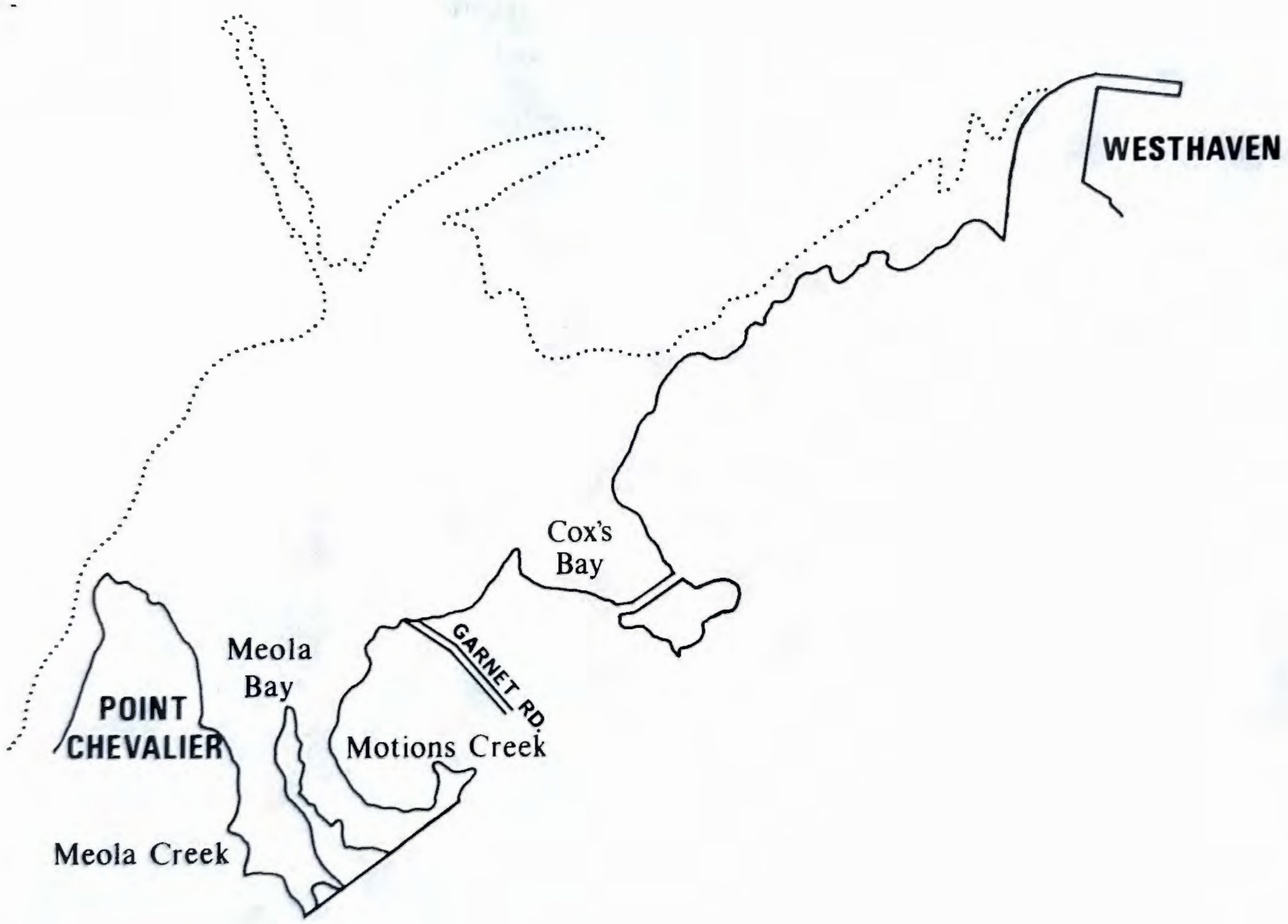
The ecological condition of this area could be improved by preventing the contribution of large quantities of silts and delays to the tidal region. The education of the local population regarding their treating tidal areas as a rubbish receptacle would also improve the natural environment and protect the flora and fauna.

The foreshore strip is an important zone in the upper reaches of rivers. It is from this strip that most of the sediment and pollution is derived. If the foreshore is protected by the planting of stabilising vegetation this will help protect the intertidal.

10.12 Potential Use of the Ecological Assets

There is little direct use to be made of the ecological assets of this area. As part of a residential environment, however, the ecology of the intertidal zone has considerable importance, and is an asset that only a limited number of people possess.

AREA 11



POINT CHEVALIER – WESTHAVEN

AREA 11. POINT CHEVALIER TO WESTHAVEN

This is an area in which there is considerable natural variations in environmental and biological parameters. It is discussed in three parts:

A. Meola Bay

B. Westmere Reef

C. Cox's Bay to Westhaven.

11.A Meola Bay

11.A.1 General Description

This region includes the area inside the bay between the point near the end of Garnet Road and Point Chevalier, which in effect consists of two narrow inlets, one on each side of the basal part of the Westmere Reef. The Meola Creek enters the inlet to the west and the Motions Creek enters the eastern inlet.

The foreshore on both sides of the bay is attractive with steep banks largely clothed in native trees; pohutukawa, kowhai, and punga being prominent. The basal part of the reef is used as a rubbish tip by the Auckland City Council, while the head of the bay lies adjacent to Meola Road and previously reclaimed land which is now in grass.

11.A.2 Intertidal Substrates

Within the sheltered inlets on either side of the Reef substrates consist of soft, rapidly-accumulating sediment. Towards the outer part of the bay there are high tidal flats of firmer sand on the eastern side of the Reef with softer areas towards low tide and on the western side of the Reef.

The Reef is formed of a basaltic larva flow and the surface largely consists of broken rock and boulders. There has been considerable accumulation of soft sediments in sheltered areas enabling colonisation by mangrove and salt marsh plants at appropriate levels.

11.A.3 Intertidal flora and Invertebrate Fauna

Soft shores - In the sheltered inlets there is generally a band of sedges near the high water mark, particularly in soft sediments amongst the rocks on the Reef. Salt marsh plants include :

Salicornia australis
Samolus repens
Selliera radicans
Leptocarpus simplex
Juncus maritimus var australiensis

fauna

Potamopyrgus antipodum (c)
Ophicardelus costellaris (c)
Helice crassa (c)
Amphibola crenata (o)

Mangrove marsh — Enteromorpha sp.

fauna

Helice crassa (a)
Amphibola crenata (c)

Low tidal mud

spionid polychaetes (c)
Alpheus sp. (o)

Firmer sediments towards the mount of the bay

Chione stutchburyi (c)
Nucula hartvigiana (c)
Macomona liliana (c)
Zeacumantus lutulentus (a)
Zediloma subrostrata (c)
Cominella glandiformis (c)
Pectinaria australis (o)
spionid polychaetes (a)

Hard substrates - The hard substrate of this region is of two types; the soft sandstone on both sides of the bay, and the hard basalt of the Reef. There is little sandstone exposed between tide marks, mainly at a high level.

Enteromorpha sp. (winter)
Zeacumantus subcarinatus (o)
Zediloma subrostrata (o)

Fauna of the Reef is described in 11.B.3.

11.A.4 Fish

Little is known of the fish which utilise this area. The paucity of invertebrate life towards the head of the small inlets indicates that this area would have little value as a feeding area for fish. Richer areas towards the mouth of the bay could well be more important.

11.A.5 Birds

Black-backed gulls often roost in this area, particularly in the vicinity of the tip from which large numbers obtain food.

Pukekos are common in the tip region and amongst the mangrove adjacent to the shore.

Mallard ducks are often seen in the small creeks beside the Reef, particularly up near Meola Road.

11.A.6 Edible Invertebrates

No edible invertebrates reach sufficient size in this area to be taken for food.

11.A.7 Natural Ecological Changes

The deposition of fine sediments is to be expected in sheltered inlets such as Meola and Motions Creeks which receive land runoff. With the slow buildup of sediment level there would be a spread of mangrove marsh.

11.A.8 Ecological Interference by Man

An extensive shallow marsh area has been reclaimed behind Meola Road. At present the most obvious ecological changes occurring in this area are due to sedimentation and pollution. Deposition of fine sediments appears to be proceeding at a rapid rate over most of the intertidal substrates and mangrove marshes are extending rapidly. There are few living organisms in areas of rapid sedimentation. In the entrance area of the bay, previously healthy invertebrate communities have been smothered by fine sediment.

The rate of deposition of fine sediments in this area will probably decrease as the contribution of this material to the two creeks is reduced. The mangrove will probably spread over most of the intertidal area before this occurs.

11.A.9 Pollution

Pollution of this area may be attributed mainly to the presence of the refuse tip, although there may also be some contribution of organic material from the Creeks.

The soft sediments show a rapid deterioration in quality when they are in contact with iron rubbish scattered over the intertidal around the tip site.

There are small quantities of liquor seeping from the tip. This liquor has a high B.O.D. and smells of hydrogen sulphide. Substrates in the vicinity of liquor seepage are black immediately beneath the surface and also smell strongly.

At times there is a buildup of yellow-green microfauna on the mud surfaces of this area. This is an indication of enrichment of the muds, probably from the high quantity of organic material contained in tip liquor, and possibly from organic material carried into the Harbour from the Creeks.

11.A.10 Ecological Value

This area has considerable ecological value even in its present state. Much of this value is derived from the combination of the tree-clad foreshore and healthy high tidal mangrove marsh. These form a rich and attractive environment.

The reef fringes surrounding the tip reclamation are of considerable potential value because of their unique combination of salt marsh, mangrove and hard shore flora and fauna. This is an area that could well be developed for educational purposes when the tip reclamation is completed.

11.A.11 Improvement and Protection of Ecological Assets

Immediate improvement can be made to the ecological condition of this area by effective facing of the tip to prevent erosion of soft material, preventing tidal water from coming into contact with even inorganic rubbish, and reducing the flow of tip liquor and addition of wind-blown rubbish to the tidal area. The removal of metal and other rubbish from the region outside the tip is recommended.

The environment of this area will be adequately protected if the sediment contribution is reduced and the natural foreshore retained in its present state. Care should be taken with the formation of the artificial foreshore along the tip margins.

11.A.12 Potential Use of Ecological Assets

The Reef area is used extensively at present for individual thesis research, and class teaching, by the University.

If the high tidal area of the Reef, immediately outside the tip reclamation is preserved in a natural state it may well be used for educational purposes. Easy access across the hard Reef surface enables inhabitants of soft muds to be studied with relative ease.

11.B Westmere Reef

11.B.1 General Description

The Westmere Reef is a basaltic larva flow originating from the volcanoes of Mt Eden and Mt Albert, and flowing northwards to a point two-thirds of the distance across the upper Waitemata.

The surface of the Reef is extremely broken with fissures and cracks and many loose boulders providing a range of habitats not found elsewhere in the Upper Harbour.

11.B.2 Intertidal Substrates

Whereas the Reef itself is hard basalt rock there is a variety of soft substrates associated with the Reef. Soft mud has accumulated in the inner protected areas and at a high level supports a mangrove community. In shallow pools there is often an accumulation of sand and shell, while in areas adjacent to the Reef sediments vary from coarse sands and shell in current exposed areas to soft muds in sheltered regions.

11.B.3 Intertidal Flora and Invertebrate Fauna

The flora and fauna is described for a series of habitat types.

Immediately outside the tip reclamation at the basal part of the Reef there is an extensive area of mangrove. These trees are growing in the accumulated soft silt between blocks of larva.

fauna	Nerita melanotragus (c)
	Melagraphia aethiops (c)
	Zediloma subrostrata (c)
	Lunella smaragda (c)
	Cominella glandiformis (o)
	Zeacumantus lutulentus (c)
	Zeacumantus subcarinatus (c)
	Sypharochiton pelliserpentis (o)
	Onchidella nigricans (c)
	Crassostrea glomerata (c)
	Petrolisthes elongatus (c)
	Alpheus sp. (o)
	Helice crassa (a)
	Anthopleura aureoradiata (a)
	Pomatoceros coeruleus (o)

The grazing gastropods grow to a large size in this area where they feed on a rich growth of Gelidium and small algae growing on the perpetually damp rock and mangrove surfaces. Of interest also, is the presence of isolated patches of Zostera growing in pools with sandy substrate.

Outside the mangrove area the Reef has jagged edges with a spine of large basalt blocks. Areas of broken rock and boulders are common on the flanks. Some large pools occur on the spine and contain:

algae	Hormosira banksii (large bladders)
	Corallina officinalis
fauna	Amaurochiton glaucus (c)
	Isocladus sp. (a)
	Anthopleura aureoradiata (c)
	Watersipora cucullata (o)
Beneath loose boulders	Eulalia viridis (o)
	Perinereis novaehollandiae (c)
	Lepidonotus sp. (c)
	Onchidella nigricans (a)
	Sypharochiton pelliserpentis (c)
	Melagraphia aethiops (c)

Lunella smaragda (o)
Elminius modestus (c)
Halicarcinus sp. (o)
Hemigrapsus edwardsi (o)
Petrolisthes elongatus (a)
bdellid mite (c)
flatworms (c)

on upper rock surfaces

Crassostrea glomerata (a)
Lepsiella scobina (a)
Melagraphia aethiops (a)
Elminius modestus (a)
Eulalia microphylla (c)

At low levels there is a rich growth of sponges including:

Hymeniacidon perlevis
Halichondria moorei
Haliclona sp.

Half a mile out from the point at the end of Garnet Road the reef is similar in form with a more or less solid spine and areas of loose rock on both sides. There is an increase in the degree of silting of horizontal surfaces in this area. The density of Crassostrea is reduced, but Elminius modestus is still dense even when silted over. The fauna of pools and boulder habitats is similar to that described above, but there are a number of different species towards low tide level.

About low water neap

algae

Hormosira banksii
Corallina officinalis
Codium adhaerens

fauna

Cominella virgata (a)
Cominella adspersa (c)
Cominella maculosa (c)
Buccinulum heteromorphum (a)
Lunella smaragda (c)
Watersipora cucullata (a)
Anthopleura aureoradiata (a)
Perna canaliculus (o)
Ostrea sp. (a)
Anomia walteri (c)
Watersipora cucullata (c)
Fenestrulina malusii var thyreophora (c)
Beania sp. (a)
Microcosmus claudicans (c)
Styela plicata (c)
Pyura sp. (o)
Microciona coccinea (o)
Tethya aurantica (o)

In some of the higher parts of the Reef in the middle region there is a seasonal growth of the algae Scytothamnus australis on open surfaces, and Gelidium sp. in shaded areas.

Two-thirds of the distance to the end of the intertidal part of the Reef is an area known as the Causeway, through which a strong current passes on all but the lowest tides. This region is particularly rich with the currents keeping the rock surface free from fine sediment and suitable for colonisation by a large number of algae and sedentary animals.

Low tide level

algae
Sargassum sinclairii
Ecklonia radiata
Codium adhaerens
Colpomenia sinuosa (winter)
Dictyota sp.

fauna
Rostangia rubicunda (o)
Dendrodoris citrina (c)
Dendrodoris nigra (r)
Scutus breviculus (o)
Murexul octogonus (c)
Neothais scalaris (o)
Taron dubius (o)
Cryptoconchus porosus (c)
Perna canaliculus (o)
Anomia walteri (c)
Ostrea sp. (a)
Patiriella regularis (o)
Flabelligera affinis (c)
Suberites cupuloides (c)
Aaptos aaptos (c)
Tethya aurantium (o)
Zoobotryon pellucidum (c)
Beania sp. (c)

In coarse sediments near the reef

Dosinula zelandica (o)
Paphirus largilleirti (o)
Notocorbula zelandica (o)
Cancer novaezelandiae (c)

Beneath low tidal stones

Beania sp. (c)
Maoricrypta monoxyla (c)
Sigapatella novaezelandiae (c)
Pilumnus lumpinus (o)
Petrolisthes elongatus (c)
Flabelligera affinis (c)
Corella eumyota (c)
Microcosmus claudicans (a)
Styela plicata (o)
Pyura sp. (c)

A similar fauna is found towards the distal end of the reef. In some areas below low water mark there are dense patches of Perna canaliculus, and occasional specimens of Evechinus chloroticus.

11.B.4 Fish

The Westmere Reef supports a rich flora and fauna and undoubedly forms a rich food source for Harbour fish.

11.B.5 Birds

Only small numbers of birds use the hard reef as a feeding area, although considerable numbers of shore feeders utilise the low tidal flats on either side.

Occasionally little blue herons are seen near the base of the reef, while small numbers of black-backed gulls and red-billed gulls feed along its whole length.

Pied shags and little black shags rest at low tide and feed in the area at high water. Small numbers of white-fronted terns and caspian terns also feed in the area.

11.B.6 Edible Invertebrates

Two species of edible shellfish attain edible size on the Reef, the rock oyster, Crassostrea glomerata, and the mussel Perna canaliculus. Crassostrea is restricted to the inner portion of the Reef and is only exploited to a small extent. Perna is found in dense beds about the low water mark near the end of the Reef and is taken mainly by boat parties, although some people walk the length of the Reef to reach these populations.

It is not known how extensive the mussel beds are, or what effect the present rate of exploitation is having.

11.B.7 Natural Ecological Changes

The only natural change to be expected in this area is a slight degree of silting in protected areas.

11.B.8 Ecological Interference by Man

The activities of Man have had no effect on the ecology of the unreclaimed part of the Reef.

11.B.9 Pollution

There is no sign of pollution in this area, apart from the region in the immediate vicinity of the rubbish tip where soft sediments have been affected.

11.B.10 Ecological Value

The hard rock of the Westmere Reef is of considerable ecological value to the Harbour ecosystem. It provides a suitable surface for colonisation by a large range of plants and animals that would not otherwise be present in this area of the Harbour, and which considerably enrich the region by their presence.

The Westmere Reef is of considerable interest to the marine biologist because of the wealth of animal and plant species. It also has the attraction of being close to the city and easily accessible. Several theses have been written on aspects of the ecology and biology of animals from this area, and it is used extensively for laboratory collection and field courses.

11.B.11 Improvement and Protection of Ecological Assets

The ecology of this region is natural and healthy at present and requires no improvement.

11.B.12 Potential Use of Ecological Assets

It is probable that this area will be used increasingly for educational purposes. If the basal end of the Reef is developed to preserve the ecology of that region the Reef will be an extremely valuable asset to the City and Harbour.

11.C Cox's Bay to Westhaven

11.C.1 General Description

From the opposite side of the Harbour this stretch of coast is typified by the series of small bays with cliffed headlands. The exposed yellow sandstone contrasts pleasantly with the dark green of the fringing pohutukawa. The surrounding land is residential with large numbers of houses overlooking the Harbour.

11.C.2 Intertidal Substrates

Intertidal substrates are composed mainly of soft sediments. At high tide level there is an accumulation of shell and coarse sand, both at the base of the cliffs and in the bays. Towards mid tide level the sediment becomes finer, and the shore levels out. There are extensive low tidal flats of fine sand, with a Zostera bed exposed on low spring tides. The low tide mark extends in an almost straight line from Westhaven towards the Westmere Reef.

On some of the points the sandstone extends into the intertidal zone, and occasionally as far as low water neap. Most of the rock is eroded and smooth, although there are accumulations of boulders beneath the cliffs in some places.

11.C.3 Intertidal Flora and Invertebrate Fauna

Hard Shores - Hard shores are of soft sandstone, although there are occasional patches of basalt spawls that have been dumped in the intertidal.

There is a zone of blue-green algae on the cliff faces, particularly in areas with fresh water seepage. About the high tide level a conspicuous band of bright green *Enteromorpha* species is developed in winter, but disappears with the warmer well developed band of brown *Gelidium* sp.

High tidal reef flats	*Actinia tenebrosa* (o) (beneath over-hangs)
	Zeacumantus subcarinatus (a)
	Zeacumantus lutulentus (c)
	Zediloma subrostrata (c)
	Melagraphia aethiops (c)
	Onchidella nigricans (c)

Mid-tidal reef flats

Cominella glandiformis (a)
Sypharochiton pelliserpentis (c)
Lunella smaragda (c)
Lepsiella scobina (o)
Elminius modestus (o)
Isactinia olivaeea (a) in pools
Anthopleura aureoradiata (a) in pools
Crassostrea glomerata (r)
Pomatoceros caeruleus (r)

Beneath Stones

Notoacmea helmsi (a)
Hemigrapsus crenulatus (c)
Pilumnopeus serratifrons (c)
Alpheus sp. (o)
Nucula hartvigiana (c)
Amaurochiton glaucus (c)
amphipods (a)
flatworms (c)

Because of the soft nature of the rock of this area there is a noticeable absence of several common sedentary species including limpets, oysters, barnacles, and tubeworms. These are well-represented on the basalt retaining walls in the Westhaven area. (see Area 12)

Soft Shores -

High tide level - Substrates are coarse and shelly with good drainage. There is no conspicuous macrofauna apart from amphipods on the drift line.

Mid tide level - Towards mid tide level the shore levels out and the sediments become finer.

Chione stutchburyi (c)
Macomona liliana (c)
Cucula hartvigiana (c)
Cominella glandiformis (c)
Glycera sp. (c)

Low water neap flats - Sediments are fine and sandy

Mactra ovata (o)
Chione stutchburyi (a)
Macomona liliana (a)
Nucula hartvigiana (a)
Cominella glandiformis (a)
Cominella adspersa (a)
Callianassa filholi (c)
Lysiosquilla spinosa (c)
spionid polychaetes (a)
Aglaophamus macroura (o)
Glycera sp. (o)

Low spring tide flats - Sediments are fine and sandy with Zostera being abundant.

Solemya parkinsoni (o)
Soletellina nitida (c)
Nucula hartvigiana (o)
Callianassa filholi (c)
Lysiosquilla spinosa (c)
Hemiplax hirtipes (o)
Halicarcinus sp. (c)
Cominella adspersa (c)
Psammolyce antipoda (o)
spionid polychaetes (a)
Aglaophamus macroura (o)

Towards Westmere Reef on open sand

Alcithoe arabica (r)
Struthiolaria vermis (o)
Haminoea zelandica (o)
Baryspira australis (c)
Soletellina nitida (a)
Macomona liliana (c)

The Zostera bed in the low tidal region is healthy and important to several of the less common low tidal species.

Scallops, (Pecten novaezelandiae) and horse mussels (Atrina zelandica) were found in this area some years ago. These now appear to be absent.

11.C.4 Fish

Large numbers of juvenile flatfish occur in this area. In the region between low water neap and low water spring there are often signs of activity by bottom-feeding species - probably snapper.

Numbers of children fish from the Ponsonby Wharf at the end of Wairangi Street. Species most often caught are spotties and yellow-eyed mullet. The goby, Acentrogobius lentiginosus is also common in this area.

11.C.5 Birds

Large flocks of red-billed gulls feed in this area on low tides, particularly on the low spring flats when they are exposed. Numbers of black-backed gulls rest in the area to the east of the Westmere

Reef and near the end of Garnet Road. These probably feed on the rubbish tip.

Small numbers of pied stilts, and white faced herons visit the region occasionally, and there are a few kingfishers feeding in the area.

11.C.6 Edible Invertebrates

The only edible invertebrates in this area are shellfish; principally the cockle, Chione stutchburyi, with small numbers of oysters, Crassostrea glomerata, and Mactra ovata.

Most of the small bays to the east of Cox's Bay support populations of Chione down to the low tide neap level. Individuals reach a maximum size of just over 30 mm and the beds are probably exploited to a small extent by local residents.

The small numbers of Crassostrea and Mactra are probably not exploited.

At present the intertidal substrates of most of this area are ideal for colonisation by Chione and little change can be expected in population levels.

11.C.7 Natural Ecological Changes

There are no large scale natural ecological changes to be expected in this area, although it is possible that the Zostera beds will expand.

11.C.8 Ecological Interference by Man

All ecological interference by man is dealt with below.

11.C.9 Pollution

This is a generally untidy intertidal area with localised areas showing considerable pollution.

Pollution is described under four categories:

a. Floating rubbish
b. Dumped rubbish
c. Intertidal constructions
d. Organic pollution.

11.C.9a. Floating Rubbish

Included in this category is wood, plastic, glass and other rubbish derived from other areas.

In some parts of this region, particularly towards Westhaven, there are large quantities of waterlogged wood lying in the intertidal. As these rot and break up they contribute to the untidy nature of the region. The incorporation of rotting material into the substrate results in small patches of anaerobic sediment.

Plastic bags and bottles are also a problem in this area. Plastic is often caught on waterlogged wood and becomes partially submerged in the soft substrates.

Broken glass is widespread along this shore. It appears that floating bottles are broken when they are carried ashore.

11.C.9b. Dumped Rubbish

Private residences with foreshore frontage are the source of considerable quantities of inorganic rubbish. Remains of steel and metal objects are widespread, and particularly noticeable to the west of Herne Bay and in Coxs Bay. Tree prunings are also dumped in the intertidal.

Metals lying in soft sediments provide substrates and ions for a variety of bacterial actions, some of which result in the formation of anaerobic conditions and obnoxious gases.

11.C.9c. Intertidal Constructions

Some of the local residents of this region have been privileged to build boatsheds in the intertidal area. Several boatsheds are now dilapidated with ramps and other parts falling to pieces. Repairs done to some sheds have resulted in unwanted material being dumped into the water.

11.C.9d. Organic Pollution

Cox's Creek is the source of large quantities of organic material which is having a detrimental effect on the ecology of surrounding soft sediment areas. (see Report on Water Quality, A.R.A.)

The banks and bottom of the low tidal Creek, where it flows across the sand flats to the mouth of Cox's Bay, are highly polluted with black muds exposed at the surface, and green slimes of micro-organisms. Substrates smell strongly of hydrogen sulphide.

Towards the mouth of the Bay where the low tidal Creek enters the Harbour there has been considerable enrichment of the substrate surface. A layer of filamentous algae occurs on the surface and a larger brown algae, probably Punctaria latifolia grows attached to shells in the winter. Often there is a considerable accumulation of comminuted toilet paper fibre on these low tidal substrates.

At present the area with a growth of algae on the surface extends for only three of four hundred metres near the low tidal Creek, with a decrease in the density of the alga both towards Westmere Reef and towards Herne Bay.

The effects of pollution by Cox's Creek on tidal waters are discussed in the Report on Water Quality (A.R.A.).

11.C.10 Ecological Value

Most of the intertidal area of this region contains a rich and natural invertebrate fauna. Low tidal shellfish beds are probably of considerable importance to fish populations.

The presence of the low tidal Zostera bed in this area is of some value to the Harbour ecosystem. This is a remnant of a once abundant habitat type, and is important to several less common invertebrate species. (See Report on Ecological Changes.) The protection afforded by Zostera may well be important to populations of juvenile flatfish.

11.C.11 Improvement and Protection of Ecological Assets

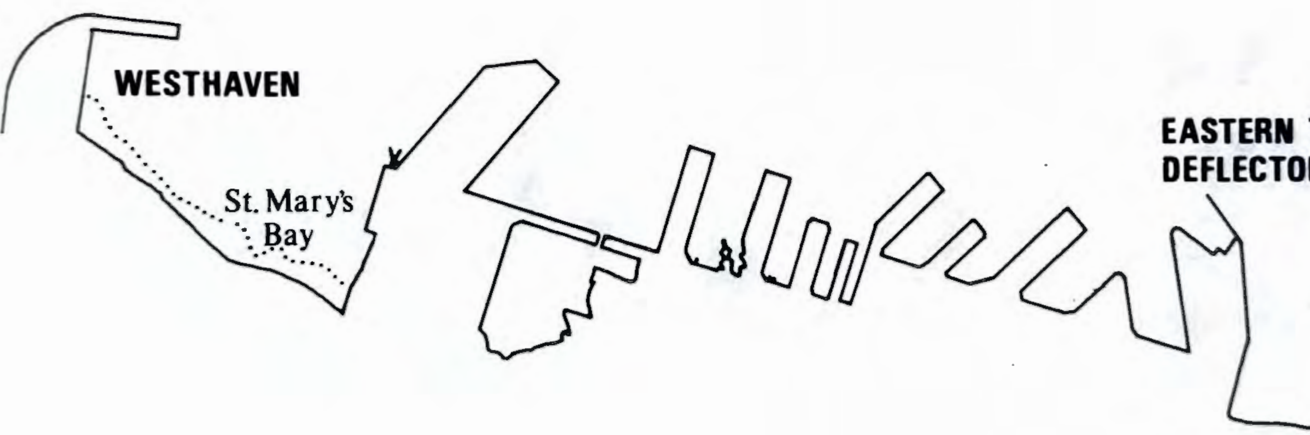
Considerable improvement can be made to the healthy ecological functioning of this area by removing the polluting influences mentioned in 11.C.9.

11.C.12 Potential Use of Ecological Assets

Recreational fishing and gathering shellfish for food are the two most important uses of the ecological assets of this area at present. The level of participation in these activities is unlikely to change.

Of some importance in this region is the polluting effect of Cox's Creek on tidal waters. The small bays along this shore are popular swimming areas at high tide.

AREA 12



WESTHAVEN TO EASTERN TIDE DEFLECTOR

AREA 12 WESTHAVEN TO THE EASTERN TIDE DEFLECTOR

12.1 General Description

This area contains the wharves of the Port of Auckland. The Westhaven boat harbour is situated in the west and provides moorings and marina berths for a large number of pleasure craft. At St Marys Bay immediately east of Westhaven there is a concentration of boat-building and maintenance yards.

The natural foreshores and intertidal of this area have been destroyed in the course of providing deep water berthage in the Port area and servicing facilities in Westhaven and St Marys Bay.

12.2 Intertidal Substrates

Almost all the shoreline of this area has been altered by reclamation and is now faced with basalt block walls or concrete. Wharf pilings also provide a large surface area of intertidal substrate. The vertical faces of wooden and concrete piles remain clean in silty water and provide suitable attachment surfaces for a variety of animals and algae.

12.3 Intertidal flora and Invertebrate Fauna

There is considerable variation in the numbers and types of animals and plants inhabiting the wharf piles and rock faces of this area, dependant upon the degree of current exposure, light intensity, and water quality.

The richest faunas are found on the exposed end piles of the wharves and in other exposed areas such as the Eastern tide Deflector, and the outside of the Westhaven tide Deflector. Inside the wharf basins there is a reduction in the biomass caused principally by the amount of suspended material in the water which restricts the algae, and probably inhibits settling of fouling organisms, and also a general deterioration in water quality which could inhibit larval settlement and certainly retards growth of attached animals.

Open rock faces - Areas of basalt retaining wall such as those at Westhaven and on the Eastern tide deflector support a fauna and flora similar to that described for the rock wall at Okahu Bay (Area 13.3.A).

Wharf Piles - ends of the wharves

Generally, the piles near the outer ends of the wharves support the most healthy fauna and flora.

About high water level there is a band of blue-green algae with green Enteromorpha procera prominent below this in the winter. The small acorn barnacle Elminius modestus is found in a zone below high water neap and also extends to the low water mark. In current exposed areas the small black mussel Modiolus neozelanicus also occurs in large numbers below high water neap. A rock oyster zone is well developed with a variety of smaller animals being found between the oysters. Included are:

Pomatoceros caeruleus (o)
Sypharochiton pelliserpentis (c)
Watersipora cucullata (c)

The tube worm Pomatoceros may occur in high densities in places. Below the oyster zone a wealth of encrusting forms is found between low water neap and low water spring.

Perna canaliculus (c)
Mytilus edulis (r)
Ostrea sp. (c)
Bugula sp. (o)
Watersipora cucullata (a)
Microcosmus kura (a)
Botrylloides leachii (o)
Botryllus schlosseri (c)
Aplidium phortax (a)
Amphisbetia bispinosa (c)

The large brown alga Ecklonia radiata occurs on current exposed piles, but the other larger algae are absent.

In shaded areas there is a reduction in density of many of the mid-tidal animals and algae are absent apart from the blue-greens about high water level. The low tidal fauna is prolific however with colonial ascidians becoming dominant.

In sheltered waters inside the wharf basins there is a reduction in density of fauna and flora at all intertidal levels. This is caused to some extent by reduced current flow, but it is felt that inferior water quality in terms of heavy sediment burden and increased pollutant concentrations is largely responsible for such a pattern.

12.4 Fish

Little is known of the fish in this area. Several of the common Harbour species are caught by line fishing in the region.

12.5 Birds

Scavenging red-billed and black-backed gulls are common in this area. Pied shags are seen occasionally and white-fronted terns feed in open water outside the wharves.

12.6 Edible Invertebrates

Two species of edible shellfish occur in large numbers on retaining walls and wharf pilings in this area. Rock oysters Crassostrea glomerata, and mussels Perna canaliculus are probably taken in small quantities for food, particularly from the Westhaven and Eastern tide Deflector areas. The possible effects of reduced water quality on these shellfish should be investigated.

12.7 Natural Ecological Changes

There are few natural changes to be expected in the ecology of this area. The most significant will be the gradual buildup of communities of intertidal organisms on the newly formed walls facing reclamations.

12.8 Ecological Interference by Man

Deteriorating water quality could have an important ecological impact in this area. Of particular importance is the quantity of suspended material in the water which reduces light penetration, and also the feeding efficiency of many animals. The regular occurrence of light films of an oily nature on the water surface also has an adverse ecological effect as the piling and rock faces are coated with this material with the falling tide.

12.9 Pollution

Pollution in the Port area is discussed in the Ecological Report on Pollution.

From an ecological point of view the major threat to the natural communities of this area is not from a single pollutant source, but rather by the cumulative effects of a number of minor sources, none of which is independently particularly serious.

A reduction in the biomass of natural communities is apparent in some parts of this area. Further reductions are probable, although these will occur slowly under present water quality conditions.

12.10 Ecological Value

The large intertidal surface areas of piles and retaining walls provides a potential settling area for a variety of fauna and flora. Unless conditions are sufficiently bad to reduce the biomass of natural fouling communities these will play an important part in preserving and improving water quality in the area while interacting with the entire Harbour ecosystem through food chains and the provision of larvae.

12.11 Improvements and Protection of Ecological Assets

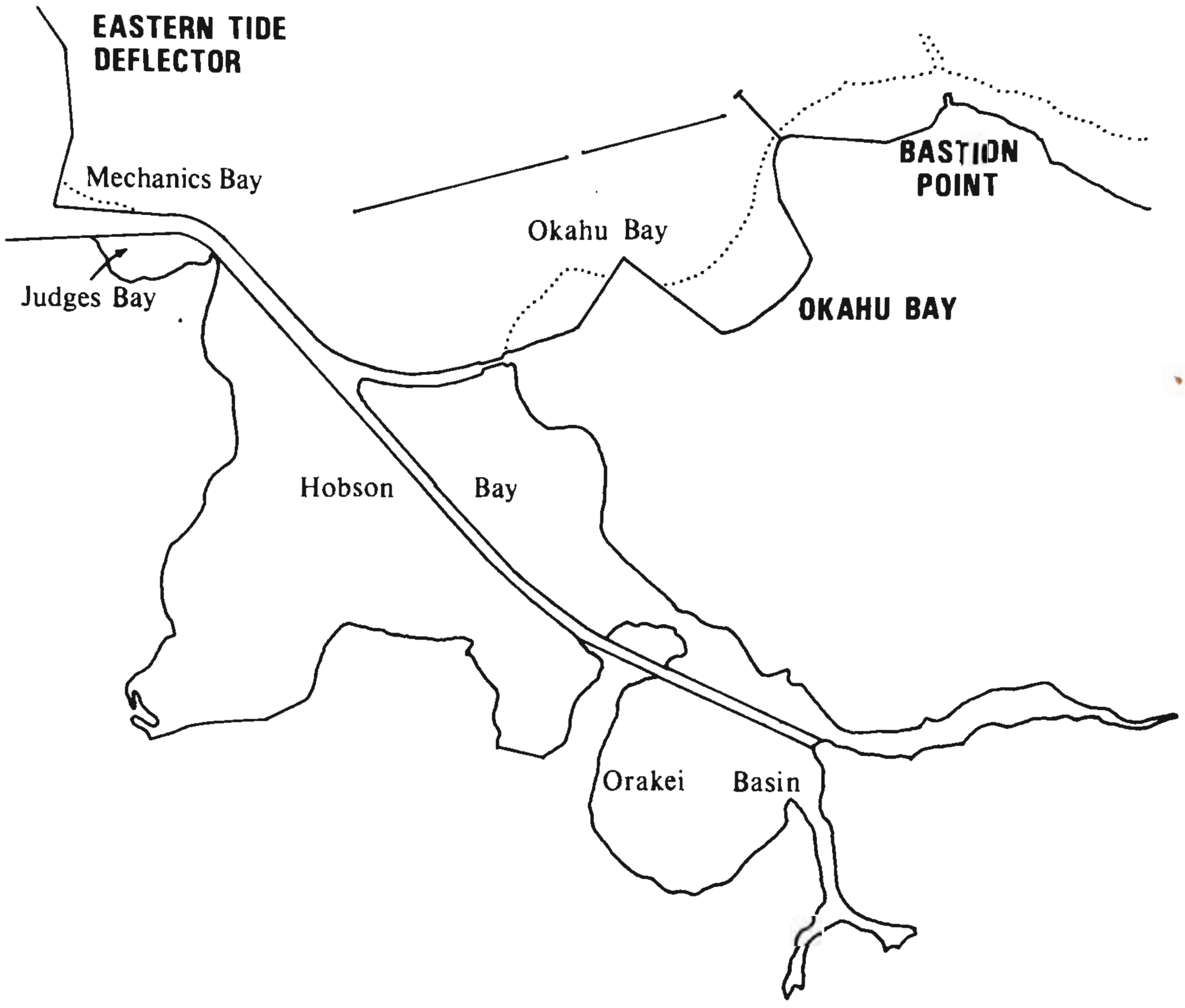
It is of a definite advantage to the ecology and environment of the Waitemata Harbour to keep the intertidal communities of the Port Area in a natural state. At present ecological conditions are healthy, although there are signs that a slow reduction in biomass and diversity of organisms is occurring.

Protection of the ecological assets of this area can be given by reducing pollutant contributions to the waters, and also reducing the contribution of silt if possible.

12.12 Potential Use of Ecological Assets

There is little direct use of the ecological assets of this region at present, apart from a small amount of recreational fishing and occasional shellfish gathering, and this situation is unlikely to change.

AREA 13



BASTION POINT TO EASTERN TIDE DEFLECTOR

AREA 13. BASTION ROCK TO THE EASTERN TIDE DEFLECTOR (EXCLUDING HOBSON BAY)

13.1 General Description

This is an area that has been considerably modified by the construction of the Tamaki Drive across the mouth of Hobson Bay. Much of the foreshore has been altered by reclamation and is now faced with basalt block walls. The eastern tide deflector extends some four to five hundred metres into the Harbour from Mechanics Bay.

13.2 Intertidal Substrates

There are three types of intertidal substrate in this area.

A. Basalt retaining walls of the Tamaki Drive, Eastern tide deflector, and reclamations at Mechanics Bay and Okahu Bay.

B. The soft shell and sand of Okahu Bay.

C. Sandstone reefs exposed at a low intertidal level outside Judges Bay, immediately west of Okahu Bay slipways, and at Bastion Point.

13.3 Intertidal Flora and Invertebrate Fauna

13.3.A Flora and Fauna of Basalt Retaining Walls

The organisms found on the wall in Okahu Bay near the dinghy lockers are listed below. This fauna and flora is representative of all such walls in this region, although there may be some minor variations in the availability of certain habitats and in the abundance of some species.

On the open rock surface above high tide level there is a lichen zone with species including the pale yellow *Parmelia*, orange *Xanthoria parietina*, and grey-white *Lecania*.

At the upper limit of loose rock there is an abrupt transition from the exposed faces of the cemented blocks to an area with loose rock and shade and humid hollows. At high water neap the occasional *Melarapha oliveri* is found on the open rock faces, while amongst drift material and small rocks a typical high tidal boulder fauna is found.

Talorchestia sp. (a)
Ligia sp. (a)
Cyclograpsus lavauxi (c)
pink nemertean (c)

In shaded areas immediately below high water neap the first of the algal grazers are found

Onchidella nigricans (c)
Notoacmea daedala (c)
Nerita melanotragus (o)

Also common are

Lasaea maoria
Levconopsis obsoleta (c)
Elminius modestus (o)
flatworm (grey)

In the area below mean high water and the top of the oyster zone exposed rock surfaces are covered by a flat encrusting alga, probably *Apophloea sinclairii*, and there are patches of green *Enteromorpha sp.* in shaded areas.

Lepsiella scobina (o)
Zediloma atrovirens (c)
Nerita melanotragus (c)
Risselopsis varia (o)
Siphonaria australis (r)
Actinia tenebrosa (c)
Tetraclita purpurascens (o)
Elminius plicatus (o)
Petrolisthes elongatus (o)

At the top of the oyster zone which forms a conspicuous band 1.25 m in vertical extent about mid tide level there are patches of the brown *Gelidium caulacantheum* and a variety of gastropods

Cellana ornata (o)
Melagraphia aethiops (c)
Zediloma atrovirens (o)
Lunella smaragda (o)
Sypharochiton pelliserpentis (c)
Haustrum haustorium (o)
Onchidella nigricans (c)
Acanthochiton zelandicus (c)
Notoacmea daedala (c)

in shaded crevices

Petrolisthes elongatus (c)
Watersipora cucullata (c)
Microcosmus kura (o)
Ciona sp. (o)

Most of the above species are found throughout the oyster zone. Towards low tide level the oysters become less dense and turfing algae cover more of the rock surface.

About low water neap

Cellana radians (c)
Acanthochiton zelandicus (c)
Sypharochiton pelliserpentis (c)
Onchidella nigricans (c)
Lunella smaragda (a)
Neothais scalaris (c)
Coscinasterias calamaria (c)
Patiriella regularis (c)
Elminius modestus (o)

algae

Corallina officinalis
Codium adhaerens (shade)
Colpomenia sinuosa (autumn-winter)
Laurencia spp.
Scytosiphon lomentaria (winter)
Prophyra columbina

Below low water neap the boulders are generally completely covered with turfing Corallina officinalis and other small species of algae. On boulders about low spring tide level there is a band of large brown algae.

Sargassum sinclairii
Carpophyllum flexuosum
Carpophyllum maschalocarpum
Ecklonia radiata

fauna

Ischnochiton maorianus (c)
Sigapatella novaezelandiae (o)
Terenochiton inquinatus (c)
Cominella virgata
Perna canaliculus (o)
Ostrea sp. (c)
Anomia walteri (c)
Flabelligera affinis (c)
terebellid (c)
Tethya aurantica (o)
Halichondria sp. (a)
Microciona sp. (c)
Beania flabellifera (c)
encrusting bryozoa (c)

Some retaining walls in this area do not have loose rock to the high tidal level and the fauna described above for Okahu Bay is absent. The oyster zone is still well developed on cemented block walls and most of the species associated with oysters above are present. Low tidal fauna and flora are also similar.

Slight variations in exposure in this area result in the presence of the small barnacle Chamaesipho columna in more exposed areas such as the eastern tide deflector and a small area of Chamaesipho brunnea on rocks at the inlets to Hobson Bay where there are strong tidal currents.

13.3.B Soft Substrates of Okahu Bay

Okahu Bay has a typical soft shore form of a sloping beach and a low tidal flat. As for other similar beaches in the Waitemata Study Area (Bucklands, Cheltenham, Mission Bay, etc) the sloping beach consists of fairly coarse material, predominantly broken shell. This area is well drained and supports little in the way of macrofauna. Drift material is cleaned from the high water mark, and common fauna of drift algae are reduced.

At the foot of the sloping beach there are a few small specimens of Amphidesma australe.

At the inner edge of the lower intertidal flat substrates are firm and sandy with accumulations of shell at the eastern end of the beach. Colonists here are

Chione stutchburyi (a)
Zeacumantus lutulentus (c)
Cominella glandiformis (c)

The shelly area at the eastern end of the beach extends in a series of bars towards the low water mark. Several common invertebrates are associated with the shell

Amphidesma australe (c)
Zediloma subrostrata (o)
Amaurochiton glaucus (c)
Notoacmea helmsi (c)
Anthopleura aureoradiata (c)

In firm sandy areas

Macomona liliana (a)
Chione stutchburyi (c)
Amphidesma australe (o)
Mactra ovata (o)
Cominella glandiformis (c)
Cominella maculosa (x)
Glycera sp. (c)
Marphysa sp. (c)
spionid polychaetes (a)
Callianassa filholi (c)
Lysiosquilla spinosa (o)

Towards low water there is a clean sandy area with dense beds of young Chione, particularly towards the western end of the Beach. Outside the Chione beds there is clean fine sand.

Macomona liliana (c)
Mactra ovata (o)
Cominella glandiformis (c)
Cominella adspersa (o)
Baryspira novaezelandiae crystallina (c)
Callianassa filholi (c)
Urechis sp. (o)

13.3.C Sandstone Reefs

Because of foreshore reclamation in this area natural sandstone reefs are now exposed only in lower intertidal areas, outside the basalt retaining wall of Tamaki Drive, except for the small area at Bastion Point. Most of the fauna and algae listed for the basalt wall of Okahu Bay are also found on the sandstone areas, although the soft nature of the rock surface inhibits sedentary organisms.

The soft rock is bored into by a number of animals including Sphaeroma quoyana near the high water mark and the pholad Anchomasa similis in mid tidal regions. There are extensive sandstone shelves at low tide level on some of the reefs. These are covered by algae, mainly Corallina officinalis and in the winter by the pale brown Colpomenia sinuosa and Scytosiphon lomentaria. The anenomes Isactinia olivacea and Anthopleura aureoradiata are common amongst the algae.

Accumulations of broken rock on the reef fringes support the same fauna as is found on the basalt walls, and a similar band of brown algae is found near the low water mark.

13.4 Fish

Numbers of recreational fishermen fish along the Tamaki Drive by casting out beyond the rock retaining walls on to the sandy bottom. Species most often taken are schnapper and kahawai. Large numbers of fishermen also use the jetty off the point at the eastern end of Okahu Bay and children use this area and the bridges over the channels entering Hobson Bay. Other fish often caught include koheru, yellow-eyed mullet and paketi.

The teeth marks of feeding parore are often seen in areas where there is a mat of fine algae on the rock surface.

The sandstone reefs and basalt walls of this region support a rich and healthy fauna and flora which are of considerable food value to fish populations. The rich fauna of the soft shores of Okahu Bay is also valuable.

13.5 Birds

Birds are not generally abundant along the waterfront. Occasional red-billed gulls feed along the bases of the basalt walls at low water and there are small aggregations of this species and black-backed gulls on the sandy flats of Okahu Bay. Pied shags are often seen in the sheltered waters of Okahu Bay.

13.6 Edible Invertebrates

Rock oysters occur in a solid band along the basalt retaining walls in this area. These are frequently taken in small numbers and often eaten on the spot.

The green mussel, Perna canaliculus occurs in small numbers near low water on the rocky shores and wharf piles. This species is also taken in small numbers.

The shellfish most utilised in this area are Chione stutchburyi and Amphidesma australe from the soft flats of Okahu Bay. Populations in this area have been taken for food for a considerable period by local Maoris, but present exploitation rates are not affecting the beds unduly. Recruitment of these two shellfish appears normal in this area.

Mactra ovata also occurs in small numbers in Okahu Bay. This species is probably only taken when found accidentally in the course of searching for the above species.

13.7 Natural Ecological Changes

There are few natural changes occurring in this area. A slow build-up of typical fauna and flora is to be expected on the basalt facing new reclamations or forming breakwaters at Mechanics Bay. There is also some movement of soft sediments in Okahu Bay, notably the shell banks at the eastern end of the beach.

13.8 Ecological Interference by Man

Significant changes have been wrought by man in the nature of this foreshore and intertidal area. Foremost among these has been the formation of near vertical intertidal regions where previously there were gently shelving shores with occasional outcrops of sandstone. This transition has imposed a certain uniformity on the shoreline both in terms of the ecology and aesthetics of the region.

The building of retaining walls from hard basalt has provided a substrate suitable for colonisation by a large number of animals and plants that would otherwise not have been found in this area. At the same time, large areas of natural shoreline with communities not now abundant in the area, have been destroyed.

13.9 Pollution

Water-borne material is deposited in large quantities amongst the boulders of the waterfront retaining wall in this area. Rubbish includes glass, wood, plastics and rubber.

Localised sewage pollution occurs in the vicinity of the stormwater drain at the base of the Eastern tide deflector near Mechanics Bay. At times raw sewage can be seen flowing from this pipe, particularly after heavy rain. Light oil slicks often extend from the pipe for considerable distances into the Harbour.

The effect of this discharge is only detectable in the close proximity of the end of the pipe where common flora and fauna are reduced and there is a layer of soft oily organic material on the rock. There is a possibility that bottom sediments may be adversely affected by the discharge.

13.10 Ecological Value

This area has considerable ecological value because of the large biomass of organisms on the hard shores and also on the soft shore of Okahu Bay. Such communities of intertidal organisms are important to the Harbour ecosystem because of their interactions with fish populations, and potential effects in improving water quality.

13.11 Improvement and Protection of Ecological Assets

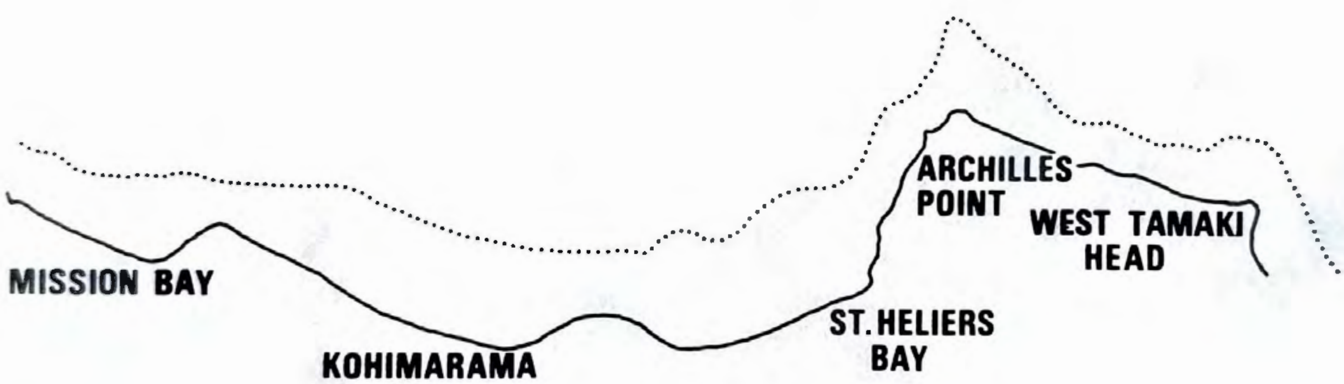
The fauna and flora of this area are in a normal and healthy state. Little improvement can be made at the present time, although the removal of water-borne rubbish from the rock walls would make the area appear cleaner.

The discharge of sewage overflows through the stormwater drain at Mechanics Bay should be prevented.

13.12 Potential Use of Ecological Assets

The present levels of shore fishing and shellfish gathering in this area are unlikely to change. The healthy state of intertidal ecology of this area is of considerable importance to the region as part of its aesthetic attraction.

AREA 14



MISSION BAY TO TAMAKI HEAD

AREA 14. MISSION BAY TO TAMAKI HEAD

14.1 General Description

This stretch of coast is one of the most populated and popular on the southern side of the Harbour. Residential suburbs cover the higher land overlooking the water and the Tamaki Drive passes along the waterfront as far as St Heliers. There are foreshore reserves at Bastion Point, Mission Bay and Archilles Point.

The foreshore and intertidal areas have been considerably altered between St Heliers Bay and Bastion Point by the reclamations and retaining wall for Tamaki Drive, and the retaining walls outside the reserve at Mission Bay.

The three white sand and shell beaches at Mission Bay, Kohimarama and St Heliers are extremely popular for swimming and sunbathing in summer. Small yachting clubs are based at Kohimarama and St Heliers. The cliffed headlands between the three beaches add to the attraction of this region. To the east of St Heliers rise the cliffs of Archilles Point. These sandstone cliffs are prominent from a wide area of the Harbour and extend to the eastern boundary of this area at Tamaki Head. Pohutukawa trees on the foreshore at the base of these cliffs make this an attractive area.

14.2 Intertidal Substrates

A variety of intertidal substrates is found in this area. Outside the cliffed headlands between the three beaches and along the shore to the east of St Heliers are a series of sandstone reefs and rock outcrops. In some areas these are gently shelving, near horizontal rock surfaces; in others the rock is eroded to a vertical fragmented face. Boulders and broken rock are abundant.

The soft shores of Mission Bay, Kohimarama and St Heliers have shelly substrates on a sloping beach and a low tidal flat of sand (Mission Bay and Kohimarama) or shelly sand (St Heliers). There are also areas of soft substrate to the east of St Heliers, at Ladies Bay and further to the east. Accumulations of boulders in this area are also common.

14.3 Intertidal Flora and Invertebrate Fauna

14.3.A Hard Shores - The hard shores of this area are similar in the flora and fauna they support. Local variation is caused by differences in aspect, (slope of the rock) siltation and the amount of boulder cover.

The following descriptions are for the natural sandstone shore. The fauna and flora of basalt retaining walls in this area are similar to those described in Area 13.

14.3.A1 High tide level - About and above high spring tide level the sandstone cliffs may be either bare, where they are eroding rapidly, or they may support a limited growth of small encrusting blue-green algae. Such growth is rarely prominent enough to impart a recognisable coloured band to the rock as is common on shaded cliffs on the northern side of the Harbour.

In winter the green alga Enteromorpha sp. is common at high levels, particularly where there is fresh water seepage. In regions with harder rock, and particularly near small pools, Melarapha oliveri occurs in small numbers about high water neap.

Accumulations of boulders at the foot of the cliff to the east of St Heliers protect

Cyclograpsus lavauxi (c)
Ligia sp. (c)
isopod (o)

14.3.A2 Upper Intertidal (down to mid-tide neap)

The most conspicuous animal of the upper interdal region on the sandstone shores is the boring isopod Sphaeroma quoyana. Constant erosion of the soft surface reduces the abundance of microscopic algae which provide the food for grazing gastropods and these animals are scarce.

alga	Gelidum caulacantheum (patchy)
fauna	Melagraphia aethiops (o) Sypharochiton pelliserpentis (o) Lunella smaragda (o)

Beneath boulders at this level

Hemigrapsus edwardsi (o)
Hemigrapsus crenulatus (o)
Petrolisthes elongatus (c)
Notoacmea daedala (c)
Zediloma subrostrata (o)
flatworms (c)
Elminius modestus (o)
spionid polychaetes (c)

In more exposed areas, such as Glendowie Reef to the east of Ladies Bay, where the rock surface is more stable, the following occur:

algae

Splachnidium rugosum
Leathesia difformis

fauna

Elminius modestus (c)
Chamaesipho columna (c)
Elminius plicatus (o)
Cellana ornata (o)
Modiolus neozelanicus (o)
Pomatoceros caeruleus (c)

14.3.A3 Mid-tide level to low water neap

Sandstone substrate in this zone is generally more stable than that higher on the shore; the surface appears harder and is less prone to crumbling and erosion. There is still a reduction in the density of common fauna and flora compared with harder rock at a similar level.

algae

Laurencia spp
Corallina officinalis
Hormosira banksii
Scytosiphom lomentaria (winter)
Colpomenia sinuosa (winter)

fauna

Lepsiella scobina (o)
Haustrum haustorium (c)
Cominella virgata (o)
Cominella maculosa (o)
Crassostrea glomerata (o)
Onchidella nigricans (o)
Pomatoceros caeruleus (o)
Elminius modestus (c)
Anthopleura aureoradiata (c)

Towards low water mark there is a dense covering of turfing algae on horizontal surfaces. In the vertical faces from mid tide to low water are found the conspicuous holes of the rock-boring pholad bivalves:

Anchomasa similis (a)
Pholadidea spathulata (c)
Pholadidea tridens (r)
Zelithophaga truncata (c)

A number of animals live in pholad holes

Notirus reflexus (o)
Notopaphia elegans (c)
Ryenella impacta (o)
Diplodonta globa (o)
Anthopleura aureoradiata (c)
Isactinia olivacea (c)
Watersipora cucullata (a)

Amongst the mat of algae on horizontal low tidal surfaces

Lunella smaragda (a)
Sypharochiton pelliserpentis (c)
Haminoea zelandica (o)
Paratrophon stangeri (c)
Cominella virgata (c)
Cominella maculosa (c)
Neothais scalaris (o)
Perna canaliculus (o)
Isactinia olivacea (a)
Anthopleura aureoradiata (c)
Isocladus armatus (c)
terebellid polychaetes (a)
Sabellaria kaiparensis (r)
Lepidonotus sp. (c)
Patiriella regularis (o)
Microcosmus kura (c)

Beneath boulders on the lower shore

Amaurochiton glaucus (c)
Ischnochiton maorianus (c)
Terenochiton inquinatus (c)
Buccinulum heteromorphum (o)
Taron dubius (o)
Micrelenchus huttoni (r)
Sigapatella novaezelandiae (c)
Maoricrypta monoxyla (o)
Anomia walteri (c)
Ostrea sp. (c)
Flabelligera affinis (c)
Lepidonotus sp. (c)
spionid polychaetes (c)
Corella eumyota (o)
Coscinasterias calamaria (o)
Beania sp. (o)

At low water spring there is a band of large brown algae

Ecklonia rediata
Sargassum sinclairii
Carpophyllum maschalocarpum

Fauna at this level is similar to that described for Area 13.

14.3.B Soft Shores - The soft shores at Mission Bay, Kohimarama and St Heliers have a sloping beach of shell and coarse sand in the upper intertidal and a flat shelving area in the lower intertidal.

At Mission Bay and Kohimarama the sloping beach extends to low water neap and the sandy flats beyond are exposed only on spring tides. Accumulations of drift algae are removed, along with other debris, by beach cleaners, and the fauna of this zone is reduced.

The sloping part of the beach is well drained and supports very few animals. At the foot of the slope, however, there is a low density band of Amphidesma australe.

The sandy flats below low water neap support

Mactra ovata (c)
Dosinea subrosea (c)
Myadora striata (o)
Macomona liliana (c)
Struthiolaria papulosa (r)
Cominella adspersa (o)
Baryspira australis (o)
Arachnoides zelandiae (o)
Branchiomma sp. (c)
Owenia fusiformis (o)
Callianassa filholi (o)
Lysiosquilla spinosa (o)

The flat, low tidal region at St Heliers Bay occurs at a slightly higher level than that at Mission Bay and Kohimarama. Major differences are found in the abundance of dead shell at St Heliers and extensive beds of Chione stutchburyi.

Common fauna includes:

Chione stutchburyi (c)
Amphidesma australe (o)
Macomona liliana (a)
Nucula hartvigiana (o)
Zeacumantus lutulentus (c)
Zediloma subrostrata (c)
Notoacmea helmsi (c)
Cominella glandiformis (c)
Cominella adspersa (c)
Elminius modestus (c) (on shell)

14.4 Fish

A small amount of shore fishing occurs in this area and many small boats are launched from the beaches for fishing trips immediately offshore. Most common Harbour fish are caught in the area.

The soft flats of this region are probably important as feeding grounds for demersal species such as schnapper. Rich low tidal areas of hard shores are probably important to smaller fish such as paketi, parore and yellow-eyed mullet. The offshore reefs are of considerable value in providing rocky reef habitats in the midst of an extensive soft bottom area. Concentrations of fish are usually found in such areas.

14.5 Birds

Whereas the full populations on these popular beaches is probably increased by the presence of large numbers of people the wading birds are generally absent. Pied stilts occur in small numbers in the unfrequented stretch between Ladies Bay and Tamaki Head, and small flocks of oyster catchers feed in this area and occasionally on the rocky reefs near the populated beaches.

Pied shags are generally common in the Harbour in this area.

14.6 Edible Shellfish

Apart from the band of oysters on basalt walls, edible shellfish are not common on the hard shores of this area. Low tidal *Lunella smaragda* reach an edible size but are not often taken. A few mussels are taken from the low tidal areas of sandstone reefs but these are not abundant or particularly large. Rock oysters are reduced in density on the soft sandstones but are often taken in small quantities.

From the soft shores several species are taken.

Amphidesma australe - Few people seem aware of the presence of the populations near the foot of the sloping beaches of this area. Because of the low density of large individuals, however, it is unlikely that *Amphidesma* populations would form an important source of food.

Chione stutchburyi - Populations attain a mean adult size of about 32 mm at St Heliers. These are often exploited. It appears that there has been a marked reduction in the abundance of Chione on St Heliers beach but there is no obvious cause. Recruitment at low tidal levels has occurred in the past two years.

Mactra ovata - Easily located in the clean sand flats near low water spring at Mission Bay and Kohimarama, this species is sought by Maoris and Islanders. Mean adult length is about 70 mm.

Dosinea subrosea - Taken by Maoris and Islanders who detect the presence of this deep burrowing bivalve by siphonal marks on the surface of the sand. Common at Mission Bay and Kohimarama.

Macomona liliana - Taken by Maoris and Islanders from low tidal falts at Mission Bay and Kohimarama where it reaches a particularly large size - up to 50 mm length.

It is unlikely that the utilisation of shellfish for food will change much in this area. Most of the above species are only found in fairly low densities and require some skill to locate. Chione populations at St Heliers appear to be fluctuating and may well increase.

14.7 Natural Ecological Changes

There are no significant natural changes to be expected in the ecology of this area.

14.8 Ecological Interference by Man

The natural shoreline between Mission Bay and St Heliers has been considerably altered by reclamation and the construction of retaining walls. This action has had little impact outside the reclaimed areas and the fauna and flora on the basalt walls are normal and healthy.

On the remaining natural shores of this area there is little indication of any ecological interference.

14.9 Pollution

The most significant pollution of this area is by water-borne rubbish including organic waste, paper, plastic, wood and glass. Accumulations of this material in low tidal areas are having a small adverse ecological impact, particularly in soft sediment areas where plastics and paper become partly buried in the substrate.

14.10 Ecological Value

Because of the soft nature of the rock in this area the densities of many hard shore animals are not high and there is a corresponding reduction in the total number of species. The soft shores of Mission Bay and Kohimarama have a low biomass and low species diversity largely because of the physical form of the boulder-strewn area between St Heliers and Tamaki Head. Of particular value are the low tidal reefs which provide habitats for the larger brown algae which in turn promote the growth of many sessile invertebrates and afford protection to populations of small fish. The offshore reefs are of particular importance in this respect.

14.11 Improvement and Protection of Ecological Assets

Minor improvements could be made to the ecological condition of this area by removing waste material from the low tidal areas.

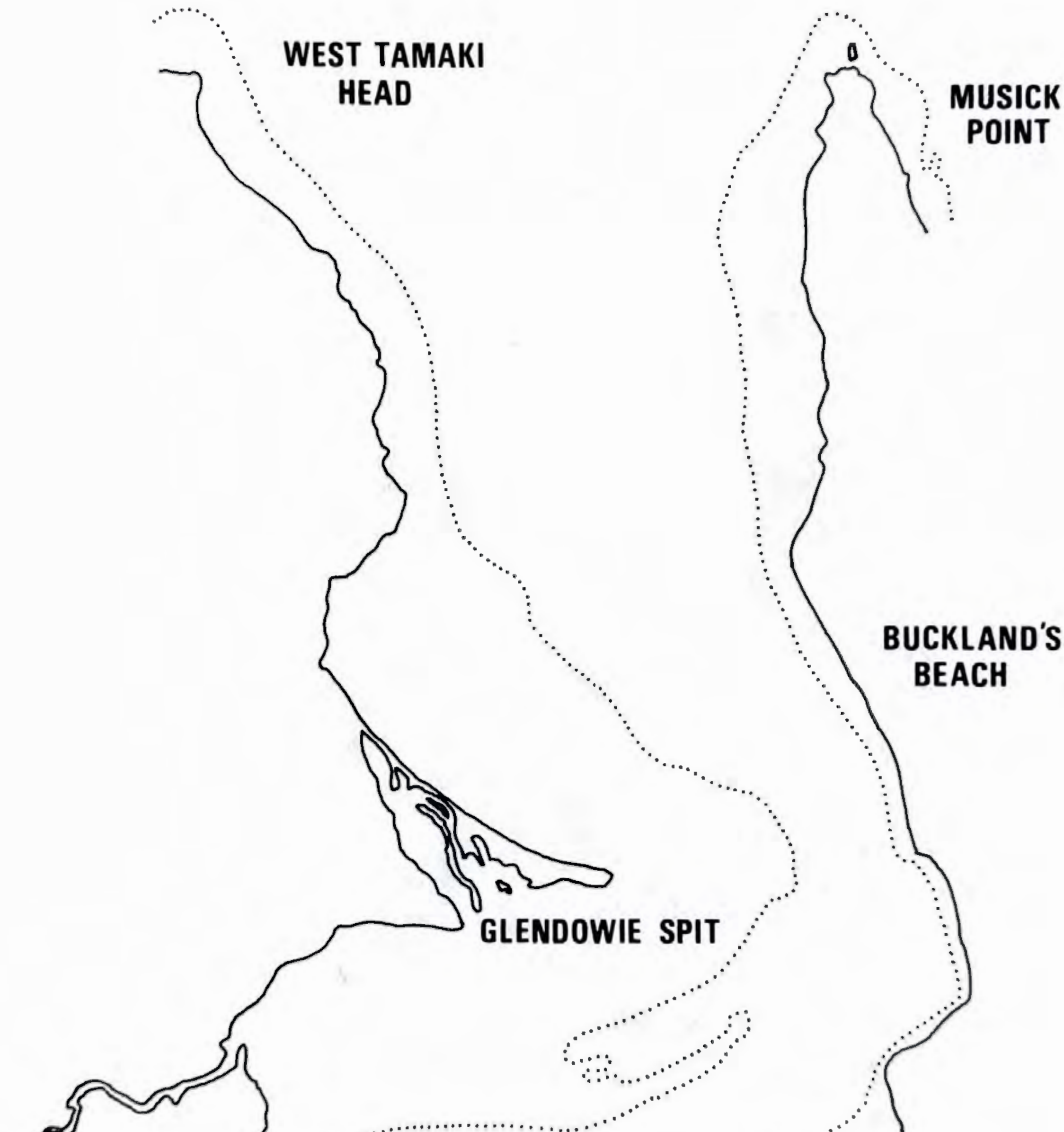
The best protection will be given by keeping the intertidal area clean and preventing the release of waste material into the water in other areas.

14.12 Potential Use of Ecological Assets

Direct use of ecological assets by fishing and shellfish gathering will probably continue on much the same scale as at present.

The ecological condition of this area is also important in terms of the considerable recreational use of the area. Healthy ecological conditions will enhance the recreational use.

AREA 15



ENTRANCE TO THE TAMAKI ESTUARY

AREA 15 ENTRANCE TO THE TAMAKI ESTUARY

This ecologically variable area will be discussed in four parts:

A. Musick Point

B. Bucklands Beach

C. The Glendowie Spit

D. Glendowie Spit to West Tamaki Head

15.A. Musick Point

15.A.1 General Description

The prominent headland of Musick Point extends northwards from Bucklands Beach on the western side and Eastern Beach on the eastern side. Sandstone cliffs rise more than 200 feet from the shore, and the white rock faces are conspicuous from a wide area of the Waitemata Harbour and Tamaki Estuary. Pohutukawas and lesser vegetation fringe the cliff top and also grow on the less steep areas of the face.

The land on top of the headland is mainly in grass, being a golf course in the southern part and a reserve towards the tip.

15.A.2 Intertidal Substrates

There is generally some accumulation of shell and sand about the high water mark at the base of the cliffs, and also areas of boulders eroded from the steep faces. A wave-cut platform of sandstone occupies the upper part of the intertidal as far as low water neap, and there is a sand flat outside the rock platform between low water neap and low water spring. At the Point the rock platform extends over the whole tidal range and prominent rock outcrops extend offshore.

15.A.3 Intertidal Flora and Invertebrate Fauna

High water level - Above high water neap the sandstone cliff face is soft and there is little growth of blue-green algae and *Enteromorpha* species except in some areas where freshwater seepage occurs. Below high water neap shaded areas support a rich growth of *Gelidium caulacantheum*, and there are small numbers of *Melarapha oliveri* and *Modiolus neozelanicus* in crevices.

Mid tidal level - In the upper part of this region the rock borings of Sphaeroma quoyana are conspicuous. Barnacles are scarce on the soft rock with only occasional specimens of Elminius plicatus being present.

Towards mid tide level there are small pools and crevices in the sandstone platform with several common gastropods

Melagraphia aethiops (c)
Sypharochiton pelliserpentis (c)
Nerita melanotragus (o)
Lunella smaragda (o)
Lepsiella scobina (o)
Zediloma subrostrata (c)
Zeacumantus lutulentus (c) (sandy areas)

Beneath stones

Amaurochiton glaucus (c)
Notoacmea helmsi (c)
Lepidonotus sp. (c)
Hemigrapsus crenulatus (o)
Petrolisthes elongatus (c)

In pools

Anthopleura aureoradiata (c)
Isactinia olivacea (c)

Towards the outer edge of the platform the rock surface is apparently harder and there are increasing numbers of Elminius modestus, and algae.

Corallina officinalis
Hormosira banksii

fauna

Crassostrea glomerata (o)
Lunella smaragda (c)
Zeacumantus subcarinatus (c)
Cominella virgata (o)
Cominella maculosa (c)
Neothais scalaris (o)
Lepsiella scobina (c)
Buccinulum heteromorphum (c)
Pomatoceros caeruleus (o)
Eulalia microphylla (o)

The pholads Anchomasa similis and Zelithophaga truncata bore into the rock near low water neap. Small mussels, Perna canaliculus also occur at this level.

Low water neap to low water spring - At this level there is an extensive flat of firm clean sand. Fauna is similar to that described for low tidal flats in Area 15.C.

15.A.4 Fish

Forsterygion nigripenne is common under boulders near low water neap.

Little is known concerning the use of this area by fish populations, but large numbers of fish pass through this region when entering or leaving the Tamaki Estuary. The rocks on the end of Musick Point are popular sites for line fishing.

15.A.5 Birds

Small numbers of red-billed and black-backed gulls feed in this area. The occasional Blue Reef Heron is seen, and Pied shags, white-fronted terns and occasional Caspian terns feed offshore.

15.A.6 Edible Invertebrates

Small numbers of mussels, Perna canaliculus and sea urchins, Evechinus chloroticus, occur on the low tidal reefs, but are not often taken.

There are insufficient rock oysters to support constant exploitation.

15.A.7 Natural Ecological Changes

There are no predictable natural ecological changes expected in this area.

15.A.8 Ecological Interference by Man

Man has had little ecological impact on this area.

15.A.9 Pollution

Small quantities of water-borne material are deposited on the shore in this area but at present are having little adverse ecological impact.

15.A.10 Ecological Value

The ecology of this area is natural and healthy. Densities of mid tidal invertebrates are reduced by the soft nature of the rock which prevents adhesion by sedentary species such as oysters and barnacles but the low tidal platforms support a rich fauna and flora.

15.A.11 Improvement and Protection of Ecological Assets

The ecology of this region requires no improvement. Continued protection will be afforded by maintaining the foreshore in a natural state.

15.A.12 Potential Use of Ecological Assets

At present the only direct use of the ecological assets of this area are by fishing from the shore in the vicinity of Musick Point, and small scale gathering of shellfish for food. These uses are unlikely to change, and no further direct use can be foreseen.

15.B. Bucklands Beach

15.B.1 General Description

Bucklands Beach is evenly graded from high water spring to about low water neap, with small flat areas exposed at low water spring at the northern and southern ends of the Beach. Surrounding land is residential and a road runs right along the foreshore. Retaining walls have been built in some places.

15.B.2 Intertidal Substrates

The sloping part of the beach has a well drained substrate of coarse sand and shell, with accumulations of shell about the high water mark. Below low water neap flats of sandy substrate are exposed in some areas with occasional patches of small boulders in the sandy mud. A sandstone reef divides the beach into two parts, and more sandstone is exposed at the northern and southern ends.

15.B.3 Intertidal Flora and Invertebrate Fauna

Soft substrates - Amphipods are found in small numbers beneath the drift weed which sometimes collects at the high water mark.

Between high water neap and mid tide level there are very few macrofauna because of the harsh conditions of coarse, mobile, well drained sediments.

About mid tide level are found

Cominella glandiformis (r)
Diplodonta sp. (o)
Nucula hartvigiana (r)
Chione stutchburyi (r)
Amphidesma australe (o)

From mid tide level to low water neap there is an increase in density of Amphidesma australe with an extremely dense band with densities above 1,500 per square metre about low water neap.

Low water neap

Cominella glandiformis (c)
Cominella adspersa (c)
Cominella maculosa (o)
Diplodonta sp. (c)
Chione stutchburyi (r)
Nucula hartvigiana (o)
Halicarcinus sp. (o)
Hemigrapsus crenulatus (o)

In sandy areas below low water neap there are beds of Chione stutchburyi and Amphidesma australe.

Hard shores - Sandstone outcrops at both ends, and in the middle of the Beach support a flora and fauna similar to that described for Musick Point. (Area 15.A)

15.B.4 Fish

Little is known of the utilisation of this area by fish populations. The dense shellfish beds provide a potential food source for demersal feeding species such as schnapper.

15.B.5 Birds

Small numbers of red-billed and black-backed gulls are the only common birds in this area.

15.B.6 Edible Invertebrates

Considerable quantities of the bivalve shellfish Amphidesma australe and Chione stutchburyi are taken from this area for human consumption.

At present the dense beds on the sloping beach contain predominantly small and young individuals, and the area most exploited for edible sized shellfish is towards the northern end of the beach on the flats between low water neap and low water spring. With continued growth of the Amphidesma populations on the sloping beach it is expected that these will soon be exploited also.

15.B.7 Natural Ecological Changes

There are no natural ecological changes to be expected in this area, although it is apparent that the density of edible shellfish will fluctuate.

15.B.8 Ecological Interference by Man

Changes in this area include the construction of retaining walls along parts of the beach, and a boatyard and slipway on the sandstone reef in the middle of the Beach. The ecological impact of these changes has been slight.

15.B.9 Pollution

The most obvious pollution of this area is by water-borne rubbish which is largely deposited near high water mark. This is not a serious problem and has no ecological impact.

15.B.10 Ecological Value

The dense beds of bivalves have some ecological value in terms of their ability to filter and purify large volumes of water. These shellfish are also of potential importance as food for fish populations.

15.B.11 Improvement and Protection of Ecological Assets

At present the ecology of Bucklands Beach is in a natural and healthy state. Protection can be given by keeping the road margins and foreshore clean.

15.B.12 Potential Use of Ecological Assets

At present there is considerable exploitation of shellfish in this region. This direct use of ecological asset will continue and perhaps increase. There is little other direct use made of the ecological assets.

15.C Glendowie Spit

15.C.1 General Description

The Glendowie Spit extends eastwards from the west side of the Tamaki Estuary. Intertidal flats cover a large area on both sides of the low lying central spine of accumulated shell, and stretch to an apex opposite the central part of Bucklands Beach. Part of the basal area of the spit is above high water level, being formed of shell bars with areas of sedge and rough scrub, and is part of the Glen Innes Domain. Inshore there are mature trees where the land starts to rise towards the residential areas, while a grassed reserve extends along the foreshore to the north. Foreshores in the protruding part of the spit are natural with a beach of sand and shell along the northern side, and indented high tidal inlets with sedge along the high tide mark on the southern side. Near the basal part of the spit there is a stone retaining wall facing the foreshore reserve.

15.C.2 Intertidal Substrates

On the northern side of the spit substrates consist of clean sands with accumulations of dead bivalve shell in some areas. The intertidal region slopes gradually from high water neap to low water spring. Outside the above tidal portion of the Glen Innes Reserve there is a shell bar extending towards Bucklands Beach. Substrates to the south of the main shell bar are generally shelly with clean sand areas towards low water. Towards the base of the spit on the southern side there are low outcrops of soft semi-consolidated sandstone with patches of soft mud, accumulations of bivalve shells, and clean sand areas.

The high tidal inlets of the spit itself have substrates varying from soft muds in the mangrove marshes to firm sands and accumulations of shell.

15.C.3 Intertidal Flora and Invertebrate Fauna

The fauna of several representative areas is described.

Mudstone, sand and shell areas on southern side of spit

Zeacumantus subcarinatus (c)
Zeacumantus lutulentus (c)

Zediloma subrostrata (c)
Notoacmea helmsi (c)
Cominella glandiformis (c)
Chione stutchburyi (c)
Macomona liliana (c)
Nucula hartvigiana (a)
Helice crassa (c)
Hemiplax hirtipes (o)
Hemigrapsus crenulatus (c)
Alpheus sp. (o)
Elminius modestus (o)
spionid polychaetes (a)
Anthopleura aureoradiata (c)

Shell patches, southern side

Notoacmea helmsi (a)
Zediloma subrostrata (c)
Amaurochiton glaucus (c)
Cominella maculosa (c)
Micrelenchus huttoni (o)
Anthopleura aureoradiata (a)
Elminius modestus (c)

Clean sand, towards low water, southern side

Callianassa filholi (c)
Lysiosquilla spinosa (o)
Baryspira australis (c)
Solemya parkinsoni (r)
Mactra ovata (r)
Macomona liliana (c)
Cominella adspersa (o)
Cominella glandiformis (c)
Marphysa sp. (c)
Pectinaria australis (o)
Notomastus zeylanicus (c)
Balanoglossus australiensis (c)

Towards the end of the intertidal spit opposite Bucklands Beach, the effects of strong tidal currents on the substrate are noticeable. There is a predominance of coarse sand and shell. Extensive beds of Chione stutchburyi occur on the southern side of the tip, with beds of Amphidesma australe at the tip and to the north about low water spring. The starfish, Coscinasterias calamaria, feeds on low tidal Amphidesma populations.

On the north side of the spit there are extensive sand flats at a high level which support large numbers of small polychaetes and amphipods. Towards mid tide level dense beds of Chione stutchburyi occur and extend to low water neap. Also found in this region are:

Macomona liliana (a)
Nucula hartvigiana (c)
Mactra ovata (o)
Zediloma subrostrata (o)
Zeacumantus lutulentus (c)
Notoacmea helmsi (c)
Amaurochiton glaucus (o)
Cominella glandiformis (c)
Xymene plebejus (o)
spionid polychaetes (a)
Aglaophamus macroura (o)
Owenia fusiformis (o)
Elminius modestus (c)
Hemigrapsus crenulatus (o)

Low tidal clean sand contains

Chione stutchburyi (r)
Macomona liliana (c)
Soletellina nitida (o)
Baryspira australis (o)
Haminoea zelandica (o)
Cominella adspersa (o)
Owenia fusiformis (o)
Notomastus zeylanicus (a)
Pectinaria australis (o)
eunicid polychaete (c)
Callianassa filholi (c)
Lysiosquilla spinosa (c)

High level inlets on southern side of spit - The high level inlets of this region are fringed with sedge bands and shell bars which support a variety of typical salt marsh and shell bar vegetation.

Leptocarpus simplex
Juncus maritimus var *australiensis*
Salicornia australis
Selliera radicans

fauna

Ophicardelus costellaris (c)
Helice crassa (c)

Open sand flats

Amphibola crenata (c)
Helice crassa (c)

Mangrove marsh

Amphibola crenata (a)
Helice crassa (a)

The mangrove in this area is limited in size by the high intertidal level of the substrate. Attached fauna of roots, trunks and pneumatophores is absent.

15.C.4 Fish

The low tidal flats of this region provide a valuable source of invertebrate food for fishes. The results of feeding activity can be seen after almost every tide in the low tidal, polychaete-rich sands. Shellfish beds also provide important food.

15.C.5 Birds

The combination of rich intertidal flats for feeding, and above tidal secluded shell bars for roosting makes this an area of considerable value to bird populations. Common birds utilising this area include red-billed gull, black-backed gull, kingfisher, pied stilt, pied oystercatcher, white-faced heron, banded dotterel, and godwit. Small numbers of migratory species are occasionally present.

15.C.6 Edible Invertebrates

Four species of edible shellfish are found in this area. Macomona liliana does not reach an edible size and is not sought, and Mactra ovata occurs only in localised areas in small densities. Beds of Chione stutchburyi are widespread, and edible sized individuals are taken from low tidal beds near the end of the spit and along the northern side.

The most sought shellfish in this region is the pipi, Amphidesma australe. Dense beds occur in the coarse low tidal sands at the end of the spit and these are exploited by large numbers of people. Access is gained by walking or riding horses from the western side of the estuary, or by boat from Bucklands Beach. High exploitation levels appear to have depleted the beds near the end of the spit, but it is probable that these will regenerate with successful spatfalls.

Locals claim that the beds of Chione have also become reduced in extent. There is no apparent reason for this, and there is a possibility that beds of edible sized Chione will become more extensive in future.

15.C.7 Natural Ecological Changes

There are no predictable natural ecological changes occurring in this region at present.

15.C.8 Ecological Interference by Man

Some depletion of edible shellfish beds can be attributed to exploitation by Man. In the case of Chione stutchburyi, however, the abundance of dead shell in low tidal regions indicated a mass mortality of this species. The cause of such mortality is not known.

The construction of retaining walls along the foreshore near the basal art of the spit has had little apparent impact on intertidal ecology.

15.C.9 Pollution

There is no evident pollution of this area.

15.C.10 Ecological Value

This area has considerable ecological value to bird populations, particularly some of thosespecies which are intolerant of the close proximity of urban activity. The naturally rich intertidal region provides a wealth of invertebrate food organisms, and the shell banks and vegetated region of the Glen Innes Domain provide high tidal roosting grounds.

The rich soft shore fauna of this region is important in terms of providing food for fish populations, and because of its potential interaction within the Waitemata Harbour ecosystem. Extensive low tidal clean sand flats such as those of this area are not common in the Waitemata.

15.C.11 Improvement and Protection of Ecological Assets

The intertidal ecology of this region is natural and healthy and requires no improvement. Protection will be given by maintaining the present natural foreshores.

15.C.12 Potential Use of Ecological Assets

Direct use of the ecological assets of this area is made by the gathering of shellfish for food, and fishing for edible fish species attracted to the area. These uses are unlikely to change, although the degree of exploitation of shellfish beds will vary with the natural variations in abundance of edible shellfish.

15.D. Glendowie Spit to West Tamaki Head

15.D.1 General Description

The land rises steeply from the shore in this area with sandstone cliffs and steep vegetated banks. Pohutukawa is conspicuous in the foreshore strip. Surrounding land is residential.

15.D.2 Intertidal Substrates

Substrates in the southern part of this area consist of muddy sand between reefs of sandstone. At high tide level there are accumulations of sand and shell at the base of the cliff with aggregations of boulders in some places. At Karaka Bay there is a built up beach of shell and sand with a low tidal flat of clean sand. To the north of Karaka Bay a boulder extends to West Tamaki Head.

15.D.3 Intertidal Flora and Invertebrate Fauna

Sandstone reefs and out crops:

High level - At the base of the cliff above high water neap there are bands of small blue-green algae. At high water neap the borings of *Sphaeroma quoyana* are conspciuous and extend over a wide zone towards mid tide level.

About mid tide level are found

algae	*Gelidium sp.* *Scytothamnus australis*
fauna	*Melagraphia aethiops* (c) *Lunella smaragda* (o) *Sypharochiton pelliserpentis* (c) *Lepsiella scobina* (o) *Haustrum haustorium* (o) *Crassostrea glomerata* (o) *Pomatoceros caerulus* (c) *Elminius modestus* (o) *Anthopleura aureoradiata* (c) *Isactinia olivacea* (o)

Towards low tide level

algae	*Leathesia difformis* *Corallina officinalis* *Hormosira banksii* *Codium adhaerens*

fauna	Cominella virgata (o) Cominella maculosa (c) Neothais scalaris (o) Dendrodoris citrina (o) Perna canaliculus (o) Cleidothaerus maorianus (o) Ryenella impacta (o) Anchomasa similis (c) Zelithophaga truncata (c) Pholadidea spathulata (o) Notopaphia elegans (c) Coscinasterias calamaria (c) Patiriella regularis (o)
Beneath ledges	Anomia walteri (c) Ostrea sp. (a) Microcosmus kura (c) Beania sp. (c) Actinothoe albocincta (o)

About low water spring the brown alga Sargassum sinclairii is common on hard substrates.

Boulders towards West Tamaki Head

High tide level	Cyclograpsus lavauxi (c) Ligia sp. (a) isopod (o)
Towards mid tide	Hemigrapsus edwardsi (c) Petrolisthes elongatus (a) Heterozius rotundifrons (c) Melagraphia aethiops (o) Notoacmea helmsi (c) Cominella virgata (o) Cominella maculosa (o) Lunella smaragda (o) Amaurochiton glaucus (c) Lepsiella scobina (o) Elminius modestus (o)

Soft shores - The fauna of the soft shores in this area is similar to that described for the Glendowie Spit. (Area 15.C)

15.D.4 Fish

Little is known of the fish in this area. Rich invertebrate faunas of both hard and soft intertidal areas are potentially important as food sources for fish.

15.D.5 Birds

Small numbers of several common shore feeding birds are found in this area. These include red-billed bulls, black-backed gulls, pied stilts, pied oystercatchers, and kingfishers. Blue Reef herons occasionally feed on the sandstone outcrops. Pied Shags often feed immediately offshore, and fish feeding white-fronted terns and Caspian tern are also present.

15.D.6 Edible Invertebrates

On the hard shores of this area there are small quantities of mussels, Perna canaliculus, and oysters Crassostrea glomerata. These may be taken in small quantities for food.

The soft shore of Karaka Bay supports a dense bed of Chione stutchburyi which is exploited by locals.

15.D.7 Natural Ecological Changes

There are no predictable natural ecological changes occurring in this area.

15.D.8 Ecological Interference by Man

Man has had little impact on the intertidal ecology of this region. The construction of boatsheds beneath the cliffs near the high water mark has resulted in the contribution of waste material to the tidal zone but this is having little ecological impact.

15.D.9 Pollution

There is little apparent pollution in this region. Water-borne material including glass, wood, and plastics is a minor problem particularly where such material is becoming entrapped in soft sediments. In some areas rubbish is being dumped on the foreshore and over cliffs into the tidal zone.

15.D.10 Ecological Value

The flora and fauna of this area are in a healthy and natural state. Low tidal regions of both hard and soft substrates support rich flora and fauna.

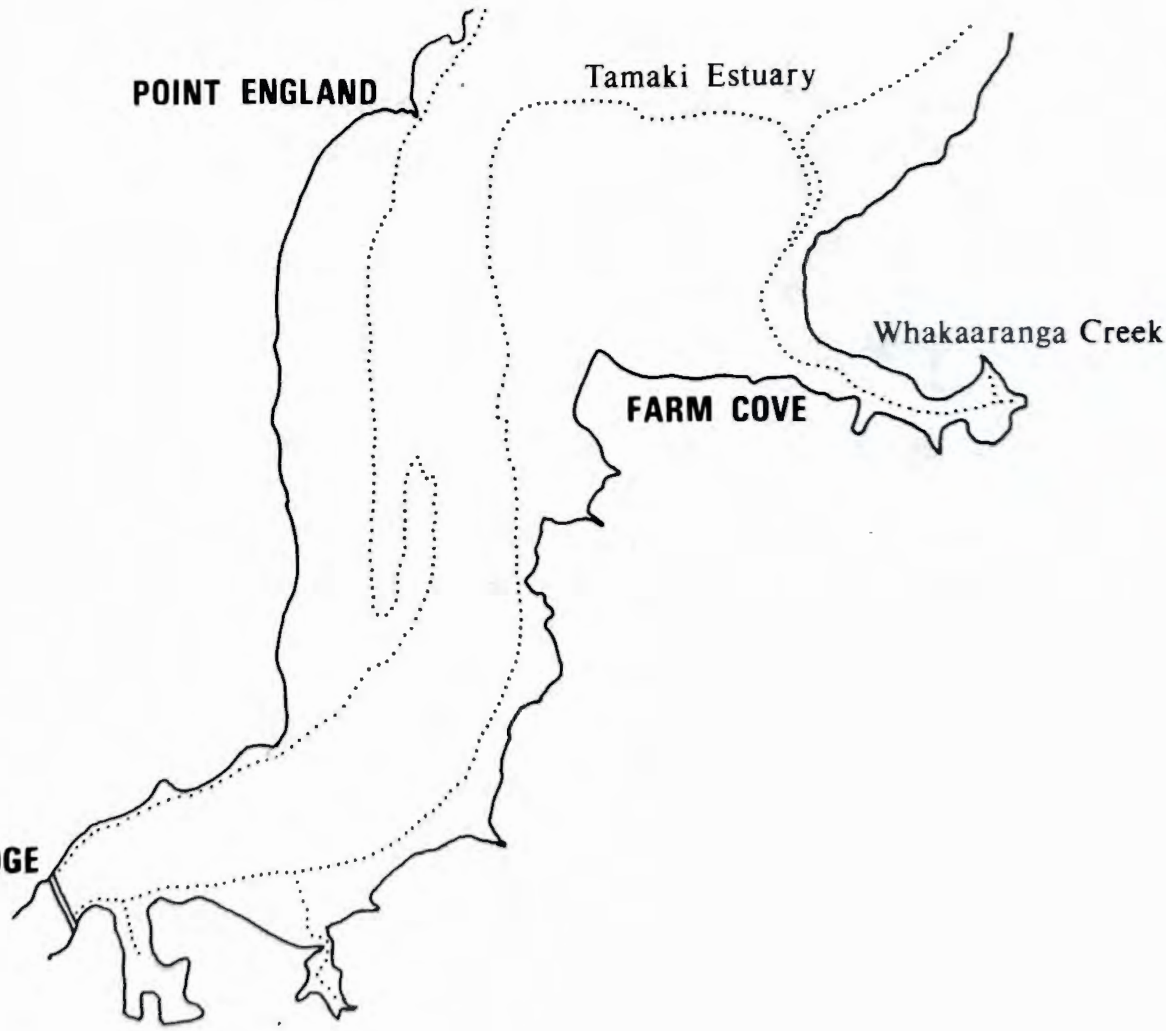
15.D.11 Improvement and Protection of Ecological Assets

The ecology of this area requires no improvement. Added protection will be given by maintaining the foreshore in a natural state and preventing the contribution of foreign material by rubbish dumping.

15.D.12 Potential Use of Ecological Assets

At present direct use is made of the ecological assets of this region by shellfish gathering and line fishing offshore. These uses are unlikely to change, and little further direct use of ecological assets can be foreseen.

AREA 16



FARM COVE TO PANMURE BRIDGE

AREA 16 FARM COVE TO PANMURE BRIDGE

This area will be described in three parts:

A. Farm Cove

B. Whakaaranga Creek

C. Point England to Panmure Bridge

16.A. Farm Cove

16.A.1 General Description

In this region there is a wide intertidal flat. Foreshores are generally sloping, with low cliff on the eastern side of the Cove fringed with Pohutukawas and smaller native trees. On the southern shore the land is being progressively developed by subdivision for residential purposes. There are still areas of farmland immediately south of the Cove and along the eastern side. Foreshores in the developed area at the head of the Cove have been modified by reclamation with stone retaining walls.

16.A.2 Intertidal Substrates

There is very little hard substrate in this area. Small outcroppings of soft sandstone occur at high intertidal levels on the eastern side of the Cove, and there are patches of semi-consolidated sandstone with embedded tree remains at the head of the Cove.

The vast majority of the intertidal area has soft substrates varying from accumulations of shells, bivalve shells, to soft muds. There is very little sloping beach, the intertidal being gently graded from high water neap to low water spring. On the high tidal flats substrates are generally firm and sandy with accumulations of shell in some areas. Mid-tidal flats are also firm with surface shell and banks of shell in the area towards Point England. Towards low water the substrates become progressively softer and at low spring tide level they are quite muddy.

16.A.3 Intertidal Flora and Invertebrate Fauna

Hard shores - About the high water mark there is a zone of blue-green algae, particularly well developed in damp areas. In winter the green alga *Enteromorpha sp.* forms a conspicuous band on hard surfaces about high water mark.

On the few outcrops of intertidal rock:

Zeacumantus lutulentus (c)
Zediloma subrostrata (c)
Melagraphia aethiops (r)
Crassostrea glomerata (o)
Onchidella nigricans (r)
Elminius modestus (o)

Soft shores

High tidal sand flats	*Chione stutchburyi* (a)
	Nucula hartvigiana (c)
	Macomona liliana (c)
	Cominella glandiformis (c)

In mid-tidal areas the above animals are present, along with:

	Zeacumantus lutulentus (c)
in shelly areas	*Zediloma subrostrata* (c)
	Lunella smaragda (o)
	Micrelenchus huttoni (o)
	Xymene plebejus (o)
	Notoacmea helmsi (c)
	Amphidesma australe (o)
	Phoronis ovalis (c)
	Hemigrapsus crenulatus (c)
	Halicarcinus cooki o)
Low tidal areas	*Lysiosquilla spinosa* (c)
	Halicarcinus cooki (o)
	Owenia fusiformis (c)
	Pectinaria australis (c)
	Trochodota dendyi (c)
	Mactra ovata (r)
soft areas	*Hemiplax hirtipes* (c)

Chione stutchburyi is absent from the low tidal regions although it appears that beds of this species were once more extensive than they are at present. Banks of dead shell testify to the past abundance of *Mactra ovata* but live specimens are now rare.

16.A.4 Fish

Large numbers of juvenile flatfish are often seen in drainage channels from this area on the falling tide. The small crustacea and polychaetes of the intertidal area provide a rich food source for these fish.

Excavations made by larger fish in search of invertebrate food are often seen in the softer low tidal areas.

16.A.5 Birds

This extensive area of variable substrate is one of the most valuable feeding grounds for shore birds in the Waitemata Harbour. Together with the nearby Glendowie Spit, this region supports large populations of several species, the most common being pied stilt, pied oyster-catcher, white-faced heron, red-billed gull, black-backed gull and godwit. Fish feeders often seen in the area are Caspian tern and pied shag.

Several further species of migratory birds utilise this area in summer. These are discussed in the report on birds.

16.A.6 Edible Invertebrates

Two common shellfish occur in this area. Chione stutchburyi is widespread but few populations reach an edible size. It is only near low water that Chione reaches a length greater than 30 mm and it appears that there has been a considerable mortality of adult Chione in low tidal regions with the result that there are now only small numbers of edible animals. There is a possibility, however, that successful spatfall in low tidal areas will result in the formation of dense beds of edible sized Chione. If this occurred, exploitation by the human population would increase.

Amphidesma australe of edible size is only found in small beds near shell accumulations. Few people seem aware of the presence of this species and it is not taken for food from this area.

16.A.7 Natural Ecological Changes

There have been considerable ecological changes in this area. It appears that Zostera was once widespread but it is now entirely absent, (See Report on Ecological Changes). With the disappearance of the Zostera several species of shellfish have virtually disappeared. These include

Mactra ovata
Alcithoe arabica
Struthiolaria vermis
Micrelenchus huttoni

Widespread mortality of previously healthy Chione beds may also be a consequence of the disappearance of Zostera, although it appears that there has been considerable alteration of the nature of low tidal sediments by the deposition of fine muddy material over the top of clean sand.

There are no apparent natural changes occurring at present, although the buildup of soft low tidal sediments may well be continuing.

16.A.8 Ecological Interference by Man

It is difficult to determine to what extent the alteration of sediment nature in low tidal regions is the result of the contribution of fine material to the Tamaki River during development of the watershed. Evidence further up the River suggests that sedimentation has occurred at a rapid rate in sheltered areas and it appears that the buildup of sediment in this area has been at a rate which is well in excess of what could be considered 'natural'. Further sedimentation will result in the mortality of present invertebrate populations and their replacement by Hemiplax hirtipes and Alpheus sp. which are common in low tidal areas further up the River.

16.A.9 Pollution

There is little apparent pollution of this area. A source of some concern was a small sewage treatment plant at Farm Cove. This has been closed down.

16.A.10 Ecological Value

The extensive intertidal flats of this region are particularly valuable to bird populations and also to juvenile flatfish. It remains to be seen what effect the increase in human population of the surrounding area will have on the bird populations, but it is considered that in view of the considerable distance from the shore to the low tidal areas where the birds concentrate while feeding that interference by human activity will be slight.

16.A.11 Improvement and Protection of Ecological Assets

The most serious ecological change occurring in this region is as a result of the deposition of fine sediments. Improvement will only be achieved by reducing the contribution of silts and clays to tidal regions throughout the Tamaki River.

Care is required during the development phase of the soft foreshore of this area - particularly that to the immediate south of the Cove - to prevent the undue release of clay and mud into the tidal region.

16.A.12 Potential Use of Ecological Assets

Little direct use of ecological assets of this area can be expected unless there is a reversal of the present trend in reduction of edible shellfish populations.

As part of a residential environment, however, a natural and healthy intertidal area has considerable importance.

16.B. Whakaaranga Creek

16.B.1 General Description

This small tidal creek enters the south-eastern corner of Farm Cove. The entrance is partially blocked by a shell bar and mangrove marsh and most of the intertidal area is at a high level with only a narrow channel remaining at low tide.

Foreshores are generally fairly steep banks, although the southern side has been graded for residential development. The area around the head of the Creek is still farmland while on the northern side there is a patch of bush on the south facing slope. Most of the surrounding land is to be developed for residential purposes in the near future.

16.B.2 Intertidal Substrates

At the mouth of the Creek a shell barrier extends from the northern shore. This bar is now fairly stable and supports mangrove marsh on its flanks. Inside the shell barrier there are areas of mangrove on both sides of the low tidal channel with soft mud substrate amongst the trees and firmer areas of open sandy mud near the banks. Towards the head of the Creek, the mangrove is reduced and there are open sandy areas with sedge marsh near the shoreline.

A few small outcrops of soft sandstone occur near the southern side.

16.B.3 Intertidal Flora and Invertebrate Fauna

Mangrove areas - The mangrove marsh near the entrance to the Creek is healthy and supports a normal fauna and flora.

Helice crassa (a)
Alpheus sp. (o) (low water)
Amphibola crenata (c)
Potamopyrgus antipodum (a)
spionid polychaetes (a)

In the sedge band along the shoreline and in the Upper creek

Ophicardelus costellaris (c)
Potamopyrgus antipodum (a)
Helice crassa (o)

Open flats

Amphibola crenata (c)
Helice crassa (c)

16.B.4 Fish

Little is known of the utilisation of this area by fish populations. The most likely species to be found are juvenile flatfish, yellow-eyed mullet, and *Acentrogobius lentiginosus*.

16.B.5 Birds

Common birds feeding in this area include pied stilt, white-faced heron, kingfisher, pukeko, and mallard duck. Caspian terns occasionally feed in the channel area, and pied shags may also feed in the region at high tide.

16.B.6 Edible Invertebrates

There are no edible invertebrates in this region.

16.B.7 Natural Ecological Changes

Under natural conditions a slow buildup of intertidal substrate level by the deposition of fine sediments is to be expected. In the Whakaaranga Creek this process will result in the gradual spread of the salt marsh communities, and eventually the death of high level mangrove.

16.B.8 Ecological Interference by Man

A foreshore strip along the southern side of the creek inside the entrance has been reclaimed and faced with basalt rock. During this process some of the remaining intertidal area has been disturbed and quantities of fine sediment released into the tidal area.

The contribution of fine sedimentary material to the tidal zone during development of the small basin in which the Creek is situated, is a threat to the ecological 'health' of this naturally sensitive area.

16.B.9 Pollution

There is no obvious pollution of this area at present.

16.B.10 Ecological Value

In its natural state this creek has some ecological value in providing a range of habitats that is not otherwise available in the lower part of the Tamaki River. Natural organic detritus produced in an area such as this is of considerable value to deposit and detritus feeding invertebrates on flats outside the area, and also of value to juvenile fish populations.

As part of a residential environment this creek in a natural ecological condition could be of considerable value.

16.B.11 Improvement and Protection of Ecological Assets

Protection of an area such as this is best provided by careful development procedure to minimise interference with the tidal region, and the retention of as great an area of natural foreshore as possible.

16.B.12 Potential Use of Ecological Assets

Indirect use of ecological assets as part of a residential environment is of considerable importance in this area. This use will be best served by maintaining the area in a natural condition.

16.C. Point England to Panmure Bridge

16.C.1 General Description

To the south of Farm Cove on the east side of the Tamaki, and to the south of Point England on the west side, there are wide intertidal areas of soft substrate, with soft sandstone exposed in the constricted part of the River near the Panmure Bridge.

Foreshores on the eastern side generally consist of low sandstone cliffs and steep banks with occasional shelly beaches. Near the Panmure bridge there are two shallow inlets with a higher cliffed area facing the River. Retaining walls are common in places.

On the western side foreshores are generally low with a retaining wall of loose rock. Towards the Panmure Bridge there are areas of cliff.

The land surrounding this area of the Tamaki River is largely developed for residential purposes although there are large areas of open grass in the foreshore reserve on the western side, with farmland immediately south of Farm Cove, and the Selwyn College grounds on the eastern side.

16.C.2 Intertidal Substrates

There are occasional outcrops of soft sandstone on the points in this region, the most prominent being at Point England, and also in the narrow part of the River near the Panmure Bridge. Horizontal surfaces are generally heavily silted and the exposed rock surface is usually soft and eroding.

Soft shores are generally soft and muddy in places. High tidal beaches are not formed, although there are often accumulations of shell at lower levels on the shore. Generally areas above mid tide are fairly sandy and firm while towards low water they become progressively softer. There are patches of soft peaty material exposed intertidally on the eastern side of the River, particularly in the region towards Farm Cove. Mangrove marsh and soft muds occur in the small inlet near the Panmure Bridge.

16.C.3 Intertidal Flora and Invertebrate Fauna

The flora and fauna are described for a number of habitats found in this region.

High tidal boulders (beneath eroding cliffs)

Sphaeroma quoyana (a)
Cyclograpsus lavauxi (c)
Ligia sp. (c)
Talorchestia sp. (c)

Open rock face - About high water mark there is a band of blue-green algae which is well developed in the damp areas near the Panmure Bridge. Green Enteromorpha sp. occurs in a band about high water level in the winter.

Upper shore - alga: Gelidium caulacantheum

fauna:
Nerita melanotragus (r)
Zeacumantus subcarinatus (c)
Onchidella nigricans (a)
Zediloma subrostrata (o)

Mid tide

Crassostrea glomerata (o)
Lunella smaragda (o)
Notoacmea helmsi (c)
Lepsiella scobina (o)
Elminius modestus (o)
Isactinia olivacea (c)
Eulalia microphylla (o)

Beneath mid-tidal boulders

Amaurochiton glaucus (c)
Hemigrapsus crenulatus (c)
Elminius modestus (c)

Firm sand flats - Firm sand flats are generally limited to the upper intertidal level near Farm Cove and being further reduced towards the Panmure Bridge.

Chione stutchburyi (a)
Macomona liliana (a)
Nucula hartvigiana (a)
Amphidesma australe (o)
Notoacmea helmsi (c)
Cominella glandiformis (c)
Anthopleura aureoradiata (c)
Elminius modestus (c)

Soft sandy mud of mid-tidal areas

Chione stutchburyi (c)
Nucula hartvigiana (c)
Macomona liliana (c)
Cominella glandiformis (c)

Cominella adspersa (o)
Notoacmea helmsi (c)
Helice crassa (o)
Hemigrapsus crenulatus (c)
spionid polychaetes (a)
Elminius modestus (c)
Anthopleura aureoradiata (a)

Soft low tidal muds - In patches towards Farm Cove, widespread near Panmure Bridge

Hemiplax hirtipes (c)
Alpheus sp. (a)
Helice crassa (c)
spionid polychaetes (a)

16.C.4 Fish

Excavations by bottom feeding fish are often widespread in soft low tidal sediments where the main food organisms are polychaetes and bivalve molluscs. Soft bottom organisms are also important to flatfish.

16.C.5 Birds

Most of the common shore feeding birds are found in small numbers in this area. These include pied stilt, godwits, black-backed gull, red-billed gull, and white faced heron. Kingfishers are common near the Panmure Bridge where there is an abundance of crabs in the intertidal area.

Of the fish feeding species pied shags are generally common, with occasional flocks of little black shags. White-fronted tern and Caspian tern also feed in this area.

16.C.6 Edible Invertebrates

Although Chione stutchburyi is found throughout this area it does not reach an edible size. Only in small patches near the low water mark towards Farm Cove does the mean adult size exceed 25 mm.

Small populations of Amphidesma australe are found in shelly areas but only small numbers reach edible size. It is unlikely that these are exploited.

Crassostrea glomerata are found in high densities on isolated patches of basalt spawls dumped in the intertidal. Oysters are taken from these areas.

16.C.7 Natural Ecological Changes

Zostera may well have spread over much of this area but is now entirely absent. There appears to have been a steady accumulation of soft sediments in some areas with a slow disappearance of sandy substrate communities.

Erosion of the soft foreshore is having a minor ecological impact in the upper intertidal in places where sandy sediments are being covered with clay.

16.C.8 Ecological Interference by Man

Retaining walls have been built along much of the foreshore of this area, but have had little impact on the ecology of the intertidal region.

The contribution of fine sediments to the tidal areas is a problem throughout the Tamaki Estuary, and in this area has resulted in considerable sediment deposition, particularly near low tide level in sheltered situations.

16.C.9 Pollution

The most obvious pollution of this area is caused by the dumping of rubbish into the tidal region. Shores are littered with large quantities of plastic, wood, paper and glass.

Two boatsheds near the end of Tamaki Road have dilapidated ramps with wood and other debris spread on the surrounding mud.

16.C.10 Ecological Value

This area is in a healthy ecological 'condition', although biomass and faunal diversity are being reduced by the deposition of fine sediments. Bird and fish life is normal, although the numbers of birds and fish may well be reduced as a result of changes in the invertebrate populations.

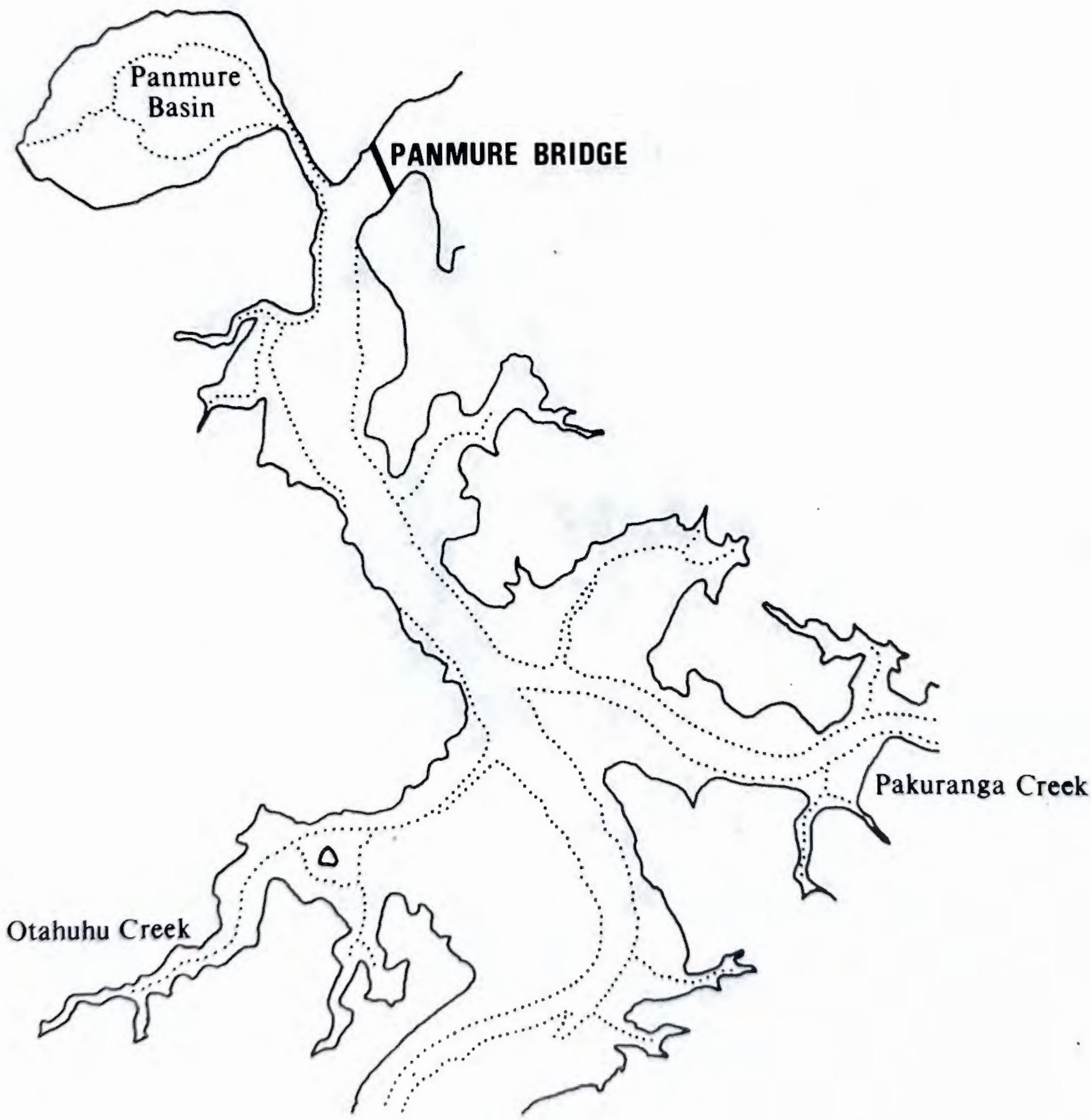
16.C.11 Improvement and Protection of Ecological Assets

Significant improvements could be made to the intertidal environment by preventing the contribution of inorganic silts and clays to the tidal region. The stabilisation of foreshore is also important in this respect.

16.C.12 Potential Use of Ecological Assets

There is little direct use of the ecological assets of this area at present apart from a small amount of recreational fishing. This situation is unlikely to change, although a minor educational use might be made of shores near populated areas.

AREA 17



PANMURE BASIN, OTAHUHU CREEK AND TAMAKI ESTUARY

AREA 17 PANMURE BASIN, OTAHUHU CREEK, AND TAMAKI ESTUARY

The ecology of this region is discussed in three parts:

A. The Panmure Basin

B. The Otahuhu Creek

C. Tamaki Estuary

17.A. The Panmure Basin

17.A.1 General Description

At low tide the water all but leaves the Basin, remaining only in a small area adjacent to the entrance channel.

Foreshores generally consist of low banks of soft sedimentary rock but on the eastern side basalt blocks face a reclamation for Lagoon Drive. The foreshore strip is grassed.

Surrounding land is mainly residential with many houses overlooking the Basin.

17.A.2 Intertidal Substrates

Most of the area has a substrate of deep soft mud. There are small firm areas near high water mark around the perimeter and a built-up beach in the eastern corner. Localised outcrops of soft sandstone occur in the upper intertidal and over the whole tidal range of the entrance channel. A basalt wall faces the Lagoon Drive side of the Basin.

17.A.3 Intertidal Flora and Invertebrate Fauna

Soft muds - Substrates of soft mud are uniform over most of the Basin.

Alpheus sp. (a)
Helice crassa (a)
Hemiplax hirtipes (o)

Firm areas near the beach in the eastern corner

Chione stutchburyi (c)
Amphidesma australe (o)
Macomona liliana (c)
Nucula hartvigiana (o)
Zeacumantus lutulentus (o)
Anthopleura aureoradiata (o)
Elminius modestus (o)

Hard substrate - On the basalt wall bordering Lagoon Drive and to a lesser extent on the natural soft sandstone outcrops a number of typical hard shore species are found.

Crassostrea glomerata (o)
Lepsiella scobina (o)
Onchidella nigricans (a)
Modiolus fluviatilus (o)
Elminius modestus (c)

17.A.4 Fish

Nothing is known of the fish utilising this area.

17.A.5 Birds

Considerable numbers of red-billed gulls and pied stilts feed in this area. Small numbers of white-faced herons and black-backed gulls also occur. Banded dotterels occasionally feed on the shelly area near the eastern end of the Basin. Pied shags and Caspian terns are common fish feeders at high water.

17.A.6 Edible Invertebrates

Localised populations of Chione stutchburyi and Amphidesma australe occur in the firm sand region at the eastern end of the Basin but these shellfish do not reach edible size.

Rock oysters, Crassostrea glomerata occur in small numbers on the basalt retaining wall bordering Lagoon Drive. These are taken for food in small quantities.

17.A.7 Natural Ecological Changes

Natural ecological changes in a shallow sheltered area such as the Panmure Basin will be a gradual change in substrate nature and slow rise in substrate level caused by the deposition of fine sediments derived from land runoff. There is a possibility of mangroves becoming established unless they are actively removed.

Over a considerable period it appears that widespread beds of Chione stutchburyi along with other firm substrate fauna have been destroyed by sediment deposition in this area. Further changes in the fauna will not be great as most of the substrate is now very soft and muddy. Minor changes will be associated with the increase in intertidal level due to sediment deposition.

17.A.8 Ecological Interference by Man

The alteration of the foreshore on the eastern side of the Basin has had no serious ecological impact.

Sediment deposition, although a natural process, appears to have been increased by the contribution of fine soils and clays to the tidal region during development in the watershed.

17.A.9 Pollution

There is no apparent serious pollution of this area at present, although the beach at the eastern end is often untidy with litter.

17.A.10 Ecological Value

This area has a large surface area for the exchange of gases between tidal waters and the atmosphere which is potentially important in maintaining water quality.

The Basin also functions as a natural sediment trap and prevents water-borne sediments from passing to areas further down the Tamaki Estuary.

A rich crustacean fauna is important to bird populations for food, and may also be important to fish populations.

17.A.11 Improvement and Protection of Ecological Assets

Areas of fine soft sediment are prone to pollution through incorporation of organic material into the sediment where decomposition leads to the formation of anaerobic environments close to the substrate surface. At present there is no sign of deterioration but every precaution should be taken to limit the input of organic material.

17.A.12 Potential Use of Ecological Assets

There is only minor direct use of the ecological assets of this area at present. Indirect uses include sailing, swimming, boating and water skiing which require high standards of water quality.

17.B. The Otahuhu Creek

17.B.1 General Description

The Otahuhu Creek is a shallow inlet on the western side of the Tamaki River. At low water large areas of gently shelving soft mudflat are exposed on both sides of the narrow low tidal channel.

Foreshores generally consist of steep low banks of soft sandstone or clay. There is an area of natural larva flow on the northern side at the entrance to the creek with local modifications by reclamation and facing with stone. On the southern side of the creek entrance there is a large reclamation faced with broken concrete and stone.

Surrounding land is almost flat and largely residential apart from an area on the south side which is used for market gardening, and the reclamation near the southern entrance. Foreshore reserves are in grass, and there is rough scrub on some steep areas of foreshore.

17.B.2 Intertidal Substrates

In the outer part of the creek there are extensive soft mud flats in the middle and lower intertidal region, with fringing mangrove. Mangrove is more extensive towards the head of the creek where substrates are also soft.

In the northern entrance area there is some naturally occurring lava in the upper intertidal, along with placed rock of retaining walls.

17.B.3 Intertidal Flora and Invertebrate Fauna

High tidal fringe - About the high water mark there is often a band of sedges.

Juncus maritimus var australiensis
Leptocarpus simplex

fauna

Ophicardelus costellaris (c)
Potamopyrgus antipodum (o)
Helice crassa (c)

Mangrove marsh - Mangrove marshes are extensive. Trunks and pneumatophores support a variety of small algae and plants along with:

Crassostrea glomerata (o)
Onchidella nigricans (c)
Elminius modestus (c)

In soft sediments — Helice crassa (a)
Alpheus sp. (o)
Amphibola crenata (a)

Open mud flats

High levels	Helice crassa (a) Amphibola crenata (c)
Low levels	Helice crassa (o) Alpheus sp. (a) Hemiplax hirtipes (a)

Natural larva flows - Natural lava occurs only in the upper intertidal region, near the northern entrance to the creek.

	Salicornia australis Caloglossa leprieurii
fauna	Crassostrea glomerata (o) Ophicardelus costellaris (c) Onchidella nigricans (a) Elminius modestus (c)

17.B.4 Fish

Nothing is known concerning the utilisation of this area by fish.

17.B.5 Birds

Common shore feeding birds occur in small numbers. Pied stilts, white-faced heron, black-backed gull, red-billed gull, and kingfisher are regularly present. Pied shags feed in the area at high tide.

17.B.6 Edible Invertebrates

Although there are a few rock oysters on the lava flow and retaining walls these do not appear to be taken for food. No other edible invertebrates are found in the region.

17.B.7 Natural Ecological Changes

Natural ecological changes to be expected in this area are a slow accumulation of fine sediments resulting in an increase in level of intertidal substrates and a resultant spread of mangrove marshes. This process is occurring at present and mangroves in some areas are spreading rapidly.

17.B.8 Ecological Interference by Man

Minor foreshore reclamations and the large reclamation at the southern entrance to the creek appear to have had no major impact on the ecology of the remaining tidal area.

Sedimentation rates appear to be high, probably as a result of the added contribution of sedimentary material to the tidal region during development in the watershed.

17.B.9 Pollution

The dumping of rubbish on foreshore reserves or into the tidal region is a common practice of local residents in this area. The soft mud environment is particularly sensitive to the addition of organic wastes, and the collective impact of many small pollutant contributions will be a deterioration of the present healthy ecological condition.

The retaining wall around the new reclamation on the southern side of the creek entrance is partularly untidy with a conglomeration of broken rock, concrete and power poles.

17.B.10 Ecological Value

The ecological value of this area lies in its function of retaining fine land derived sediments, providing a large surface area for the exchange of gases between water and the atmosphere, providing natural organic detritus from the mangrove marshes for detritus feeders in other parts of the Waitemata ecosystem, and possessing a natural and healthy fauna which is a food source for fish and birds.

17.B.11 Improvement and Protection of Ecological Assets

The best means of improving and protecting the ecology of this area is by cleaning up the foreshores and preventing the dumping of pollutant material in or near the tidal region.

17.B.12 Potential Use of Ecological Assets

There is little direct use of the ecological assets of this area at present, although a small amount of net-fishing for flatfish is practised. Little change can be foreseen in use of this area.

17.C. Middle Tamaki River

17.C.1. General Description

This area extends from the Panmure Bridge to the south side of the Otahuhu creek. The river channel is about 200 metres wide at low water with mudflats exposed along the indented shoreline.

Foreshores are generally fairly steep, apart from the low area to the north of the Otahuhu Creek. Banks of clay and soft sandstone are exposed in places with low cliffs near the Panmure Bridge. North of the Otahuhu Creek the foreshore consists of natural basalt lava with rock retaining walls in places. Foreshore vegetation varies from grass to mature exotic trees including pine and willow.

On the eastern side of the river surrounding land to the north of the Pakuranga Creek is residential, whereas that to the south is rural. On the western side there are residential areas north of Otahuhu Creek and near the Panmure Basin with a large industrial area in between.

17.C.2 Intertidal Substrates

A variety of intertidal substrates is exposed in this area. Most substrate consists of soft sediment, both along the banks of the river and in subsidiary inlets and bays. To the north of the Otahuhu Creek is an area of natural basalt lava and constructed retaining walls, while towards the constricted part of the river near the Panmure Bridge there are sandstone shores

17.C.3 Intertidal Flora and Invertebrate Fauna

Upper Intertidal - At high tide level there is often a band of sedges.

Leptocarpus simplex
Juncus maritimus var australiensis

fauna

Ophicardelus costellaris (c)
Potamopyrgus antipodum (o)
Helice crassa (c)

Mangrove marsh - Mangrove marsh is not widespread on the banks of the river but occupies large areas in indented inlets.

Helice crassa (a)
Amphibola crenata (a)
Crassostrea glomerata (o)
Alpheus sp. (o)
Elminius modestus (c)

Soft mid tidal and low tidal muds - Most of the intertidal area of this region is of this nature

Helice crassa (c)
Alpheus sp. (a)
Hemiplax hirtipes (c)

Areas with firmer substrate - Some high level regions near the Panmure Bridge have a relatively firm substrate

Zeacumantus lutulentus (c)
Chione stutchburyi (o)
Macomona liliana (c)
Cominella glandiformis (o)

Hard shores - Some areas of heavily silted sandstone are exposed intertidally near the Panmure Bridge and there is a stretch of hard basalt to the north of the Otahuhu Creek.

Crassostrea glomerata (c)
Onchidella nigricans (a)
Zeacumantus lutulentus (c)
Lepsiella scobina (r)
Sypharochiton pelliserpentis (o)
Anthopleura aureoradiata (c)
Elminius modestus (c)

17.C.4 Fish

Of the fish utilising this area, schnapper and kahawai, are often caught by line fisherman and flatfish - mainly yellow-bellied flounder - and parore are caught in nets.

The shallow intertidal flats of this area and the extensive Pakuranga Creek and Otahuhu Creek, are of considerable importance to populations of flatfish.

17.C.5 Birds

Red-billed gulls, black-backed gulls, pied stilts, white-faced herons, and kingfishers occur in small numbers. Fish feeding pied shag and Caspian tern are also found. In winter large flocks of little black shags feed in the area.

17.C.6 Edible Invertebrates

Small numbers of rock oysters are found in this area. These are not often taken for food. No other edible invertebrates are present.

17.C.7 Natural Ecological Changes

Natural ecological changes to be expected in this area are a slow increase in the level of intertidal substrates as a result of sediment deposition with a consequent spread of mangrove marsh, particularly in the sheltered bays and inlets.

17.C.8 Ecological Interference by Man

Foreshore reclamations have modified several parts of the shoreline in this area, particularly in the inlet on the eastern side of the river to the south of Panmure Bridge. For the most part the reclamations have had little apparent ecological impact outside the area reclaimed, but the reclamation for the approaches to the new bridge has resulted in considerable quantities of soft sediment being released into the tidal zone.

Increased sediment deposition rates due to the contribution of clays and silts to tidal waters during development of surrounding land is a widespread problem in this area, although the present fauna and flora is adapted to soft mud conditions and is unlikely to change significantly.

17.C.9 Pollution

The most noticeable pollution of this area is by the dumping of household and garden refuse on the foreshores and into tidal regions. Although these actions are having no serious ecological impact at present the cumulative effect of continued pollution of this nature will be increasingly detrimental.

17.C.10 Ecological Value

In a natural state this area has considerable ecological value in providing suitable protection and food for fish populations, particularly juvenile flatfish, in possessing extensive sheltered regions for the deposition of water-borne sediments, and thus preventing their being carried further down the river into the cleaner areas of the Harbour, and in possessing a healthy flora and fauna which provides food for fish and birds and natural detritial material for deposit and detritus feeders elsewhere in the Harbour.

17.C.11 Improvement and Protection of Ecological Assets

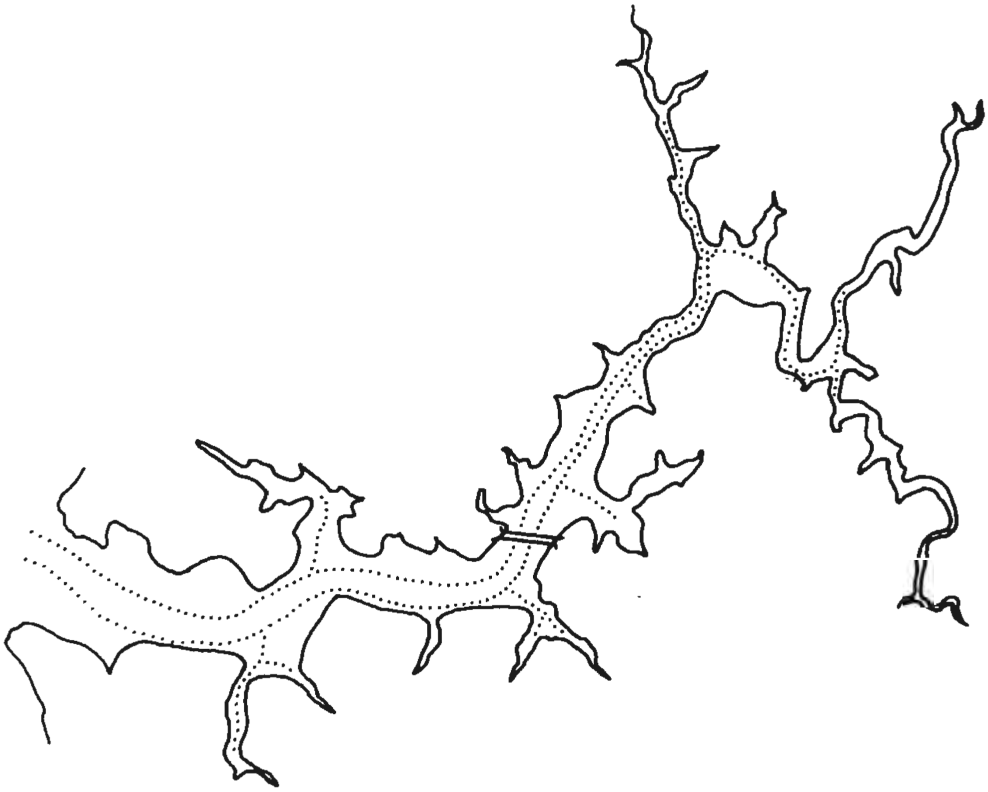
Improvement and protection of the ecological assets of this region will be best afforded by maintaining the foreshores in a clean and natural state.

17.C.12 Potential Use of Ecological Assets

At present fishing occurs on a small scale in this area.

It is unlikely that any further direct use of ecological assets will be made.

AREA 18



PAKURANGA CREEK

AREA 18 PAKURANGA CREEK

18.1 General Description

The Pakuranga Creek and its tributaries form an extremely indented inlet of the Tamaki River. The entire tidal area is shallow. At low water extensive mud flats and mangrove marshes are exposed on both sides of the narrow channel.

Surrounding land on the northern side of the Creek has been recently subdivided and developed for residential purposes, while that to the south remains largely as farmland. The country is gently rolling with the foreshore usually consisting of a steep bank between 20 and 30 feet in height. In some places low cliffed headlands with exposed faces of soft rock and clay project into the Creek, but around much of the shoreline the banks are covered with vegetation.

18.2 Intertidal Substrates

Intertidal substrates consist largely of soft sediments. Fine muds occur in sheltered areas, particularly in mangrove marshes, while there are some areas of firmer sandy substrate towards the low tidal channel, and near the mouth of the Creek.

Small outcrops of soft sandstone occur in some places, but these are usually heavily silted.

18.3 Intertidal Flora and Invertebrate Fauna

Around much of the shoreline, particularly in sheltered regions there is a well developed band of sedge above the high water mark.

flora	*Leptocarpus simplex* *Juncus maritimus* var *australiensis* *Stipa teretifolia* *Salicornia australis* *Samolus repens*
fauna	*Ophicardelus costellaris* (c) *Potamopyrgus antipodum* (a) *Amphibola crenata* (o) *Helice crassa* (c)

Mangrove marshes occupy large areas in the upper half of the inter-tidal zone. Pneumatophores, trunks and roots support a typical assemblage of blue-green algae and fauna while in the soft substrates are found:

	<u>Amphibola crenata</u> (a) <u>Helice crassa</u> (a) <u>Potamopyrgus antipodum</u> (c) (high tidal) <u>Zeacumantus lutulentus</u> (r)
Open low tidal mud flats	<u>Helice crassa</u> (c) <u>Alpheus sp.</u> (c) spionid polychaetes (c)
In firmer sand sediments	<u>Chione stutchburyi</u> (c) <u>Macomona liliana</u> (c) <u>Mactra ovata</u> (o) <u>Anthopleura aureoradiata</u> (o) <u>Elminius modestus</u> (o)

18.4 <u>Fish</u>

Little is known of the fish in this area. Populations of flatfish, parore, and yellow-eyed mullet are expected to be present, with occasional specimens of other Harbour species. This shallow protected region is probably important to juveniles of flatfish and other species.

18.5 <u>Birds</u>

Shore feeding birds are not common in this area. Small numbers of pied stilts, white-faced herons, and red-billed gulls are widespread. Pied shags are often seen in the water, and large numbers of kingfishers feed in mangrove marshes and other areas with crab populations.

18.6 <u>Edible Invertebrates</u>

The only invertebrate that reaches edible size in this area is the bivalve Mactra ovata. This animal is not common and is not taken for food.

18.7 <u>Natural Ecological Changes</u>

In a shallow and protected area such as this which receives freshwater land runoff, a degree of sediment deposition is to be expected. Sediment deposition would be most marked in mangrove marshes and sheltered low tidal areas. Ecological effects would be a slow spread of mangrove marsh as the substrate built up to a suitable level, and a corresponding increase in populations of <u>Helice crassa</u> and <u>Amphibola crenata</u> which are associated with mangroves.

18.8 Ecological Impact of Man

A rapid increase in the rate of accumulation of fine sediments in sheltered areas has apparently been a result of the contribution of considerable quantities of sediment to the tidal region during development of the surrounding land.

Sedimentation is still occurring at a rate in excess of what could be considered normal.

Modifications of the foreshore and small reclamations have had little obvious ecological impact.

18.9 Pollution

The most obvious pollution of this area is by the dumping of small quantities of household and garden refuse into the tidal region by local residents. The ecological impact of such pollution is minor at present, but the cumulative effects of many such pollutant acts lead to a deterioration of the sediment environment through the breakdown of organic materials and ferrous metals encouraging the formation of anaerobic conditions.

18.10 Ecological Value

The major importance of a shallow protected area such as the Pakuranga Creek to the Harbour Ecosystem is in its natural function in retaining material washed from the land and preventing this being carried further into the Harbour.

Wide shallow areas are also important because of their ability to improve water quality by providing large surface areas for the exchange of gases with the atmosphere.

Mangrove marshes are important in providing natural detrital material for detritus feeders in areas throughout the Harbour.

18.11 Improvement and Protection of Ecological Assets

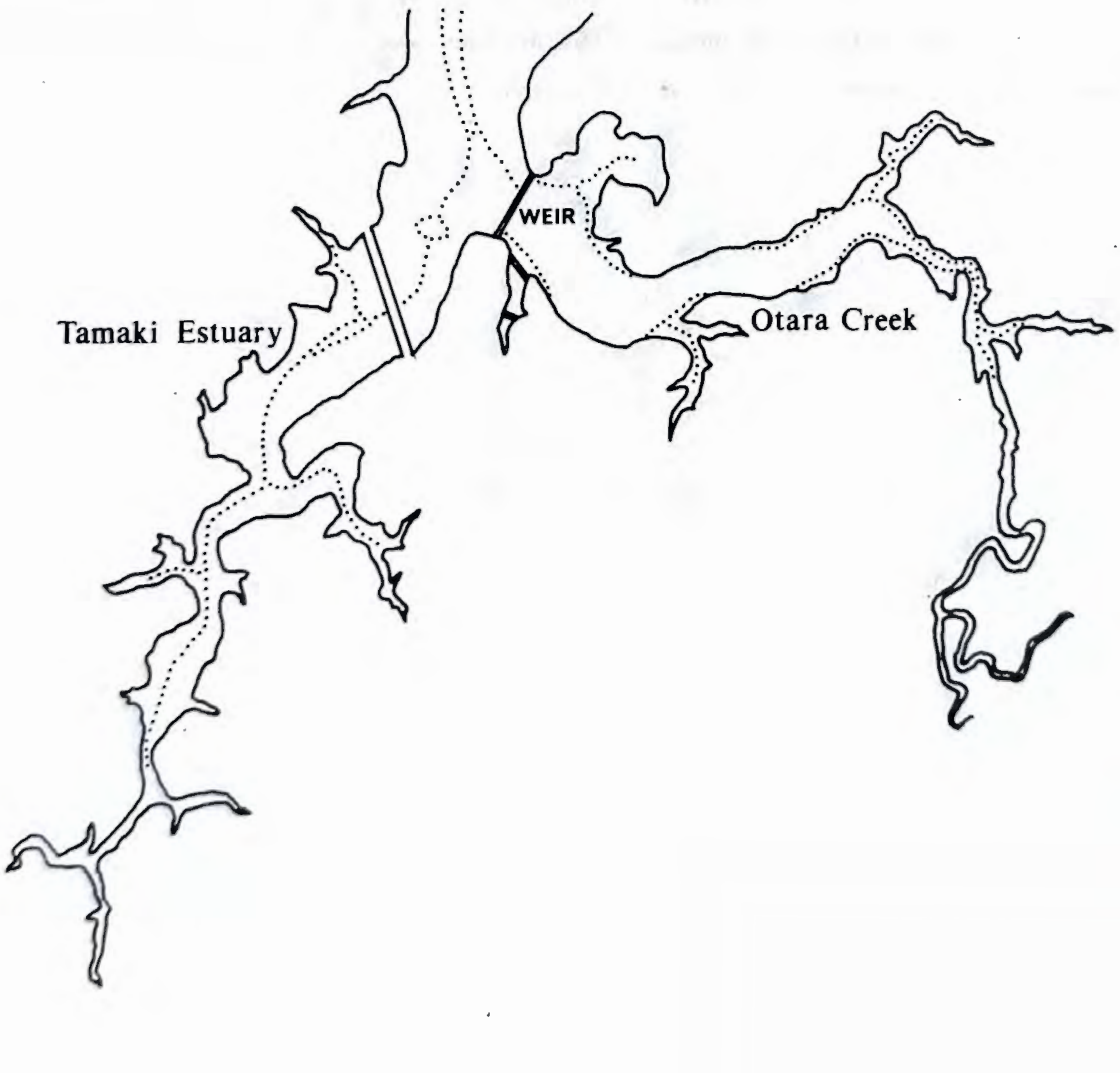
Improvement to the ecology of this area could be made by preventing pollutant contributions, and reducing the quantities of fine sediments released into the tidal area from the land.

The condition of the foreshore strip is of considerable importance to the state of intertidal ecology in this area. Soft clay foreshores are prone to erosion which leads to the contribution of clay and organic material to the tidal zone. These foreshore should be protected and stabilised.

18.12 Potential Use of Ecological Assets

There is little direct use of the ecological assets of this area at present, although there is a small amount of flatfishing and recreational fishing by children. This situation is unlikely to alter, although there will probably be an increase in recreational boating as the human population increases.

AREA 19



OTARA CREEK AND UPPER TAMAKI ESTUARY

AREA 19 UPPER TAMAKI ESTUARY AND OTARA CREEK

This area will be discussed in two parts:

A. Upper Tamaki Estuary

B. Otara Creek

19.A. Upper Tamaki Esturary

19.A.1 General Description

The Estuary in this region is almost entirely tidal with only narrow channels remaining at low water. Foreshores are generally low banks with exposed clay in some places. Minor reclamations have been made in some areas and these are faced with rock and other hard material. The vegetation of foreshores varies considerably in this area but generally there are few mature trees and a predominance of weeds and scrub.

Land on the western side of the Estuary is residential apart for a small area near the Great South Road and the golf course and hospital areas near the head. To the west of the motorway crossing, land on the eastern side is also largely residential, while to the east of the motorway there is the Otara Power Generating Station, and open farmland further to the north-east.

19.A.2 Intertidal Substrates

Natural intertidal substrates are almost entirely soft sediments. In sheltered regions substrates consist of deep soft muds, while in more exposed areas, and near the low tidal channels, firmer sands occur.

Small quantities of hard substrate in the intertidal region consist of man-made structures such as piers for roads, pipelines and retaining walls.

19.A.3 Intertidal Flora and Invertebrate Fauna

A typical natural flora and fauna of sheltered soft shores is found in this area.

High tide level - About high spring tide level there is often a band of sedge and salt marsh plants, although this community does not occupy any substantial area in this region.

Leptocarpus simplex
Juncus maritimus var australiensis
Stipa teretifolia
Cotula coronopifolia
Triglochin striatum

fauna

Ophicardelus costellaris (a)
Potamopyrgus antipodum (a)
amphipods (c)

Mangrove marsh - Fringing mangrove marsh occupies large areas in this region.

Helice crassa (c)
Amphibola crenata (a)
Alpheus sp. (o) (low tidal)
Elminius modestus (o) (on pneumatophores)

Shaded mangrove pneumatophores and trunks also support a variety of small plants and algae.

Open mud flat - There are extensive areas of open mud flat above the motorway bridge. Substrates are generally very soft. Amphibola crenata is abundant and widespread, and Helice crassa is also common. Alpheus sp. appears to be absent from the upper part of the Estuary but is common in the vicinity of the Otara Power Station.

Firmer sand flats - Substrates in the area below the motorway bridge are noticeably less muddy than those further up the Estuary. In the vicinity of Water Road are found:

Upper intertidal

Amphibola crenata (c)
Helice crassa (c)

Mid tide level

Chione stutchburyi (c)
Macomona liliana (o)
Zediloma subrostrata (c)
Zeacumantus lutulentus (c)
Notoacmea helmsi (o)
Anthopleura aureoradiata (o)
Helice crassa (c)
Elminius modestus (c) (on shell)

Low tidal level - shelly substrate

Chione stutchburyi (c)
Macomona liliana (c)
Cominella glandiformis (c)
Zeacumantus lutulentus (c)
Helice crassa (c)
Alpheus sp. (c)
Elminius modestus (c)
Anthopleura aureoradiata (c)

Low tide level - muddy substrate

Alpheus sp. (c)
Mactra ovata (dead only)

Hard substrate - The hard substrates of bridge abutments and pilings support typically estuarine fauna

Elminius modestus (a)
Balanus amphitrite (a)
Modiolus fluviatilus (c)

There is also a considerable growth of microscopic algal on hard surfaces at times, and larger green Enteromorpha sp. is common in the winter.

19.A.4 Fish

Little is known of the fish of this area. Flatfish, parore, and yellow-eyed mullet should be regularly present and other common Harbour species will occur at times. Deterioration of water quality has probably reduced the use of this area by juvenile fish.

19.A.5 Birds

Shore feeding birds are not common in this area. Small numbers of white-faced herons, red-billed gulls, black-backed gulls and pied stilt occur and kingfishers are common in areas with a vegetated foreshore. Ducks are found in the sheltered areas near the head of the Estuary. Small numbers of fish feeding pied shags and Caspian tern are also present.

19.A.6 Edible Invertebrates

No edible invertebrate species reach an edible size in this area.

19.A.7 Natural Ecological Changes

Natural Ecological changes to be expected in a shallow sheltered area such as this are a slow buildup of intertidal substrate level due to deposition of fine sediments carried from the land. As a result of the sediment accumulation the most obvious ecological change will be the spread of mangrove marsh and associated animals and plants. There are also signs of a deterioration of sandy environments due to the deposition of fine material, with the disappearance of several species indicated.

19.A.8 Ecological Interference by Man

An increase in the sedimentation rate in sheltered regions may be attributed to the contribution of increased quantities of sediment to the tidal region from the surrounding land.

There appears to have been a rapid buildup of intertidal substrate level in the region above the motorway bridge at which point the estuary has been considerably constricted by the construction of a causeway supporting the motorway.

Minor foreshore reclamations appear to have had little impact on intertidal ecology, although in some instances unfaced reclamations are contributing material to the tidal zone by erosion.

19.A.9 Pollution

The most obvious pollution of this region is by the dumping of household and garden wastes on to the foreshores and into the tidal areas. A particularly bad region is the light industrial area near the Great South Road.

Rubbish is widespread in mangrove marshes but as yet appears to have had no serious ecological impact.

19.A.10 Ecological Value

In a natural state a shallow tidal region such as this has considerable value in providing large surface areas of substrate and water for the exchange of gases with the atmosphere.

Natural communities of invertebrates supply food for birds and juvenile fish, and the natural detrital material derived from mangrove and salt marsh areas is important to food chains further down the esturary.

Changes in the physical environment of the intertidal area due to sedimentation have resulted in a decrease in the diversity of invertebrate fauna, but nevertheless this area is capable of valuable interaction within the Harbour ecosystem.

Sediments carried from the land are deposited in shallow protected regions, particularly mangrove marshes, and prevented from being carried to other areas where their effect on the environment would be considerably greater.

19.A.11 Improvement and Protection of Ecological Assets

A small use is made of this area for flatfishing and recreational fishing by children. The Waters Road area is used by local schools for ecological studies, and also for swimming and boating.

The intertidal area near Waters Road is well suited for educational purposes and this use could well increase. (See report on Intertidal Reserves.)

19.B Otara Creek

19.B.1 General Description

A weir constructed across the mouth of the Otara Creek at just above half tide level imponds water for use in cooling by the power generating station.

The Creek is shallow with a particularly indented shoreline in the upper reaches where several small streams enter the tidal region.

To the east and south there are the residential areas of Otara, while on the north side there is gently rolling farmland. Foreshores generally consist of low banks of soft clay. In the foreshore reserves of the residential areas banks are covered with untidy scrub and weeds with few mature trees. On the north side of the Creek there are foreshore areas with shrubs and trees.

19.B.2 Intertidal Substrates

Because of the weir which prevents the escape of water from below half tide mark tidal movement is restricted to what would normally be the upper intertidal zone. Substrates in this region are generally soft and muddy.

19.B.3 Intertidal Flora and Invertebrate Fauna

At high water level there is often a band of sedge along the shoreline. Common species are:

Leptocarpus simplex
Juncus maritimus var australiensis
Cotula coronopifolia

fauna
Helice crassa (c)
Potamopyrgus antipodum (a)
Ophicardelus costellaris (c)

Mangrove marsh - Mangrove marsh occupies large areas of the intertidal zone in the Otara Creek. The lower mangrove level is situated immediately above the weir determined low water level. Most of the mangrove is healthy although there are a few dead trees near the power generating station.

fauna
Helice crassa (c)
Amphibola crenata (a)
Ophicardelus costellaris (c)
Elminius modestus (c)

Open Mud - There are some areas of open mud, particularly towards the upper reaches of the tidal region. Potamopyrgus antipodum and Amphibola crenata are the only species found in such areas.

19.B.4 Fish

Nothing is known of the fish in this area, although the presence of small fish is indicated by the feeding activity of pied shags and Caspian terns.

19.B.5 Birds

With the reduction in intertidal area the potential food gathering area for shore feeding birds is reduced. Small numbers of white-faced heron, kingfisher, red-billed gull and black-backed gull occur. Mallard duck are common and small numbers of pied shag and Caspian tern feed in the area.

19.B.6 Edible Invertebrates

There are no edible invertebrates in this area.

19.B.7 Natural Ecological Changes

Minor natural changes can be expected as a result of the deposition of soft sediments in the intertidal area.

19.B.8 Ecological Interference by Man

The construction of a weir across the mouth of the Creek has led to no apparent interference with the remaining intertidal area. The effects on what was previously the lower part of the intertidal zone are unknown, although it appears that the normal invertebrate fauna of the area has disappeared.

Sedimentation appears to be occurring at a rapid rate in this Creek, particularly below the present low water level. This is a result of additional contribution to the tidal areas from the land, and the decrease of tidal flow and increase of sheltered water area created by the weir.

19.B.9 Pollution

The foreshores and intertidal parts of the Otara Creek surrounded by the residential area of Otara are seriously polluted by the dumping of household and garden rubbish. Foreshore reserves are often covered with weeds and gorse and in a state conducive to the dumping of rubbish. Council workers leave large quantities of cut gorse and weeds on the banks of the Cree' to rot.

The intertidal environment adjacent to such foreshores is showing signs of deterioration in terms of the formation of an anaerobic condition close to the surface of soft sediments. The aggravation of this problem could well lead to the formation of obnoxious gases, a high oxygen demand on overlying waters and a serious deterioration of water quality.

19.B.10 Ecological Value

In a natural state the large shallow area of the Otara Creek would have an important function in purifying tidal water, providing large areas for the exchange of gases with the atmosphere, acting as a deposition site for land derived sediments, and providing natural organic detritus for organisms further down the Estuary.

In its present condition this Creek is probably more of a liability than an asset to the Waitemata Harbour ecosystem.

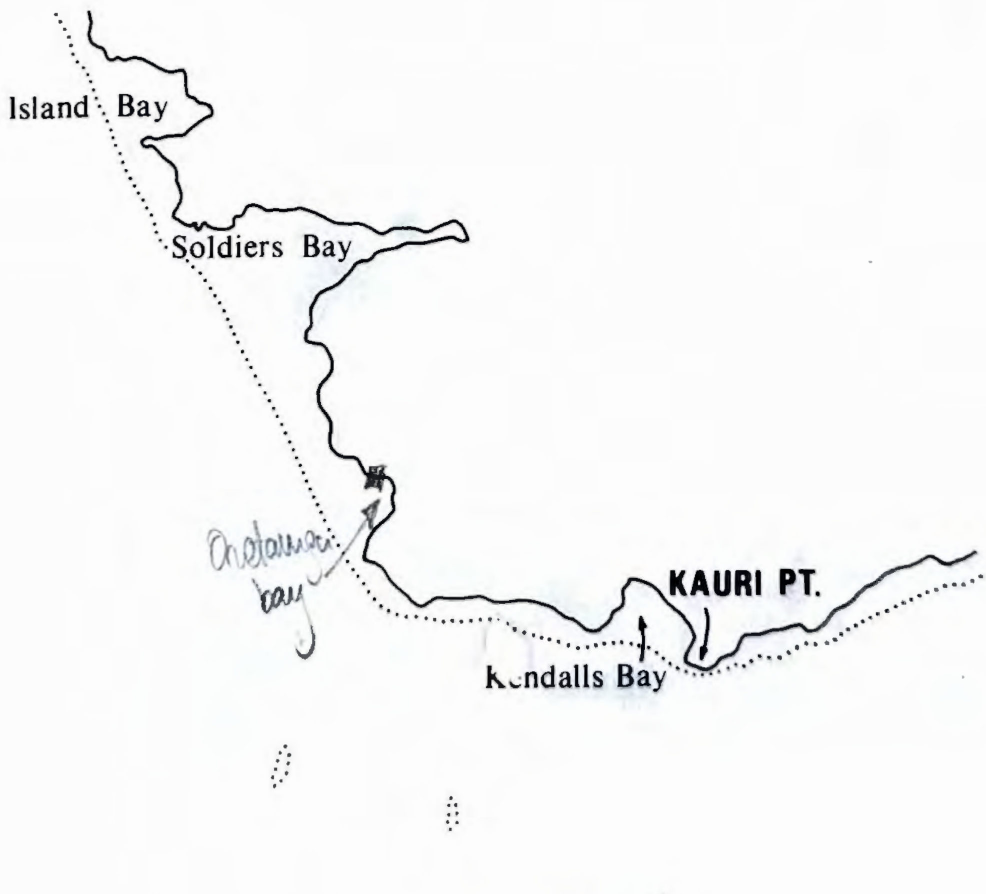
19.B.11 Improvement and Protection of the Intertidal Area

Significant improvements can be made to the ecology of this region by cleaning up the foreshores and preventing the dumping of pollutant material into or near tidal areas or streams draining into the area.

19.B.12 Potential Use of Ecological Assets

Little direct use of the ecological assets of this area can be foreseen.

AREA 20



ISLAND BAY TO KAURI POINT

AREA 20. ISLAND BAY TO KAURI POINT

20.1 General Description

This area includes the coast from the north of Island Bay to the Chelsea Sugar Refinery.

The cliffed headlands of this region, the most prominent of which is Kauri Point, are visible from a large area to the south and west of the Waitemata. To the north of the munitions wharf there is a series of headlands with deep bays between. Most of the surrounding land is fairly steep especially the foreshore, and covered with pine and native scrub. Small areas near Island Bay have been subdivided for residential properties.

To the east of the munitions wharf there are high cliffs along much of the foreshore. The surrounding land rises steeply and is covered with pine and regenerating native trees. The fringe of pohutukawa along the cliff line, and many small damp valleys close to the shore with pungas and ricker kauri, make this a green and pleasant area.

20.2 Intertidal Substrates

The intertidal substrates of this area vary considerably. From the munitions wharf to the north there is a gradation from clean sandy substrates to fine soft muds to the north of Island Bay. Soldiers Bay has generally firm fine sandy sediments on the lower shore with a mangrove marsh and some softer sediments at the head of the Bay. A shell barrier at the head of the bay shelters a salt marsh and flax swamp. Reefs of sandstone extend from the points in this region and in some places extend below low water level. Accumulations of boulders are common beneath the cliffed shores.

To the east of munitions wharf there is proportionately more hard shore, Kendall's Bay being the only bay of any size with soft sediments.

Sandstone reefs extend out from the base of the cliffs and there are accumulations of eroded sandstone boulders in places. Occasionally there is a built-up 'beach' of coarse sand and shell with finer sediments towards low water. At low water spring areas of soft muds are exposed, particularly in the shelter of the larger reefs.

20.3 Intertidal flora and invertebrate Fauna

Soft substrates - To the north of Island Bay low tidal sediments are soft and muddy while higher on the shore there are occasional firm areas. Fauna of this area is similar to that described for Area 4.

At Island Bay low tidal substrates become more sandy and the following species are common:

Chione stutchburyi (c)
Macomona liliana (c)
Mactra ovata (c)
Cominella glandiformis (c)
Cominella adspersa (o)
Zeacumantus lutulentus (c)
Elminius modestus (c)
Anthopleura aureoradiata (a)
spionid polychaetes (a)
Pectinaria australis (o)

In the low tidal regions of Soldiers Bay an increased diversity of fauna is found in the fine sandy substrate.

Chione stutchburyi (c)
Macomona liliana (c)
Mactra ovata (o)
Soletellina nitida (c)
Zeacumantus lutulentus (o)
Haminoea zelandica (c)
Aglaja sp. (o)
Baryspira australis (c)
Cominella glandiformis (o)
Cominella adspersa (o)
Callianassa filholi (o)
Lysiosquilla spinosa (c)
spionid polychaetes (a)
Notamastus zeylanicus (r)
Pectinaria australis (o)
Aglaophamus macroura (o)
Anthopleura aureoradiata (c)
Elminius modestus (c)

Higher on the shore in Soldier's Bay there are some shelly areas with:

Amphidesma australe (o)
Zeacumantus subcarinatus (o)
Zediloma subrostrata (c)
Notoacmea helmsi (c)
Elminius modestus (c)

The mangrove marsh at the head of Soldier's Bay is interesting in that the substrate is firm and sandy around the outer trees and oysters are common on the trunks.

Crassostrea glomerata (c)
Lunella smaragda (o) (very large)
Amphibola crenata (c)
Helice crassa (c)

To the east of the munitions wharf soft shores are variable in substrate nature with most of the above fauna being represented in places. In some areas low tidal substrates consist of soft muds with Hemiplax hirtipes and Alpheus sp. dominant. Mid tidal beaches of shell and coarse sand support beds of Amphidesma australe with Nucula hartvigiana and Glycera sp. common in places.

Hard shores - Hard shores in this region consist of soft sandstone rock with areas of boulders, particularly beneath the eroding cliffs. The fauna and flora is similar throughout the area, although less varied to the north of Island Bay where sedimentation is more widespread. (see Area 4)

High tidal boulder accumulations

Cyclograpsus lavauxi (c)
Hemigrapsus edwardsi (c)
Ligia sp. (a)
amphipods (a)

Cliff faces about the high tide mark support a variety of inconspicuous blue-green algae, and in the winter a conspicuous band of green Enteromorpha sp.

Immediately below high water mark the borings of Sphaeroma quoyana riddle the rock surface.

Platforms about mid-tide level

algae
Hormosira banksii
Sytosiphon lomentaria
Dictyota sp.

fauna
Zeacumantus subcarinatus (c)
Melagraphia aethiops (c)
Zediloma subrostrata (c)
Lunella smaragda (c)

	Onchidella nigricans (a) *Sypharochiton pelliserpentis* (c) *Lepsiella scobina* (c) *Haustrum harstorium* (o) *Crassostrea glomerata* (o) *Perna canaliculus* (o) *Anchomasa similis* (holes only) *Pomatoceros caeruleus* (o) *Isactinia olivacea* (c) *Anthopleura aureoradiata* (a)
Low tidal Reef	*Lunella smaragda* (c) *Neothais scalaris* (o) *Cominella virgata* (o) *Cominella maculosa* (o) *Sigapatella novaezelandiae* (o) *Perna canaliculus* (o) *Ostrea sp.* (c) *Microcosmus kura* (a) *Watersipora cucullata* (c)
Algae at low water mark	*Ecklonia radiata* *Sargassum sinclairii* *Carpophyllum flexuosum* *Corallina officinalis* *Codium adhaerens* *Laurencia sp.*
Beneath boulders - mid shore	*Zediloma atrovirens* (o) *Amaurochiton glaucus* (c) *Pilumnopeus serratifrons* (o) *Petrolisthes elongatus* (a) *Hemigrapsus crenulatus* (c)
Beneath boulders - lower shore	*Buccinulum heteromorphum* (c) *Sigapatella novaezelandiae* (c) *Maoricrypta monoxyla* (c) *Cominella virgata* (c) *Ostrea sp.* (c) *Terebella sp.* (o) *Flabelligera affinis* (c) *Lepidonotus sp.* (c) *Halicarcinus sp.* (o) *Petrolisthes elongatus* (c) *Acanthoclinus quadridactylus* (o) *Forsterygion nigripenne* (o) *Coscinasterias calamaria* (o) *Asterocarpa caerea* (o) *Microcosmus kura* (a) *Corella eumyota* (o) *Botryllus schlosseri* (c)

A rich pryozoan fauna is also found beneath boulders in this region.

20.4 Fish

Acanthoclinus quadridactylus and Forsterygion nigripenne are both found beneath intertidal boulders in this region. Parore feed intertidally on algal films and the disturbance of soft-bottom areas by schnapper is often apparent. The rocky reefs of this region are rich in invertebrate life compared with areas further up the Harbour and probably provide feeding areas for several species of migratory fish.

20.5 Birds

Shore-feeding birds occur in small numbers in this region. Pied stilts and white-faced herons are most common on the muddy soft shores, while kingfishers, red-billed gulls and black-backed gulls are found throughout the area.

Water-feeding birds include pied shag, white-fronted tern, caspian tern and the occasional gannet.

20.6 Edible Invertebrates

On soft shores Chione stutchburyi and Amphidesma australe are widespread. Chione reaches an edible size only at Kendall's Bay and occasionally at Soldiers Bay, while Amphidesma of an edible size occur only in one or two small areas to the east of Kauri Point. Another bivalve of soft shores, Mactra ovata is found only in the softer sediments of Island Bay and Soldiers Bay. These shellfish are not often taken for food in this area.

On hard shores Crassostrea glomerata, Perna canaliculus and Lunella smaragda are widespread, although Crassostrea and Perna are not generally abundant. It is unlikely that any of these species are taken in any quantity for food.

Present rates of exploitation do not appear to be affecting the population density or recruitment of the edible molluscs. It is possible, however, that there will be an increase in population density of edible Chione in the Island Bay-Soldiers Bay region, and this will lead to further exploitation as the human population of the area increases.

20.7 Natural Ecological Changes

Slow accumulation of fine sediments is to be expected in sheltered parts of this area. In places such as Island Bay where the sediment is already fairly soft, the deposition of further fine sediments will probably lead to substantial changes in the fauna.

The slow erosion of soft sandstone cliffs will provide accumulations of boulders on the shore.

20.8 Ecological Interference by Man

There has been little interference with shore ecology of this area by the human population, although sedimentation in sheltered areas may well have been increased.

To avoid considerable interference in the future the steep land behind this stretch of shore will have to be developed with extreme caution to prevent erosion and the contribution of large quantities of soft sediments to the Harbour.

20.9 Pollution

There is widespread pollution by water-borne material deposited on the shores of this area, although the ecological consequences are slight.

In the vicinity of the Chelsea Sugar Refinery low tidal sediments appear anaerobic, particularly near the effluent outlet. This could be a result of organic material being released with the effluent.

20.10 Ecological Value

At present this area possesses a natural and healthy flora and fauna. There is a considerable increase in diversity compared with areas further up the Harbour where substrates are not as variable nor the hard shores as extensive.

Of particular value to the shore ecology is the natural state of the foreshores and the steep slopes behind. This combination of intertidal reefs, prominent cliffed headlands, and green, vegetation-covered slopes, is also of considerable value to the environment of large areas of the City of Auckland.

20.11 Improvement and Protection of Ecological Assets

The ecology of this region is natural and healthy and there are no obvious improvements to be made.

The protection of shore ecology should be an important consideration when steep slopes in this region are developed for housing.

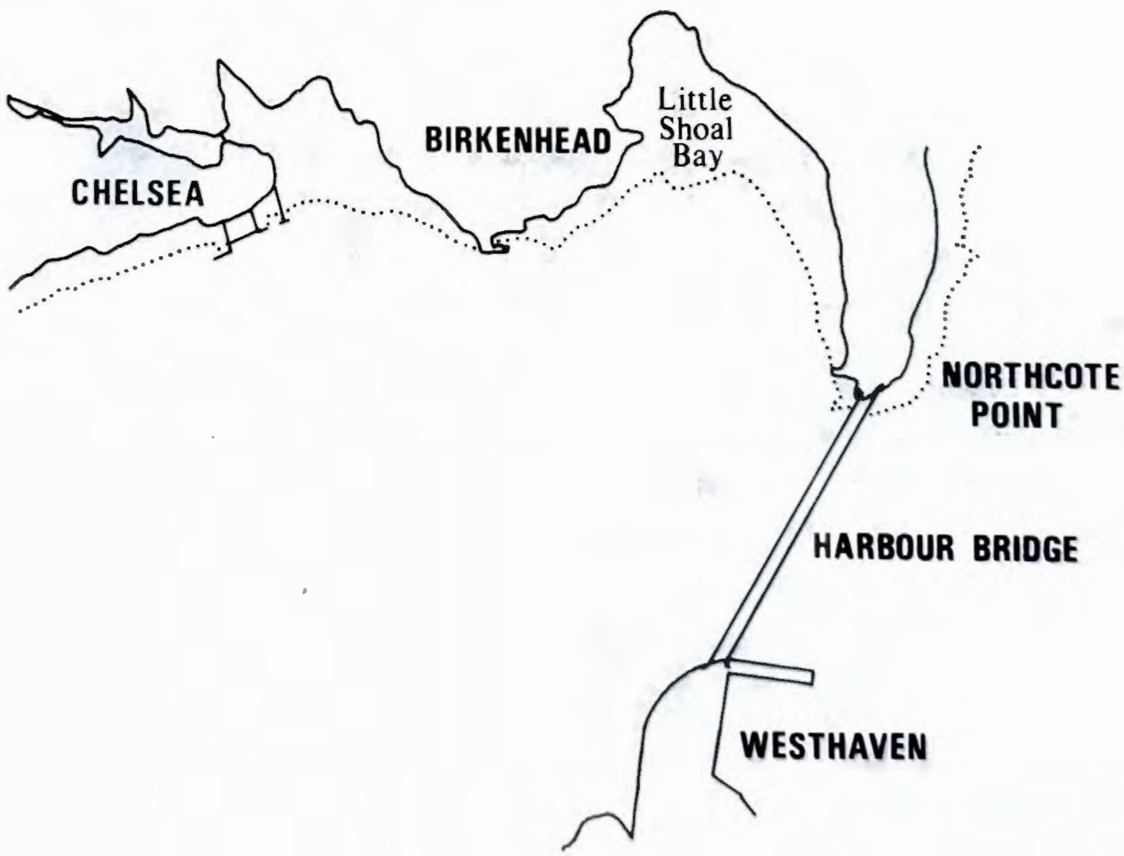
20.12 Potential Use of Ecological Assets

There is little use of this region at present, largely because of its inaccessibility.

The use of natural ecology in this area for educational purposes might well become important as several habitat types are well represented. The mangrove, salt marsh, and shell barrier at the head of Soldiers Bay is of interest in this respect.

The combination of bush reserve adjacent to the foreshore in the Kendalls Bay area might well be of educational value in providing suitable areas for both land and marine ecological studies in close proximity.

AREA 21



NORTHCOTE POINT TO CHELSEA

AREA 21. NORTHCOTE POINT TO CHELSEA

21.1 General Description

In this area there are two shallow bays with projecting headlands at Chelsea, Birkenhead, and Northcote Point. The main channel to the Upper Harbour flows across the mouth of these bays impinging on the points. Within a line between the points the bottom shelves up to intertidal levels and extensive flats are exposed at low water.

Foreshores of this area largely consist of sandstone cliffs or steeply rising land. Cliffed areas generally support large numbers of pohutukawa trees which form a green fringe between the foreshore and the residential areas behind.

21.2 Intertidal Substrates

In the bays there are extensive soft flats. Little Shoal Bay has sandy flats in the lower intertidal with some soft muddy areas higher on the shore. The Bay near Chelsea is also sandy near low water but soft on the Chelsea side, and towards the head. Both of these bays have been truncated by reclamations.

Between Chelsea and Little Shoal Bay there is a shore with sandstone reefs and accumulations of boulders and coarser sediments. Birkenhead Wharf is situated on a point in this region and has basalt block retaining walls in the surrounding area.

21.3 Intertidal Flora and Invertebrate Fauna

Sandstone Cliff and Reef Shores - In areas where the cliff face is exposed in the upper intertidal there is a band of blue-green algae developed above high tide mark, and a conspicuous zone of green algae (*Enteromorpha* sp.) developed in winter. Immediately below high water the cliff is riddled with the burrows of *Sphaeroma quoyana* and small numbers of *Melarapha oliveri* are found.

In areas where the cliff has eroded and there are accumulations of boulders about the high tide mark a typical under-boulder fauna is found.

		Cyclograpsus lavauxi (c) Hemigrapsus edwardsi (c) Ligia sp. (a) amphipods (a) Petrolisthes elongatus (c) Zediloma atrovirens (o)
Mid-tidal Reef		Modiolus neozelanicus (r) Crassostrea glomerata (o) Perna canaliculus (r) Onchidella nigricans (c) Sypharochiton pelliserpentis (c) Cominella virgata (o) Cominella maculosa (o) Lepsiella scobina (c) Haustrum haustorium (r) Melagraphia aethiops (o) Lunella smaragda (c) Eulalia microphylla (o) Pomatoceros caeruleus (o) Elminius modestus (c) Anthopleura aureoradiata (c)
Low tidal reefs	algae	Corallina officinalis Colpomenia sinuosa (autumn-winter) Codium adhaerens (shade) Laurencia sp.
	fauna	Ostrea sp. (c) Perna canaliculus (o) Anomia walteri (c) Buccinulum heteromorphum (c) Cominella virgata (c) Neothais scalaris (o) Lunella smaragda (c) Cominella maculosa (o) Acanthochiton zelandicus (o) Microcosmus kura (a) Coscinasterias calamaria (o) Patiriella regularis (o)
Reef fringe	algae	Sargassum sinclairii Ecklonia radiata Carpophyllum flexuosum Dictyota sp. Laurencia sp. Corallina officinalis Codium adhaerens

Mid-low tide boulders	Amaurochiton glaucus (c) Ischnochiton maorianus (r) Terenochiton inquinatus (o) Buccinulum heteromorphum (c) Sigapatella novaezelandiae (c) Maoricrypta monoxyla (o) Ostrea sp. (c) Anomia walteri (o) Alpheus sp. (o) Petrolisthes elongatus (c) Isocladus sp. (c) Flabelligera affinis (c) Beania sp. (c) Watersipora cucullata (c) other bryozoa (c)

Basalt Wall at Fisherman's Wharf - The hard surface of basalt enables a number of species that are not present on the neighbouring sandstone shores to colonise this area. Also, because of strong tidal currents, the substrate is kept clean and there is a rich low tidal and under-boulder fauna. (below)

On the evenly sloping basalt wall around the reclamation on which Fisherman's Wharf stands zonation of sessile fauna is well illustrated (Fig. 20.2)

High tidal rock slope		Melarapha oliveri (c) Chamaesipho columna (c)
Mid-tide level		Chamaesipho columna (c) Crassostrea glomerata (a) Melagraphia aethiops (o) Sypharochiton pelliserpentis (c) Onchidella nigricans (o) Lunella smaragda (c) Lepsiella scobina (c) Cominella virgata (c) Cominella maculosa (c) Haustrum haustorium (o) Cellana ornata (o)
	algae	Gelidium caulacantheum Hormosira banksii Corallina officinalis
Low tide level	algae	Sargassum sinclairii Carpophyllum flexuosum Ecklonia radiata Corallina officinalis

Dictyota sp.
Codium adhaerens

fauna

Lunella smaragda (a)
Sigapatella novaezelandiae (c)
Maoricrypta monoxyla (c)
Maoricrypta costata (o)
Ischnochiton maorianus (c)
Terenochiton inquinatus (a)
Acanthochiton zelandicus (c)
Cryptoconchus porosus (c)
Amaurochiton glaucus (c)
Cominella virgata (c)
Cominella maculosa (o)
Cominella adspersa (c)
Neothais scalaris (o)
Buccinulum heteromorphum (a)
Haustrum haustorium (c)
Tugali elegans (o)
Penion adusta (o)

Ostrea sp. (a)
Perna canaluculus (o)
Paphirus largillierti (r)
Anomia walteri (c)
Terebella sp. (o)
Lepidonotus sp. (c)
Acrocirrus sp. (o)
Flabelligera affinis (c)

Petrolisthes elongatus (c)
Pilumnus lumpinus (o)
Notomithrax minor (o)
hermit crabs (a)
Cnacer novaezelandiae (o)
Patiriella regularis (o)
Coscinasterias calamaria (o)
spionid polychaetes (c)
Asychis theodori (c)

21.4 Fish

Little is known about the use of this area by fish populations. Acanthoclinus quadridactylus and Forsterygion nigripenne are common beneath boulders on the sandstone reefs, and parore feed on algal films. In soft substrate areas surface sediments are often disturbed where bottom feeding species have been foraging.

21.5 Birds

Few birds appear to feed on the hard shore of this area. On soft shores the red-billed gull is most common with small numbers of black-backed gull, pied stilt, and white-faced heron also present.

Kingfishers feed in high tidal areas particularly where there are dense crab populations.

Of the fish feeders, pied shags are often seen in the area, and small flocks of white-fronted terns feed offshore. The occasional gannet and caspian tern is also seen.

21.6 Edible Invertebrates

Several species of edible shellfish are found in this area.

Chione stutchburyi is found on the sand flats of both bays and reaches an edible size near the low water mark. Beds of edible size are not dense, however, and there is only slight exploitation by the local population. Recruitment is normal.

Amphidesma australe of edible size are found in small beds in shelly areas. It is unlikely that these are exploited for food.

Crassostrea glomerata - the rock oyster is found along most of the shoreline and is particularly abundant on the basalt retaining walls at Northcote Point and Birkenhead. Only small numbers are taken for food.

Perna canaliculus is found near low tide level on the hard shores in small numbers. It is unlikely that this species is taken for food.

Mactra ovata has a patchy distribution and no beds have dense populations. It is unlikely that this species is taken for food.

Lunella smaragda - the cats eye reaches a large size on some low tidal reefs in this area. Only small numbers are taken.

Generally, there are no changes to be expected in the abundance of edible shellfish in this area, although there might be an increase in the abundance of Chione of edible size.

21.7 Natural Ecological Changes

The slow accumulation of fine sediments deposited from the water is to be expected in sheltered areas. This is seen at the head of Little Shoal Bay.

Erosion of cliff faces is also to be exptected with a consequent increase in the available niche for fauna living beneath boulders.

21.8 Ecological Interference by Man

The principal effects of development by man in this area have been the reclamation of the head of Little Shoal Bay; the damming of the head of Chelsea Bay, and the facing of small foreshore reclamations at Northcote Point and Birkenhead with basalt rock.

The destruction of the marsh and swamp areas at the head of Little Shoal Bay and Chelsea Bay has meant the removal of a potentially productive area from the Harbour. Organic material from bays such as these is important to a variety of detritus feeding organisms.

Basalt walls, such as those at Northcote Point and Birkenehad, have undoubtedly increased the diversity of fauna that is found in this area.

21.9 Pollution

Much of the pollution found in this area is untidiness, rather than of any great consequence to the ecology.

The reclamation at the head of Little Shoal Bay has been the source of soft material which has been deposited over the intertidal. The present retaining wall is insufficient to prevent wave erosion of soft fill. Drainage from the reclamation is poorly directed to the region surrounding the boat-launching ramp, and the retaining wall is untidy with telegraph poles and broken concrete.

On the shore beneath the Harbour Bridge at Northcote Point there is a litter of steel left from the construction stages.

The Fisherman's Wharf Restaurant is the source of minor pollution in the way of paper, organic scraps and coagulated fat dumped on the shore on the northern side.

Generally the shores are untidy with quantities of water-borne glass, plastic, wood and paper.

21.10 Ecological Value

The flora and fauna of this region are normal and healthy. The hard shores in particular support a large number of species with high biomasses. Rich areas such as these are able to enter into a number of reactions with other parts of the Harbour ecosystem.

21.11 Improvement and Protection of Ecological Assets

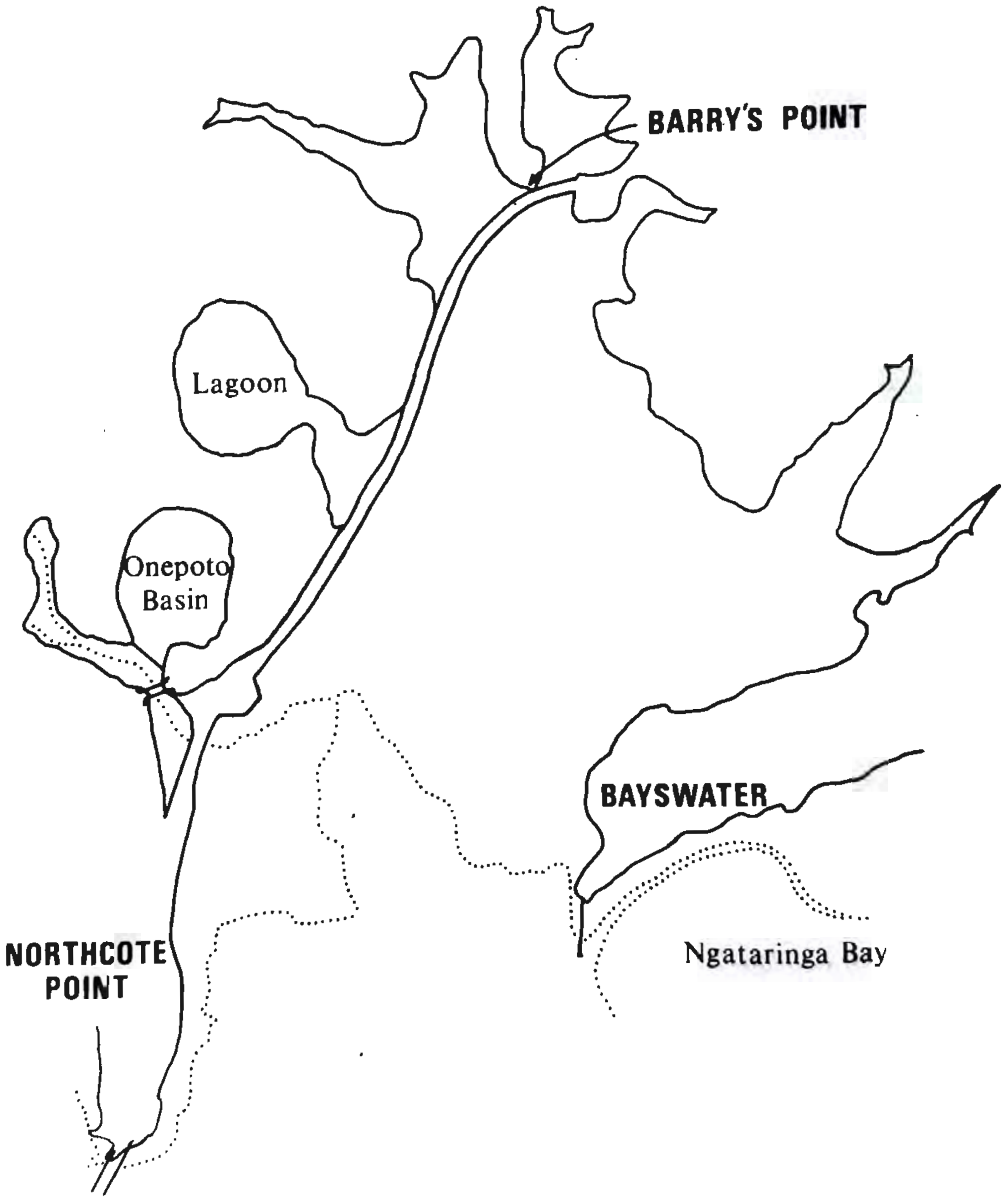
Some improvement can be made by cleaning up intertidal and foreshore areas, particularly the reclamation at the head of Little Shoal Bay.

Protection of the ecology of the intertidal area can be afforded by reducing erosion of steep foreshores and preventing the introduction of fine sediments from the land. The existing fringe of vegetation along most of the shore in this area is of considerable importance in protecting the intertidal area from these influences.

21.12 Potential Use of Ecological Assets

There is a small use of this area for gathering shellfish food and shore fishing. Such use is unlikely to change. Little further use can be foreseen at this stage.

AREA 22



SHOAL BAY

AREA 22. SHOAL BAY

Shoal Bay extends northwards from the narrow part of the Harbour opposite the commercial area of downtown Auckland. Inside a line between Northcote Point and Bayswater Wharf, the Bay is very shallow with extensive intertidal areas.

Because of the environmental variation of Shoal Bay the region is described in five parts. (Fig. 22.1)

A. The Entrance Area of the Bay
B. The West Side of the Bay
C. The East Side of the Bay
D. The Head of the Bay
E. The Centre of the Bay

22.A The Entrance Area of the Bay

22.A.1 General Description

In this region, from the Harbour Bridge Toll Plaza to Northcote Point of the western side, and inside Bayswater Point on the eastern side, there are extensive sandy flats in the intertidal zone. On both sides of the Bay foreshores are steep and have modified by reclamations and retaining walls. Pohutukawas are a feature of both foreshore areas, being particularly attractive in combination with exposed sandstone cliff faces. Land behind the steep foreshore is residential.

22.A.2 Intertidal Substrates

Inside Northcote Point there is a sandstone reef with typical soft eroding rock. A similar outcrop occurs at Bayswater Point but is not as extensive. Walls of basalt blocks face reclamations of the bridge motorway and at Bayswater. A shell bar stretches at right angles to the shore from the vicinity of the Toll Plaza, with substrates varying from shell in higher regions to sand towards low water. Low tidal substrates on both sides of the Bay are clean and sandy with accumulations of shell in some areas. Another large shell bar extends to the north-west from inside Bayswater Point.

22.A.3 Intertidal Flora and Invertebrate Fauna

Soft shores - In shelly areas of the upper intertidal, both outside the Bridge Motorway and to the north of Bayswater Point the following are found :

Chione stutchburyi (c)
Nucula hartvigiana (a)
Amphidesma australe (o)
Cominella glandiformis (c)
Zediloma subrostrata (c)
Zeacumantus subcarinatus (c)
Amaurochiton glaucus (c)
Notoacmea helmsi (c)
Boccardia sp. (a)
Anthopleura aureoradiata (c)
Elminius modestus (c)

In shelly areas towards low water

Cominella maculosa (o)
Pomatoceros caeruleus (c)
Hemigrapsus crenulatus (c)
Watersipora cucullata (c)

Towards low water there are extensive flats of clean fine sand. These flats extend outside the shell bar on the western side of the Bay, and along the low tidal level in the east.

Chione stutchburyi (c)
Macomona liliana (c)
Nucula hartvigiana (c)
Mactra ovata (o)
Soletellina nitida (c)
Baryspira australis (o)
Cominella adspersa (c)
Cominella glandiformis (c)
Zeacumantus lutulentus (c)
Haminoea zelanidca (c)
Lysiosquilla spinosa (c)
Calianassa filholi (a)
Hemiplax hirtipes (o)
Cirolana sp. (o)
Glycera sp. (o)
Aglaophamus macroura (o)
Asychis theodori (a)
Phoronis ovalis (c)

Hard shores - The sandstone reefs inside Northcote Point and in the vicinity of Bayswater Wharf support a rich low tidal fauna which includes most of the species described for the Fisherman's Wharf. (Area 21)

The basalt retaining walls of both the east and west shores of this area are typical in respect to the fauna and flora they support. (see Areas 12, 21, 23)

22.A.4 Fish

There is some utilisation of this area by bottom feeding fish, mainly schnapper. Parore are common near the rocky reefs and flatfish are caught commercially in sandy areas.

22.A.5 Birds

A variety of shore feeding birds utilise the sand flats of this area. Of particular interest are the large numbers of red-billed gulls which habitually feed on the sand flats in the vicinity of Bayswater Wharf. Small numbers of black-backed gulls and white-faced herons are also found in this area. Caspian terns feed on small fish, and rest on the shell banks.

22.A.6 Edible Invertebrates

Three species of edible shellfish are found in this area; Chione stutchburyi, Amphidesma australe, and Mactra ovata.

Chione is found in large beds on the eastern side of the Bay outside Bayswater Point, and in lesser numbers in low tidal areas adjacent to the shell bar on the western side. Populations in both these areas exceed 30 mm in mean adult length and it appears that there is some exploitation of the eastern beds for food.

Recruitment of Chione is good to both areas with dense spatfalls in the last two or three years.

It appears from the quantity of dead shell in this area and the size of the valves, that Chione beds were once more extensive than they are at present, and that individuals grew to a substantially greater size.

Amphidesma australe is found only in small numbers in shelly areas. Most populations do not reach an edible size and it is unlikely that this species is taken for food in any quantity.

Mactra ovata has a patchy distribution, but some high density beds are found on the lower shore near the shell bar on the western side of the Bay. It is unlikely that this species is sought for food in this area.

The maintenance of high water quality for Bay waters is important as far as the taking of shellfish for food is concerned.

22.A.7 Natural Ecological Changes .

There appears to be considerable movement of sediments in the region of the shell bar outside the Toll Plaza, and the shell bar itself appears to be growing. Low tidal sediments show the effects of slight deposition of fine material from the water. At present this is having no discernable effect on the ecology of the region.

22.A.8 Ecological Interference by Man

The most obvious disturbance by Man in this region has been the reclamation of foreshore areas and the construction of a basalt wall in place of the natural shoreline. The effect of these developments on the ecology of the surrounding area appears to be minimal, although they may have contributed to increased sediment movement in the region outside the Toll Plaza.

The disappearance of shellfish beds in this area cannot be attributed to any specific cause.

22.A.9 Pollution

Small quantities of waste material derived from boat building operations are dumped in the Harbour in the vicinity of Bayswater Wharf. Otherwise there is little pollution of this area.

22.A.10 Ecological Value

The ecological value of this entrance area of Shoal Bay is considerable. It is a clean and healthy environment at present with a diversity of animals which is not common within the Harbour ecosystem. Apparently stable at present, there is some threat to this region if areas towards the head of Shoal Bay continue to be polluted.

22.A.11 Improvement and Protection of Ecological Assets

The ecology of this region can be protected by reducing the contribution of fine suspended sediments and organic material to the waters of the head of the Bay. (see Areas 22.D and 22.E)

22.A.12 Potential Use of Ecological Assets

Shellfish gathering and recreational and commercial fishing occur on a small scale in this area. These activities are unlikely to change. Little further direct use of the ecological assets of this region can be foreseen. It must be remembered, however, that Shoal Bay as a whole, and particularly this entrance area, is a visual amenity of considerable value. The area will only retain this visual value if the ecology of intertidal areas remains in a healthy state.

22.B The West Side of Shoal Bay

22.B.1 General Description

This area includes two shallow inlets, the Onepoto Stream and a lagoon to the north, which have been cut off by the Northern Motorway, and an area of the upper intertidal outside the motorway.

The Onepoto Stream has been reclaimed in the vicinity of Lake Road and the Onepoto Basin separated from the tidal area by an earth dam. Foreshore on the southern side is fairly steep with residential properties, while on the northern side there is an area of trees and scrub. The foreshore between the Onepoto Stream and the Lagoon to the north has been altered by the Motorway reclamation. Land around the southern side of the Lagoon is residential while to the north Tank Farm remains in grass. The steep slopes on either side of the narrow entrance to the Lagoon are clad in mature trees making this area particularly attractive.

22.B.2 Intertidal Substrates

Much of the intertidal area of the Onepoto Creek and the lagoon is occupied by mangrove marsh with soft muddy sediments. On the western side of the lagoon substrates are too high for colonisation by mangrove and there is well-developed salt marsh in places.

Outside the motorway reclamation in the main body of the Bay there is a series of shell bars in shore with mangrove behind. Outside the shell bars the substrate is generally shelly in the upper intertidal and becomes muddy towards low water.

22.B.3 Intertidal Flora and Invertebrate Fauna

Mangrove areas - The mangrove environment of this area varies according to the intertidal level at which the marsh is found. At lower levels, in the Onepoto Stream and near the entrance to the lagoon, trees are larger and substrates softer, while at higher levels the mangrove is restricted in size and substrates tend to be firmer. There are large areas of small high tidal mangrove in the lagoon, and also behind the shell bars outside the Motorway.

Common fauna	*Helice crassa* (c) *Amphibola crenata* (c) *Alpheus* sp. (o) (low tidal)
Fringing sedge areas	*Ophicardelus costellaris* (c) *Potamopyrgus antipodum* (a)

Salt marsh and Shell Bars - Several common salt marsh plants are found in the upper intertidal regions, particularly in the lagoon. These, together with the plants found on shell bars are listed in Area 22.C.3.

Mid-tidal flats outside the motorway - These flats are generally shelly, with soft patches of sediment particularly towards the lower intertidal and Area 22.E. (Fig. 22.1)

Chione stutchburyi (c)
Amphidesma australe (o)
Nucula hartvigiana (c)
Macomona liliana (o)
Zediloma subrostrata (c)
Zeacumantus lutulentus (c)
Amaurochiton glaucus (o)
Notoacmea helmsi (o)
Cominella glandiformis (c)
spionid polychaetes (a)
Hemigrapsus crenulatus (c)
Hemiplax hirtipes (o)
Elminius modestus (c)
Anthopleura aureoradiata (c)

Soft areas

Hemiplax hirtipes (c)
Alpheus sp. (c)

22.C.4 Fish

Little is known of the fish which utilise this area. Large numbers of small flatfish are occasionally seen near the waters edge at low tide.

22.C.5 Birds

Kingfishers are abundant in the mangrove areas of the Onepoto Stream and the Lagoon. White-faced herons and pied stilts occur in small numbers at the entrance to the Onepoto Stream and lagoon and also on the flats outside the motorway. Black-backed and red-billed gulls also feed on the flats outside the motorway.

22.C.6 Edible Invertebrates

The only invertebrate which reaches an edible size in any numbers in this area is the mud snail, *Amphibola crenata*, but it is unlikely that this animal is taken for food.

22.C.7 Natural Ecological Changes

Natural changes to be expected in this area are a slow buildup of intertidal substrate level by the deposition of fine sediments from the water. Such a process has occurred in the lagoon where western areas are now at too high a level for colonisation by mangrove. In other areas mangrove has spread as the intertidal substrate has built up to a suitable level for colonisation.

Outside the motorway there appears to have been a rapid accumulation of loose shell into shell bars, some of which are moving slowly. Shell bars provide a different type of environment in an area and only cause minor ecological disruption during their formation and movement.

22.B.8 Ecological Interference by Man

There has been some contribution of soft sediment to tidal areas in the Onepoto Stream where soft fill has been used to reclaim mangrove marsh.

The deposition of fine sediment on the shore outside the motorway has caused considerable ecological interference. In this region soft sediments have accumulated at a rapid rate and substantially altered the nature of the substrate, resulting in destruction, or considerable reduction, of invertebrate populations that were previously present. This effect is worst towards low tidal levels (see Area 22.E.8)

22.B.9 Pollution

Pollution in residential areas caused by the dumping of organic garden rubbish and other refuse in the tidal area is a minor problem.

Of greater concern is the pollution of soft sediments in the main Bay by incorporation of organic material. (This effect is discussed more fully in Area 22.E.9)

22.B.10 Ecological Value

The shallow mangrove marsh and salt marsh areas of the Onepoto Stream and the lagoon remain in a natural state and are capable of normal interaction with the ecology of the Bay. The area outside the motorway has been detrimentally affected by pollution and the ecological value is decreasing as pollution becomes worse.

22.B.11 Improvement and Protection of Ecological Assets

Major improvements could be made to the natural environment of this area by preventing any further contribution of fine sediments or organic material to Bay waters.

Some protection of the region can be afforded by maintaining the naturally vegetated foreshores, and careful development of foreshore regions where such is necessary.

22.B.12 Potential Use of Ecological Assets

There is little use made of the ecological assets of this area at present. The principal value of this region lies in its visual attraction, particularly for travellers on the motorway and those residential areas overlooking the tidal region.

22.C. The East Side of Shoal Bay

22.C.1 General Description

Foreshores of this region generally rise steeply from the water, with cliffs in some areas. Most of the adjacent land is residential with properties bordering on the intertidal area in some places. The northern part of this area includes an extensive shell barrier which stretches almost half a mile parallel to the shore. This white shell bank is visible from a considerable area and contrasts pleasingly with the exposed mudflats and green foreshore behind. In the cliffed areas near the southern part of the shell bar there are many mature trees, notably pohutukawa. To the south of the shell barrier is a wide shallow bay extending to the east. Foreshores in this area are generally green with trees in steeper areas on the northern side and rough scrub in the south. Surrounding land is largely residential.

22.C.2 Intertidal Substrates

There is considerable variation in the nature of intertidal substrates in this area. The shell barrier is formed by the accumulation of dead bivalve shells and the crest is unstable and mobile, moving slowly shorewards. Inside the shell barrier there is a protected area of high tidal salt marsh and mangrove marsh. Substrates are sandy in the northern part and muddy towards the south where the tidal flow enters the protected areas. Outside the shell barrier there is a soft sandy shore becoming progressively muddy towards low water. (see Area 22.E)

In the bay to the south there are small shell barriers protecting the head regions which contain extensive mangrove marshes, while the flats outside the mangrove are generally soft and muddy but become firmer towards the south. An extensive shelly bank extends northwards from the Bayswater Point area.

22.C.3 Intertidal flora and Invertebrate Fauna

Upper intertidal salt marsh and mangrove - This type of area is found in a narrow band along much of the shore about the high water mark. More extensive areas occur in the sheltered region behind the shell bar.

Leptocarpus simplex
Salicornia australis
Samolus repens
Selliera radicans

fauna

Helice crassa (c)
Ophicardelus costellaris (c)
Potamopyrgus antipodum (a)
Amphibola crenata (o)

Mangrove marsh - Mangrove environments in this region vary with the intertidal height at which the marsh is situated. Large trees are to be found in the low tidal fringes of the marshes while towards the head of the bay to the south, and in the shelter of the shell barrier there are high level mangrove areas in which the trees are restricted in size.

Helice crassa (c)
Alpheus sp. (c) (soft areas)
Amphibola crenata (a)
Elminius modestus (c)

Shell Bars - Shell bars support a variety of plants which are adapted to the rigorous environmental conditions. Ward lists the following for the large shell barrier.

Indigenous species

Atriplex hastata novaezelandiae
Avicennia resinifera
Leptocarpus simplex
Phormium tenax
Plagianthus divaricatus
Salicornia australis
Samolus repens
Scirpus nodosus
Stipa teretifolia
Suaeda novaezelandiae

Naturalised species

Aster subulatus var *euroaster*
Cotula coronopifolia
Festuca arundinacea
Pholiurus incurvus
Plantago coronopus
Rumex crispus
Sonchus oleraceus

Sand flats outside the mangrove and shell bars

Zeacumantus lutulentus (c)
Zediloma subrostrata (c)
Notoacmea helmsi (c)
Cominella glandiformis (c)
Chione stutchburyi (c)
Macomona liliana (c)
Nucula hartvigiana (c)
Amphidesma australe (o)
amphipods (a) (sand-dwelling)
Anthopleura aureoradiata (c)
Elminius modestus (o)

Towards low tide substrates become soft and muddy

Alpheus sp. (a)
Hemiplax hirtipes (a)

22.C.4 Fish

Little is known of the fish u 'lising this area.

22.C.5 Birds

Kingfishers are abundant in the mangrove marshes of this area. On open flats small numbers of red-billed gulls, white-faced herons and pied stilts feed at low water. There are concentrations of gulls and stilts in areas with very soft substrates (see Area 22.E.5)

22.C.6 Edible Invertebrates

The only invertebrate reaching edible size in this area is the mud snail, *Amphibola crenata*. It is unlikely if this specie is exploited for food.

22.C.7 Natural Ecological Changes

Natural ecological changes to be expected in this area are a slow accumulation of soft sediments in sheltered areas resulting in a gradual transition of intertidal regions from mud flat to mangrove marsh to salt marsh to dry land. This natural process can be seen at the head of the shallow bay to the south and in the shelter of the shell barrier to the north.

A slow movement of shell barriers is to be expected. This is described in the Ecological Report on Special Environments.

22.C.8 Ecological Interference by Man

The high tidal regions in this area remain in fairly natural ecological conditions. On the lower part of the shore, however, there has been considerable disruption of natural communities by sedimentation and pollution. This is discussed in 22.E.8 and 22.E.9.

22.C.9 Pollution

There is no obvious pollution of the intertidal regions of areas above mid-tide level in this region. Pollution of low tidal areas by organic matter is considered serious. (see 22.E.9)

22.C.10 Ecological Value

This area has considerabl ecological value by virtue of the presence of the shell barriers. The combination of shell barriers, mangrove marsh, salt marsh, and sand flats is now becoming rare in the Waitemata ecosystem. Some similar areas have been destroyed, others lie under the threat of reclamation. This particular area is ecologically healthy and supports a wide variety of plants with natural invertebrate communities on its flanks. An area such as this could well assume increasing educational value in view of its easy accessibility and proximity to populated areas. The above-tidal portions of the barrier are of some value to bird populations of the area for roosting.

If this shell barrier was destroyed there would be little likelihood of the development of further shell barriers in this part of the Bay. The molluscs which produce the shell for such barriers have been killed by sediment deposition and pollution.

22.C.11 Improvement and Protection of Ecological Assets

At present the upper intertidal part of this area is in a healthy and natural ecological condition. Some protection can be afforded by careful development of adjacent land areas when this is required.

22.C.12 Potential Use of Ecological Assets

High tidal animal and plant communities of this area are well suited for educational purposes. Some use of this area has been made in the past, and it is likely that this will continue.

The shell barrier region is also an attractive area in which to walk and could well be suited for development as an environmental reserve.

22.D The Head of Shoal Bay

22.D.1 General Description

The area includes two shallow inlets at the head of the Bay on either side of Barrys Point, and another inlet extending to the east from the area outside the Esmonde Road approach to the motorway.

Large areas of the intertidal region of the inlet to the west of Barrys Point have been reclaimed, both for the motorway route, and as an organic refuse tip. The western side of this inlet is bordered by the motorway while the northern part is bordered by recreational playing fields with light industrial area at Barrys Point. Refuse tipping continues from the eastern side.

The inlet to the east of Barrys Point is still in a relatively natural state, apart from the narrowing of the entrance area by road reclamations and small reclamations at the rear of industrial properties on Barrys Point. Foreshores of the northern and eastern perimeter of this inlet are steep, tree covered and attractive, while surrounding land is residential.

The inlet extending to the east outside the bridge approach is bordered by residential properties. The intertidal region is shallow and largely occupied by mangrove, and foreshores are attractive with mature trees. Land between Esmonde Road and the entrance to this inlet is still in grass with a cliff foreshore and fringing pohutukawas.

22.D.2 Intertidal Substrates

Intertidal substrates of this area are variable in nature. In the inlet to the west of Barrys Point there has been considerable deposition of fine soft sediments making substrates extremely muddy. Much of the remaining intertidal region is occupied by mangrove.

The inlet to the east of Barrys Point is also occupied by mangrove marsh with soft muddy substrates.

Outside the Esmonde Road approach to the motorway substrates tend to be very soft in the middle of the Bay. In the mouth of the inlet to the east is an extensive mangrove marsh with large trees in the outer areas and smaller trees towards the head of the inlet. The inner five acres of this inlet is at a high intertidal level and supports a variety of salt marsh plants, on coarser substrates.

22.D.3 Intertidal Flora and Invertebrate Fauna

High tidal salt marsh - Ther is an extensive area of salt marsh in the inlet to the south of Esmonde Road.

Leptocarpus simplex
Salicornia australis
Plantago coronopus
Samolus repens
Helice crassa (c)
Ophicardelus costellaris (c)
Potamopyrgus antipodum (a)
Amphibola crenata (o)

Mangrove Areas - The mangrove marshes at the entrance to the inlet to the south of Esmonde Road, and in the inlet to the east of Barrys Point are in a fairly healthy condition, while that in the inlet to the west of Barrys Point is polluted to a varying degree dependant upon the intertidal level. The substrate around high tidal mangrove is relatively clean while that in low tidal regions is badly polluted. A normal fauna is still found in the clean areas, although densities of the common animals appear to be reduced.

Helice crassa (c)
Alpheus sp. (o)
Elminius modestus (c)
Crassostrea glomerata (r)
Amphibola crenata (c)

Open mud flat - upper intertidal

Open flats in the upper intertidal occur in a small area outside the organic refuse tip at Barrys Point, and also outside the Esmonde Road approach to the bridge motorway. These flats are still fairly clean at high levels but show the adverse effects of considerable sediment deposition and organic pollution of sediments towards low tide.

Clean areas — Chione stutchburyi (o)
Helice crassa (o)
Amphibola crenata (o)

Open mud flats - lower intertidal

Lower intertidal flats in this region show the adverse effects of considerable sediment deposition and organic pollution of sediments. The low tidal region of the stream bed to the west of Barrys Point has been badly affected by these factors and there is no macrofauna over most of this region.

22.D.4 Fish

Little is known of the fish in this area. Low tidal oxygen levels are often considerably reduced and would preclude the presence of most fish during that period.

22.D.5 Birds

Large numbers of black-backed gulls forage on the organic rubbish tip and also feed in the low tidal stream bed to the west of Barrys Point. Ducks also occur in the shallow waters outside the refuse tip.

Kingfishers are common amongst the mangrove where they feed on crustacea. Pukekos are common in the mangrove fringes. Small numbers of white-faced herons and pied stilts feed in the mangrove marsh at the entrance to the inlet south of Esmonde Road, and occasionally small flocks of pied stilts feed in the soft muds immediately outside the motorway access at Barrys Point.

22.D.6 Edible Invertebrates

The only edible invertebrates found in this area are the mud snail, Amphibola crenata, and the rock oyster, Crassostrea glomerata. Mud snails are not generally taken for food, and there are only small numbers of oysters attached to the larger mangroves. It would be inadvisable to consume shellfish from this area in view of poor water quality. (see Water Quality Report)

22.D.7 Natural Ecological Changes

Natural ecological changes to be expected in sheltered areas at the head of a shallow bay are associated with the gradual buildup of intertidal substrate level as a result of deposition of fine material from the water. The succession of mud flat, to mangrove marsh, to salt marsh, to land, is well illustrated in the bay to the south of Esmonde Road.

22.D.8 Ecological Interference by Man

Man has wrought considerable changes in this part of Shoal Bay. The construction of the motorway and access routes has required the reclamation of tidal areas; the development of land in the watershed has resulted in the contribution of large quantities of fine sediment to the Harbour with a consequent deterioration in the state of the local environment; the dumping of organic refuse in the tidal area to the west of Barrys Point has contributed to pollution of the fine sediments in the area.

22.D.9 Pollution

Liquor derived from the organic rubbish tip to the west of Barrys Point is contributing to the pollution of extensive areas of inter-tidal sediments, both immediately outside the tip and in the open low tidal areas of the main part of Shoal Bay. (see Area 22.E.9)

The tip liquor flows from the faces of the tip at a considerable rate causing substantial deterioration of water quality in the head of Shoal Bay. (see Water Quality Report, A.R.A.) It appears that organic material contained in the tip liquor has become incorporated in the soft sediments of the head of the bay leading to the formation of an anaerobic environment, the disappearance of common macrofauna, and the production of Hydrogen Sulphide. The effects of pollution of soft sediments appear to be gradually spreading towards the mouth of Shoal Bay (see Area 22.E.9)

There is also a possibility that considerable amounts of organic material are being introduced into the stream which runs through the inlet to the west of Barrys Point.

22.D.10 Ecological Value

The polluted part of this area, the inlet to the west of Barrys Point, and the low tidal area at the head of Shoal Bay are of little ecological value in their present state.

The shallow inlets to the east of Barrys Point and to the south of Esmonde Road are clean and healthy and are especially valuable in providing a large surface area for the oxidation of pollutants and re-oxygenising of oxygen-poor water derived from the inlet to the west of Barrys Point.

22.D.11 Improvement and Protection of Ecological Assets

The only way of improving the situation at the head of Shoal Bay is to prevent the contribution of fine sediments and organic pollutants to the Harbour in this area. Reclamation of offensive areas will only direct the concentrated effluent further out into Shoal Bay where the effects might well prove more catastrophic than they are at present.

The uncontrolled dumping of waste material into the inlet to the east of Barrys Point should also be prevented.

22.D.12 Potential Use of Ecological Assets

The principal use of the ecological assets of this region are as part of a residential environment. The natural state of the inlet to the south of Esmonde Road is well appreciated by those people who live in the area.

22.E. The Centre of Shoal Bay

22.E.1 General Description

There is an extensive low tidal area in the centre of Shoal Bay which has been considerably altered from its natural state, first by the deposition of fine sediments and later by the pollution of the fine sediments with organic material.

22.E.2 Intertidal Substrates

Substrates of this region are a homogeneous soft glutinous mud, except for a few small areas where there are accumulations of shell on the surface and in the bed of the low tidal channel where the current grades the sediments leaving a fine sand.

22.E.3 Intertidal Flora and Invertebrate Fauna

There are only two common macrofauna species found over most of this area, and even these two crustacea are excluded from the worst polluted areas.

Hemiplax hirtipes (c)
Alpheus sp. (c)

The soft muds in which these animals are found are up to 40 cm deep over the previously sandy bottom substrate. Beneath the deep mud the shells of molluscs associated with clean sand communities are abundant. Species once present include :

Chione stutchburyi (shells 40mm +)
Mactra ovata
Nucula hartvigiana
Alcithoe arabica
Struthiolaria vermis
Cominella adspersa
Cominella glandiformis

The presence of Alcithoe shells in large numbers indicates that much of the area of Shoal Bay was probably occupied by Zostera or eelgrass beds.

22.E.4 Fish

Occasionally there are extremely large numbers of flatfish in this area. These are caught by commercial fisherman. Small numbers of parore also occur.

22.E.5 Birds

Large numbers of red-billed gulls are characteristic of this region, particularly the less polluted areas towards the mouth of the Bay. Pied stilts are also common, with a few white-faced herons.

22.E.6 Edible Invertebrates

There are no edible invertebrates in this area.

22.E.7 Natural Ecological Changes

There are no natural changes to be expected in this region at present. If organic pollution decreases there will probably be an increase in population levels of Hemiplax hirtipes and Alpheus sp.

22.E.8 Ecological Interference by Man

There are two processes occurring in this area which are detrimentally affecting the ecology.

1. Deposition of fine sediments.
2. Organic pollution of fine sediments.

The contribution of large quantities of fine sediment to the Harbour during development of watershed areas is a widespread problem. In the low tidal area of Shoal Bay extreme alteration of the natural environment has occurred, and previously healthy clean-sand invertebrate communities have been smothered and buried to depths up to 40 cm.

22.E.9 Pollution

The incorporation of organic pollutants into the fine sediments of this area has resulted in a deterioration of the environment and a reduction in variety and abundance of invertebrate species.

Apparently the organic pollutant material is derived from both the Barrys Point Rubbish Tip and other sources contributing to the stream and inlet to the west of Barrys Point.

The worst affected areas are near the low water mark towards the head of the Bay, where the sediment environment is anaerobic and smells strongly of hydrogen sulphide. Muds are black and glutinous immediately beneath the surface. Towards the mouth of the Bay the effects are less serious but the results of organic pollution of soft low tidal sediments can be detected more than half a mile outside the bridge at Barrys Point.

It is difficult to tell whether the situation is improving or deteriorating at present. The smell of hydrogen sulphide in the tip area in calm periods is apparently as bad as it has been in the past.

22.E.10 Ecological Value

This part of Shoal Bay has little ecological value in its present state.

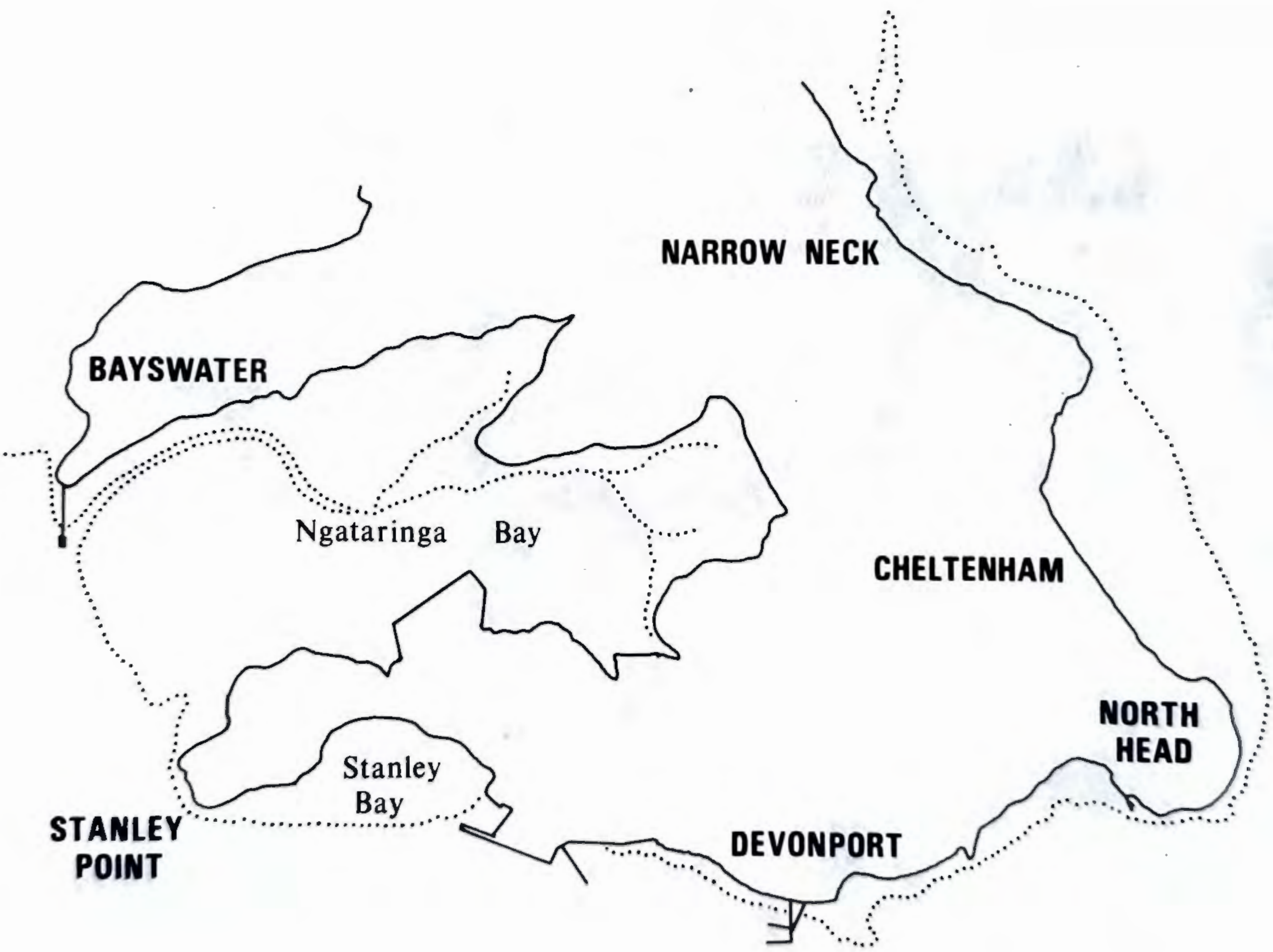
22.E.11 Improvements and Protection of Ecological Assets

Substantial improvements to the ecological condition of this area would be made by preventing `e contributions of any suspended sediments or organic materi .o tidal areas.

22.E.12 Potential Use of Ecological Assets

The principal value of this part of Shoal Bay is as a visual amenity. Fortunately, from the point of view of the public, the worst polluted areas are well away from the shore. The smell from polluted substrates is a considerable nuisance to local residents and is perhaps the most obvious indication that there is something amiss with the state of the environment in the area.

AREA 23



NGATARINGA BAY — CHELTENHAM

AREA 23 NGATARINGA BAY TO CHELTENHAM

This is a region of considerable variation in terms of both the intertidal and foreshore areas and in the natural flora and fauna.

The ecology is considered in four sections.

A. Ngataringa Bay
B. Stanley Point to North Head
C. North Head
D. Cheltenham

23.A. Ngataringa Bay

23.A.1 General Description

Almost all of this bay is exposed at low water with only a shallow and narrow low tidal channel.

Foreshores are variable with high sandstone cliffs to the east of Bayswater Wharf, on Duders Point, and on the southern side near the entrance to the Bay. In most of the remaining area the land rises steeply from the tidal region, apart from the head of the Bay near Lake Road and the Defence area where there have been extensive reclamations. Steeper foreshores retain considerable numbers of native trees and shrubs which are important in terms of their visual impact.

Most of the surrounding land is residential with large numbers of houses overlooking the Bay waters and intertidal region. Reclamations on the south side of the Bay are designated for defence purposes, and reclamation at the head of the Bay is proceeding by the dumping of inorganic rubbish.

23.A.2 Intertidal Substrates

Intertidal substrates of Ngataringa Bay are variable. Near the head of the Bay there is an extensive mangrove marsh with soft muddy sediments. In this region sediment deposition appears to be occurring at a rapid rate. A series of shell barriers partially protects the mangrove region, while outside the shell there are wide intertidal flats, muddy in some areas towards the head of the Bay but firm over most of the region to the west of Duders Point. Accumulations of shell occur in some places and there are patches of boulders on the southern side.

Hard shores are generally restricted to upper intertidal levels beneath the cliffs, although near the entrance to the Bay on the southern side the sandstone cliff faces and boulders extend below low tide level.

23.A.3 Intertidal Flora and Invertebrate Fauna

The flora and fauna are described for a number of representative habitats.

Bayswater Wharf - A basalt wall extends around the wharf reclamation, and supports a typical rock wall fauna. (See Area 12, Area 21.)

To the immediate west of the wharf reclamation there are some low tidal sandstone reefs, which support a thicket of brown algae

Sargassum sinclairii
Carpophyllum flexuosum
Ecklonia radiata

Inside the wharf there is an area of fine soft sediments where the substrate is sheltered from wave action. Common fauna includes:

Alpheus sp. (c)
Hemiplax hirtipes (a)
Cominella adspersa (c)

A few Chione stutchburyi and Amphidesma australe are found in small firm patches at the foot of the basalt wall.

Cliffs to the east of Bayswater Wharf - The sandstone cliffs of this area rise almost vertically for 100 feet above the intertidal zone. The soft rock is eroding rapidly in places exposing bare faces of yellow sandstone. Pohutukawa cling precariously to ledges along with toitoi and a variety of smaller shurbs and grasses.

Immediately above high tide level there is a zone with blue-green encrusting algae, best developed in damp areas. In winter a band of bright green Enteromorpha sp. is well developed about high water level.

There are few boulders about the high water mark, but beneath those in the upper intertidal are found

Melagraphia aethiops (c)
Zediloma atrovirens (o)
Lunella smaragda (o)
Zeacumantus subcarinatus (c)
Lepsiella scobina (o)
Cominella glandiformis (c)
Sypharochiton pelliserpentis (o)
Hemigrapsus edwardsi (c)
Petrolisthes elongatus (c)
Elminius modestus (o)

In the mid tidal region there are some outcrops of sandstone from a generally muddy substrate. These support

algae
Gelidium caulacantheum
Corallina officinalis
Hormosira banksii
Scytothamnus australis
Corallina officinalis

fauna
Sphaeroma quoyana (c)
Hemigrapsus crenulatus (o)
Elminius modestus (c)
Lunella smaragda (o)
Onchidella nigricans (c)
Sypharochiton pelliserpentis (c)
Cominella maculosa (o)
Cominella glandiformis (o)
Anchomasa similis (o)

Areas of firm sandy substrate - Much of the inner part of the Bay is at about half the level and has a firm sandy substrate. Common fauna include

Chione stutchburyi (c)
Macomona liliana (a)
Nucula hartvigiana (c)
Zeacumantus lutulentus (c)
Zediloma subrostrata (o)
Micrelenchus huttoni (o)
Notoacmea helmsi (c)
Xymene plebejus (c)
Cominella glandiformis (c)
Cominella adspersa (c)
Hemiplax hirtipes (o)
Elminius modestus (o)
Hemigrapsus crenulatus (o)
spionid polychaetes (a)
Pomatoceros caeruleus (o) (on shell)
Anthopleura aureoradiata (c)

Towards the head of the Bay there are remains of dense beds of Mactra ovata and large numbers of dead shells of Alcithoe arabica.

In firm clean sand	Notomastus zeylanicus (c) Calianassa filholi (c)

Low tidal sand flats - Low tidal flats across the mouth of Ngataringa Bay support a clean sand fauna

Soletellina nitida (c)
Macomona liliana (c)
Cominella glandiformis (c)
Cominella adspersa (o)
Baryspira australis (o)
Callianassa filholi (c)
Glycera sp. (c)
Marphysa sp. (c)
Asychis theodori (c)
spionid polychaetes (a)

Mangrove areas near the head of the Bay

Helice crassa (a)
Alpheus sp. (o)
Potamophygus antipodum (c)
Amphibola crenata (c)

Soft muds outside the mangrove and near low water:

Hemiplax hirtipes (c)
Alpheus sp. (a)
spionid polychaetes

Sandstone reef and boulders of Duders Point - A band of blue-green algae is found above high tide mark and a zone of green Enteromorpha sp. occurs in winter.

High tidal boulders		Cyclograpsus lavauxi (c) Lygia sp. (a) Talorchestia sp. (c)
Mid tide reefs	algae	Gelidium caulacantheum Hormosira banksii
	fauna	Zediloma subrostrata (a) Zeacumantus subcarinatus (a) Zeacumantus lutulentus (a) Lepsiella scobina (c) Lunella smaragda (c) Melagraphia aethiops (a) Amaurochiton glaucus (c) Modiolus neozelanicus (r)

Sphaeroma quoyana (c)
Hemigrapsus crenulatus (c)
Petrolisthes elongatus (c)
Nicon aestuariense (o)
Eulalia microphylla (c)
Dendrostomum aeneum (o)

Most of the above species tend to be most common on the more exposed and cleaner platforms and rocks near Duders Point and less common towards the head of the Bay where the sandstone is covered with increasing quantities of silt.

23.A.4 Fish

The low tidal sand flats of Ngataringa Bay are of considerable value to fish populations of the Harbour. Holes dug by demersal species in search of invertebrate food are consistently present over a wide area. Demersal species also penetrate towards the head of the Bay where concentrated feeding activity occurs near the low tidal channels.

This large shallow Bay is of considerable value to flatfish populations and most of the common Harbour fishes will be found in this area at times.

23.A.5 Birds

The extensive intertidal area of this bay is utilised by large numbers of shore feeding birds in obtaining invertebrate food.

Common species include red-billed gull, black-backed gull, pied stilt, white-faced heron. Fish feeders include pied shag and little black shag, with white-fronted tern and Caspian tern feeding when the tide is in. In mangrove fringing the head of the bay there are small numbers of pukeko, banded rail and mallard duck.

23.A.6 Edible Invertebrates

There are only small numbers of edible shellfish in Ngataringa Bay. Although Chione stutchburyi is widespread populations of edible size occur only in small areas near the low tidal channel.

The shells of large numbers of Mactra ovata indicate that this species was once abundant, although it is now all but absent.

There is a possibility that large areas of low tidal sandy substrates could be colonised by Chione populations and that beds of edible sized individuals be formed.

23.A.7 Natural Ecological Changes

There are no natural changes of any great ecological consequence occurring in Ngataringa Bay at the present time. There is some accumulation of soft sediments near the head of the Bay with a slow spread of mangrove, although the area affected in this way is largely confined by the shell bars. With time new shell barriers might be expected to form further out in the Bay and move slowly shorewards.

23.A.8 Ecological Interference by Man

Reclamation has removed considerable areas to tidal land from the head of Ngataringa Bay, and further reclamations are approved for this region. The affect of these reclamations on the remaining area of the Bay has been negligible, although it is difficult to assess the ecological impact of their removal from the tidal environment. The shallow flats of sheltered areas such as the head of Ngataringa Bay are valuable for their function of maintaining water quality and producing natural organic detritus which is utilised as food in other parts of the Harbour.

Development of the surrounding land may have resulted in the contribution of some inorganic silts and clays to the tidal region. Accumulation of soft sediments in sheltered regions appears to have been rapid.

23.A.9 Pollution

The cumulative effect of many small pollutant contributions from local residents poses a localised threat to the intertidal ecology of Ngataringa Bay. Much of the foreshore is untidy, particularly those areas at the bases of cliffs from which a variety of rubbish has been dumped.

Small quantities of fuel oil escaping from the defence area have become incorporated into the sediments and appear to remain there for a considerable period. Oil pollution has had no widespread ecological consequence as yet.

The inorganic rubbish tip at the head of the Bay is a source of some pollution, mainly through interactions of metals with salt water in a soft mud environment.

23.A.10 Ecological Value

The soft shores of Ngataringa Bay support a variety of natural and healthy invertebrate communities. This area has considerable value because of its size alone; there are few similar areas in the Waitemata Harbour ecosystem of comparable extent having comparable biological attributes.

The large surface area of intertidal substrate and the large shallow water area at high tide are both potentially important factors in maintaining or improving water quality.

23.A.11 Improvement and Protection of Ecological Assets

The introduction of foreign material to tidal regions with soft substrates can cause significant changes in the nature of the sedimentary environment. The best protection from adverse changes is afforded by keeping the foreshores clean and preventing the contribution of pollutant material from the land.

23.A.12 Potential Use of Ecological Assets

At present there is very little direct use of the ecological assets of Ngataringa Bay, apart perhaps from a small amount of recreational fishing and flatfish netting. This situation is unlikely to change, although there is a possibility that beds of edible-sized Chione stutchburyi could form in low tidal regions, in which case these would probably be exploited for food.

The natural ecology of Ngataringa Bay is an important part of its function as an aesthetically-pleasing portion of the environment of the City of Auckland.

23.B. Stanley Point to North Head

23.B.1 General Description

Foreshores in the Stanley Point area consist of high sandstone cliffs with bare faces in steep regions and attached vegetation with pohutukawa predominant where the slope is less steep. From Stanley Bay to North Head the foreshore has been considerably modified by reclamation and the construction of basalt retaining walls. Wharves at Devonport and in the naval area project from the shoreline into deep water.

Much of the surrounding land, apart from the naval dockyards, is residential, with large numbers of houses overlooking the Harbour.

23.B.2 Intertidal Substrates

At the base of the sandstone cliffs at Stanley Point there are accumulations of sandstone boulders in the upper intertidal with sand-stone reefs and areas of coarse sand extending to low water. Shelving platforms extend to the east in the Stanley Bay region with soft substrates in the Bay itself and towards low water.

Most of the intertidal zone between Stanley Bay and North Head is occupied by basalt retaining walls made from fitted basalt blocks, although towards the Devonport Wharf there are accumulations of boulders and some sandy substrates at the foot of the wall. At the naval wharves and Devonport Wharf there are concrete and wooden pilings. To the east of Devonport Wharf there are small beaches of sand and shell with some natural larva flows and broken rock.

23.B.3 Intertidal Flora and Invertebrate Fauna

The flora and fauna of this region are described for a number of representative habitats.

Stanley Point - On sandstone faces above high water mark there is a conspicuous band of blue-green algae, particularly well developed in areas with fresh water seepage. In winter a band of bright green *Enteromorpha sp.* is found about the high water mark.

Beneath high level boulders

Ligia sp. (a)
Cyclograpsus lavauxi (c)
Talorchestia sp. (a)
Zediloma atrovirens (c)

Beneath mid tidal boulders

Zeacumantus subcarinatus (c)
Melagraphia aethiops (a)
Onchidella nigricans (c)
Sypharochiton pelliserpentis (c)
Haustrum haustorium (o)
Lepsiella scobina (c)
Crassostrea glomerata (o)
Modiolus neozelanicus (o)
Elminius modestus (c)
Petrolisthes elongatus (a)
Hemigrapsus edwardsi)o)
Sphaeroma quoyana (o)
Eulalia microphylla (c)
bdellid mite (c)
nemertean (pink) (c)

On open rock surfaces there is a growth of the brown alga Gelidium caulacantheum just below high tide level. Toward mid tide level there are occasional clumps of Crassostrea glomerata and Pomatoceros caeruleus, particularly where the substrate is stable. High tidal pools contain filamentous algae and Anthopleura aureoradiata.

Below mid tide level there is a general coverage by the algae Hormosira banksii and Corallina officinalis on hard surfaces. Fauna associated with low tidal rock ledges are

Buccinulum heteromorphum (a)
Neothais scalaris (o)
Penion adusta (o)
Taron dubius (o)
Cabestana spengleri (r)
Sypharochiton pelliserpentis (c)
Anomia walteri (c)
Ostrea sp. (a)
Anchomasa similis (o)
Pholadidea spathulata (r)
Petrolisthes elongatus (c)
Pilumnopeus serratifrons (c)
Cancer novaezelandiae (o)
Coscinasterias calamaria (c)
Watersipora cucullata (a)

Below low water spring there is a band of large brown algae attached to the rock surfaces

Sargassum sinclairii
Ecklonia radiata
Carpophyllum maschalocarpum

Stanley Bay - The small beach at Stanley Bay is formed of loose sand and shell and is fronted by a basalt retaining wall. About low water neap the sloping beach gives way to a gently shelving flat of clean sand of which a considerable area is exposed on low spring tides.

Very few animals are to be found on the mobile sloping part of the beach, apart from concentrations of amphipods associated with drift material.

On the sand flat a typical fauna is present

Chione stutchburyi (a)
Nucula hartvigiana (c)
Macomona liliana (a)
Cominella adspersa (c)
Cominella glandiformis (a)
Hemiplax hirtipes (c) (soft areas)
Marphysa sp. (o)

Devonport waterfront - East of the navy dockyards the foreshore is faced with a basalt block wall which extends over the full tidal range to the west but leaves a shore with boulders and patches of sand exposed towards the wharf. Immediately west of the Devonport Wharf is a beach of yellow sand and shell.

Fauna of basalt walls

Melarapha oliveri (a)
Cellana ornata (c)
Melagraphia aethiops (a)
Sypharochiton pelliserpentis (a)
Lunella smaragda (a)
Cominella maculosa (c)
Cominella virgata (c)
Lepsiella scobina (a)
Crassostrea glomerata (a)
Onchidella nigricans (a)
Chamaesipho columna (a)
Elminius plicatus (r)
Eulalia microphylla (c)

Fauna associated with boulders at the foot of the basalt wall - west of Devonport Wharf.

Amaurochiton glaucus (c)
Ischnochiton maorianus (a)
Terenochiton inquinatus (a)
Onithochiton neglectus (o)
Lunella smaragda (c)
Taron dubius (o)
Cominella maculosa (c)
Cominella virgata (c)

Buccinulum heteromorphum (c)
Sigapatella novaezelandiae (c)
Haustrum haustorium (o)
Neothais scalaris (o)
Onchidella nigricans (o)
Zemitrella chaova (c)
Dardinula sp. (a)
Estea sp. (a)
Anomia walteri (c)
Perna canaliculus (o)
Ostrea sp. (c)
Paramithrax sp. (o)
Petrolisthes elongatus (c)
hermit crabs (a)
Elminius modestus (c)
amphipods (a)
Spirorpis sp. (c)
Filograna sp. (c)
terebellid polychaete (c)

Corella eumyota (o)
Microcosmus kura (c)
Asterocarpa caerulea (o)
Aplidium sp. (c)
Ciona intestinalis (c)
Watersipora cucullata (c)
bryozoa (c)
Beania sp. (c)
Paractis ferax (c)
Anthopleura aureoradiata (o)
Isactinia olivacea (o)
sponges (c)
brittle star (r)
Patiriella regularis (o)
Coscinasterias calamaria (o)

Low tidal sand	Chione stutchburyi (o) Protothacca crassicostata (o) Cominella adspersa (o) Alcithoe arabica (r)
Algae on low tidal rocks	Corallina officinalis Colpomenia sinuosa Dictyota sp. Sargassum sinclairii Codium adhaerens

Devonport to North Head - Devonport Wharf

The vertical faces of wharf pilings provide ideal habitats for sedentary fauna. At Devonport the fauna is particularly rich because of the strong food bearing current.

About high water spring there is a zone with blue-green algae, while in areas with sufficient light intensity green Enteromorpha sp. occurs between high water spring and high water neap. About high water neap is a dense zone of Elminius modestus, with Modiolus neozelanicus zone forming in light areas. About mid tide level Crassostrea glomerata occurs, extending in a band to low water neap. Interspersed amongst the oysters are Watersipora cucullata and Pomatoceros caeruleus. About low water neap Perna canaliculus is common, extending below low water spring. Below low water neap there is a dense growth of Ostrea sp. and Microcosmus kura. In darker areas anenomes, Actinothoe albocincta and compound ascidians, Aplidium phortax, are abundant.

To the east of Devonport Wharf the foreshore is faced with a basalt wall, which extends a variable vertical distance into the intertidal zone. Along most of the wall there is a buildup of sand, sometimes high enough to form a beach above high water mark. Intertidally there are basalt larva flows and broken basalt boulders with occasional patches of sand and shell.

Broken reef with boulders		
	High tide	Melarapha oliveri (c)
	Mid tide	Melagraphia aethiops (a)
		Nerita melanotragus (c)
		Sypharochiton pelliserpentis (c)
		Notoacmea helmsi (c)
		Cominella maculosa (c)
		Lepsiella scobina (c)
		Haustrum haustorium (o)
		Onchidella nigricans (c)
		Crassostrea glomerata (c)
		Elminius modestus (c)
In pools		Anthopleura aureoradiata (c)
	algae	Hormosira banksii
		Corallina officinalis

Towards low water neap the rock surfaces support several species of algae. Scytothamnus australis appears in autumn between mid tide and low tide neap. Hormosira banksii is also abundant in this region, with Corallina officinalis covering low tidal rock surfaces. Splachnidium rugosum is abundant in autumn immediately above the Corallina.

In shaded areas at low water neap the green alga Codium adhaerens is common, while below low water larger brown algae grow on the reef fringes

Ecklonia radiata
Carpophyllum flexuosum
Sargassum sinclairii

Low tidal boulders support a similar under-boulder fauna to that described for the low tidal region to the west of the Devonport Wharf. (above)

Sandy beach to the east of the wharf

Chione stutchburyi (c)
Baryspira australis (a)
Cominella adspersa (c)
Cominella glandiformis (c)

On the offshore sand bank are reputed to be

Pecten novaezelandiae
Atrina zelandica

although these were not seen on the present survey.

23.B.4 Fish

The rocky intertidal and subtidal fringe of this region support a variety of invertebrates that are important as fish food. Fringing thickets of low tidal brown algae also provide shelter for smaller fish.

The Devonport Wharf is a popular site for recreational fishing with a variety of common Harbour fish being taken. Whitebaiting which was once popular appears to be on the decline owing to the lack of substantial runs of this migrating fish.

23.B.5 Birds

Red-billed gulls and black-backed gulls are generally common in this area, feeding both on the shores and on detritus in the water. The occasional white-faced heron and pied stilt feed in the Stanley Bay region, but other shore feeders are absent. Pied shag often feeding in the water, with the fish feeding white-fronted tern, Caspian tern, and gannet occurring in small numbers.

23.B.6 Edible Invertebrates

On the hard shores of this area Crassostrea glomerata is abundant and apparently taken in small quantities for food. Small quantities of Perna canaliculus may also be taken. The large Lunella smaragda found in the wharf area and on adjoining low tidal reefs are also taken.

On the soft shore at Stanley Bay there are some dense populations of edible sized Chione stutchburyi. These are apparently taken only in small numbers. Large Chione from the foot of the beach to the east of the Devonport Wharf are also taken in small numbers.

Scallops used to occur on the sandy bank to the east of the Wharf at about low spring tide mark. These were avidly sought for food. It is not known if any scallops remain.

At present levels of exploitation it is unlikely that shellfish populations are being depleted. The disappearance of scallops is probably a result of exploitation with a deterioration of water quality or substrate quality preventing the re-colonisation of the area.

23.B.7 Natural Ecological Changes

The intertidal zone in this region is stable and no naturally occurring changes can be predicted.

23.B.8 Ecological Interference by Man

This stretch of shore has been considerably altered by reclamation and the construction of basalt retaining walls and projecting wharves. These changes have probably resulted in an increase in biomass and faunal and floral diversity, while having little apparent effect on the ecology of surrounding areas.

23.B.9 Pollution

There has been considerable pollution of the fauna and flora on the rock retaining walls and soft bottom substrates in the region to the east of the naval dockyards. The principle source of this pollution appears to be oil, and other water-borne substances such as paint and tar. Quantities of such substances may be derived from Calliope Dock.

Pollution by glass and plastics is also a problem with considerable quantities of broken glass occurring in the vicinity of rocky reefs and walls against which floating bottles have been dashed.

23.B.10 Ecological Value

Despite the pollution mentioned above, the hard shores of this region support a rich fauna and flora. Strong tidal currents tend to minimise the pollutant impact. High biomass and faunal diversity, particularly in low tidal regions, are important in terms of the interactions of this region with other parts of the Harbour ecosystem.

23.B.11 Improvement and Protection of Ecological Assets

The best means of improving and protecting the ecology of this area is by preventing the contribution of polluting wastes from the shore.

23.B.12 Potential Use of Ecological Assets

At present direct use is made of the ecological assets of this shore by recreational fishing and gathering shellfish for food. These uses are unlikely to alter substantially.

The shores of the Devonport region are well suited for educational purposes because they support a rich fauna in natural conditions.

The health of intertidal invertebrate communities is also important to the recreational use of the area for swimming and boating.

23.C. North Head

23.C.1 General Description

The shores of North Head are generally fairly steep in the intertidal zone. Foreshores consist of reserve land which is grass-covered and falls steeply to the tidal region.

23.C.2 Intertidal Substrates

Intertidal substrates consist of hard basalt rock. Near vertical faces are common, although there are some horizontal faces in the region near Cheltenham.

23.C.3 Intertidal Flora and Invertebrate Fauna

Above high water mark there is an area of exposed rock which supports a well developed lichen zone, and small succulents such as Salicornia australis and Samolus repens in crevices.

About high water level Melarapha oliveri is common in aggregations in damp crevices or near small pools.

Upper intertidal barnacles (Chamaesipho columna) occur in small numbers, while in the mid tidal region there is a well developed oyster zone with a number of other common species amongst the oysters.

Nerita melanotragus (c)
Lepsiella scobina (a)
Melagraphia aethiops (c)
Sypharochiton pelliserpentis (a)
Anthopleura aureoradiata (c)

Gelidium caulacantheum is common in the oyster zone with Zeacumantus subcarinatus and Onchidella nigricans which eat this alga.

Hormosira banksii is found in shaded areas in the mid tidal region and extends over flat reefs near low water neap. Scytothamnus australis is abundant just above low water neap in the winter.

In the lower oyster zone a variety of predators are found

Cominella maculosa (c)
Cominella virgata (a)
Neothais scalaris (c)
Haustrum haustorium (c)

Low tidal organisms are similar to those described for the rock wall and boulder area. (23.B.3)

23.C.4 Fish

The rich sedentary fauna and flora of this region are of considerable value as food for fish populations. Deep water immediately offshore makes this region readily accessible to fish. A favoured spot for recreational fishing is situated immediately offshore in this area.

23.C.5 Birds

Only a few birds feed on this shore. Red-billed gulls and black-backed gulls are the most often seen. Oystercatchers and blue heron feed only occasionally.

Offshore waters are fished by pied shags, white-fronted terns, and gannets.

23.C.6 Edible Invertebrates

The dense oyster populations of this area are exploited to a small extent for food. Other common shellfish which may be taken in small numbers include Lunella smaragda and Perna canaliculus.

23.C.7 Natural Ecological Changes

There are no natural ecological changes to be expected in this area.

23.C.8 Ecological Interference by Man

There has been no obvious interference with the ecology of this area, apart from minor changes in the foreshore in the vicinity of Torpedo Wharf.

23.C.9 Pollution

Sewage pollution is having an adverse effect on the intertidal ecology in the vicinity of an outfall on the south-eastern side of North Head. Common zoning organisms including oysters and barnacles are substantially reduced in number and there is a marked increase in the abundance of green algae in the polluted area.

23.C.10 Ecological Value

The rich intertidal and subtidal flora and fauna of this area are of considerable value to the Harbour ecosystem.

23.C.11 Improvement and Protection of Ecological Assets

The prevention of sewage pollution of this area would mean considerable improvement to the intertidal ecology.

23.C.12 Potential Use of Ecological Assets

At present considerable use of this area is made for offshore fishing. Small quantities of shellfish are taken, and the region is also used for educational purposes by the University.

These direct uses of ecological assets are unlikely to alter, although there could be an increase in educational use if the area received reserve status. (See Report on Intertidal Reserves.)

23.D. Cheltenham Beach

23.D.1 General Description

Cheltenham is an attractive sandy beach fronted by private residential properties. The foreshore consists largely of private land with low retaining walls at the top of the beach.

23.D.2 Intertidal Substrates

There is an area of sand above the high spring tide mark. Intertidally there is a sloping beach of fairly coarse sand and shell, with coarser shell towards the foot of the beach. The foot of the sloping beach is at about low water neap, and below this there is an extensive sand flat which is exposed on low spring tides. On the sand flats there is a variation in sediment quality with coarser sands occurring near the foot of the sloping beach and fine sand near low spring tide mark.

23.D.3 Intertidal Flora and Invertebrate Fauna

A few amphipods, *Talorchestia sp.* are found beneath drift algae in the day time and wander over the beach at night. On the sloping part of the beach there is little infauna, probably a result of the coarse mobile substrate.

Towards the foot of the sloping beach near low water neap, where there is often a seepage of water emerging at the surface is a band containing a population of *Amphidesma australe*.

On the spring flat there are dense beds of Chione stutchburyi from close to the foot of the beach almost to the low spring tide mark.

Found with Chione

Macomona liliana (c)
Cominella glandiformis (c)
Cominella adspersa (a)
Cominella maculosa (r)
Xymene plebejus (o)
Baryspira australis (c)
spionid polychaetes (c)
Notomastus zeylanicus (c)

Towards low water spring beyond the dense Chione beds the substrate consists of fine clean sand.

Struthiolaria vermis (o)
Struthiolaria papulosa (r)
Pervicacia tristis (c)
Macomona liliana (c)
Angulus gaimardi (c)
Dosinea subrosea (c)
Myadora striata (c)
Pontophilus australis (c)
Ovalipes punctatus (o)
Urechis novaezelandiae (o)

In some areas where the substrate appears firmer

Balanoglossus australiensis (a)
Amphiura aster (a)

Towards low water there are also patches with

Echinocardium australe (c)
Arachnoides zelandiae (c)
Coscinasterias calaaria (o)

23.D.4 Fish

The dense beds of shellfish found on Cheltenham Beach and also the variety of additional infauna are probably of considerable food value to bottom feeding fish such as schnapper.

23.D.5 Birds

Few birds are seen at Cheltenham except on low spring tides when large aggregations of red-billed and black-backed gulls feed on the exposed flats.

23.D.6 Edible Invertebrates

Four species of edible bivalve shellfish are found at Cheltenham. There is a band of Amphidesma australe near the foot of the sloping beach. Individuals of this specie reach an edible size but are not often taken for food.

Dense beds of Chione stutchburyi occur on the spring tide flat. Chione in this area shows the fastest growth rate for the Waitemata Harbour reaching an edible size in less than three years. At present these beds are exploited for food by only a small number of people, and it appears that the threat of pollution is responsible for the lack of exploitation of a greater degree.

Two other edible shellfish, Macomona liliana, and Dosinia subrosea occur in low densities over wide areas of the low tidal flats. It is unlikely that these species are specifically sought for food.

23.D.7 Natural Ecological Changes

There are no obvious ecological changes to be expected in this area.

23.D.8 Ecological Interference by Man

There has been little interference with the ecology of the area by man.

23.D.9 Pollution

At times there are large quantities of toilet paper residue in the shallow pools remaining on the low spring tide flats. The source of this material is not known, although it may come from the outlet on North Head.

Quantities of drift material such as plastics, wood, glass and vegetables accumulate on the beach, and sometimes become partly buried on the spring tide flat. Such material detracts from the visual attributes of the area but is having little ecological impact at present levels.

23.D.10 Ecological Value

The low tidal flats of Cheltenham beach are unique in the Waitemata Harbour Ecosystem. A variety of soft shore animals which is finely adapted to exposure and substrate conditions occurs in numbers that are not found elsewhere in the Harbour.

The rich fauna important to fish, and large beds of bivalve filter feeders are important to water quality.

23.D.11 Improvement and Protection of Ecological Assets

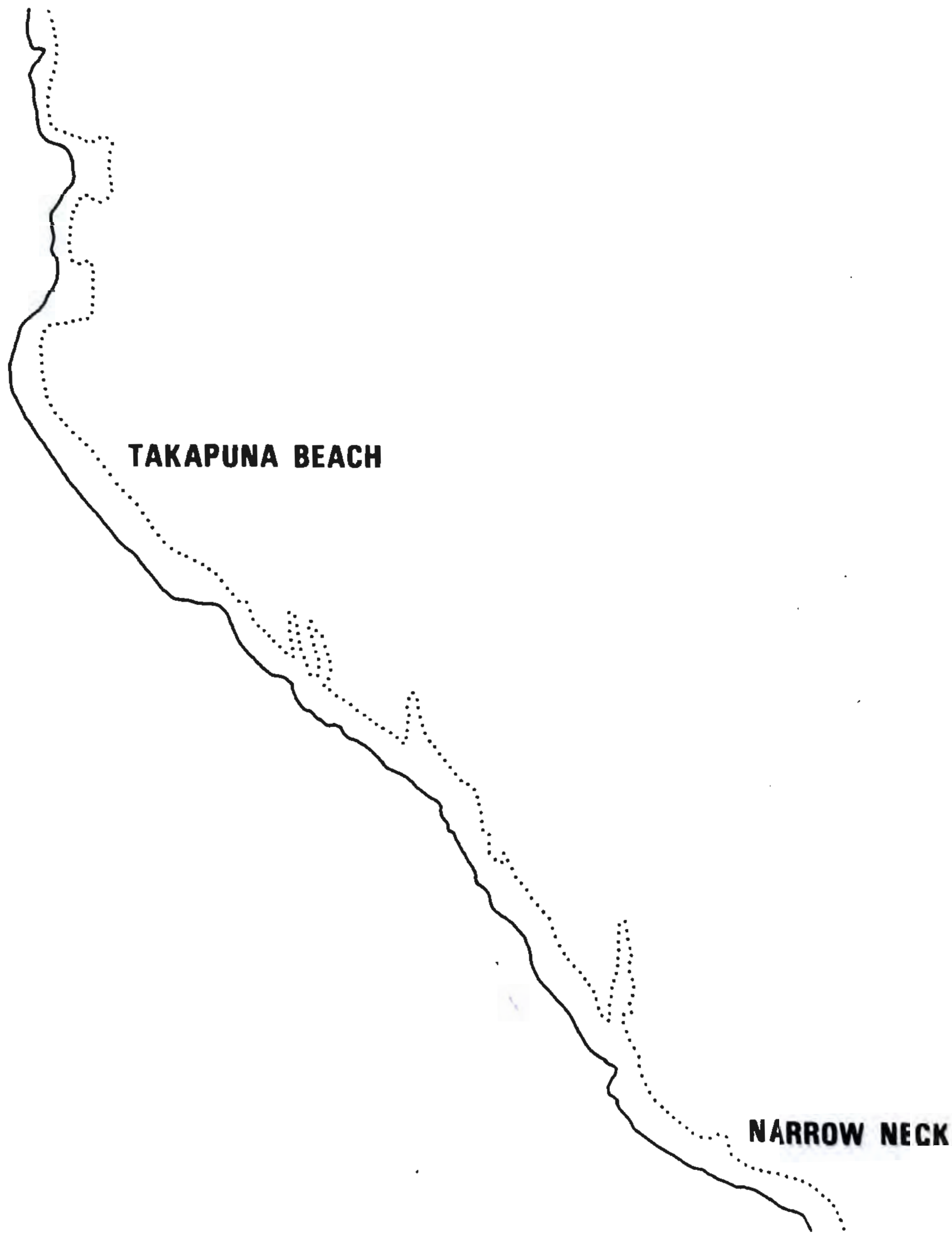
Obvious improvements can be made by preventing pollution. Pollution by sewage is of particular importance because of the use of shellfish populations for food. The quality of these animals should be tested.

23.D.12 Potential Use of Ecological Assets

This area at present is used to a considerable degree for educational purposes and collection of laboratory animals by the University of Auckland. Such use will continue.

Gathering of edible shellfish will also continue - this is one of the best sources in the Waitemata and should not be allowed to be polluted.

AREA 24



NARROW NECK TO TAKAPUNA

AREA 24 NARROW NECK TO TAKAPUNA

24.1 General Description

This is the most exposed shore in the Waitemata Harbour Study Area, with occasional easterly storms producing waves of considerable height in the Takapuna region.

Foreshores consist of high sandstone cliffs south of Takapuna Beach and between Narrow Neck Beach and Cheltenham, with lower land behind the beaches. The cliffed foreshores are particularly attractive with fringing trees and green vegetation contrasting with exposed faces of white and yellow sandstone. Immediately north of Takapuna Beach there is a foreshore of hard basaltic larva, the top of which has been reclaimed for car parking.

Much of the surrounding land is residential, although there is a foreshore reserve at Narrow Neck.

24.2 Intertidal Substrates

Within this area a variety of intertidal substrates is found. To the north of Takapuna Beach there are hard black basaltic larva flows. Cliffed areas and reefs between Takapuna and Narrow Neck and to the south of Narrow Neck consist of softer sandstone. Broken reefs and loose boulders are common in these regions. The beaches of Narrow Neck and Takapuna have clean sand sediments with small quantities of comminuted shell. A retaining wall faces the reserve at Narrow Neck while low walls front the private residences along Takapuna Beach.

24.3 Intertidal Flora and Invertebrate Fauna

The flora and fauna of this area are described for two basic habitat types: soft shores and hard shores.

Hard Shores - Hard shores of this area consist largely of broken sandstone reefs with a wide variety of niches.

Common fauna of open rock faces

Melarapha olivera (c)
Onchidella nigricans (c)
Sypharochiton pelliserpentis (c)
Cellana radians (c)
Cellana ornata (o)
Lunella smaragda (c)
Melagraphia aethiops (o)

Neothais scalaris (o)
Cominella virgata (c)
Lepsiella scobina (o)
Zeacumantus subcarinatus (o)
Modiolus neozelanicus (a)
Perna canaliculus (r)
Cleidothaerus maorianus (c)
Ostrea sp. (o)
Crassostrea glomerata (o)
Anchomasa similis (c)
Pholadidea spathulata (c)
Pholadidea tridens (o)
Zelithophaga truncata (o)
Sphaeroma quoyana (a)
Chamaesipho columna (a)
Elminius modestus (o)
Elminius plicatus (c)

Tethya aurantica (o)
Halichondria moorei (c)
Microciona coccinea (c)
Pomatoceros caeruleus (c)
Hermella spinulosa (o)
Anthopleura aureoradiata (c)
Isactinia olivacea (o)

A prolific fauna is found under stones and in crevices and pholad holes in the sandstone rock.

Anthopleura aureoradiata (c)
Diadumene neozelanicus (o)
Isactinia olivacea (o)
Acanthochiton zelandica (c)
Maoricrypta monoxyla (c)
Sigapatella novaezelandiae (c)
Risselopsis varia (c)
Melagraphis aethiops (c)
Notoacmea parviconoidea (a)
Anomia walteri (c)
Diplodonta striatula (o)
Arthritica crassiformis (o)
Notopaphia elegans (o)
Protothacca crassicosta (o)
Paphirus largillierti (o)
Leptomya retiaria (r)
Hiatella australis (c)
Bankia australis (o)
Trichomusculus barbatus (o)
Perinereis novaehollandiea (o)
Eulalia microphylla (c)
Lepidonotus jacksoni (c)
syllid (o)
Stylarioides parmatus (c)
Idyanthyrsus quadricornis (o)
Dasychone sp. (o)
Spirorbis sp. (a)
Hydroides norvegicus (c)
spionid polychaetes (o)

Dendrostomum aeneus (o)
Coelopus littoralis (c)
bdellid mite (c)
Styela plicatus (c)
Watersipora cucullata (c)
other bryozoa (c)

Algae - The algae listed below were mainly recorded by Dellow in her paper 'Inter-tidal Ecology at Narrow Neck Reef, New Zealand'. (Pacific Science Vol. IV pp 355-374)

High level - about mean high water

Calothrix scopulorum
Rhizoclonium riparium
Enteromorpha procera var minuta
Lyngbya lutea
Lophosiphonia macra
Microcoleus actissimus

Mean high water level to mid tide level

Gelidium pusillum
Gelidium caulacantheum
Ralfsia verrucosa
Centroceras clavulatum
Scytothamnus australis
Splachnidium rugosum
Pyaliella novaezelandiae
Caulacanthus spinellis
Bangia vermicularis

Lower Intertidal

Codium adhaerens
Caulerpa sedoides
Microdyction mutabile
Symphocladia marchantioides
Corallina officinalis
Colpomenia sinuosa
Laurencia botrychioides
Laurencia thyrsifera
Dictyota ocellata
Derbesia novaezelandiae

Sub-littoral fringe

Peysoniella atropurpurea
Melobesia sp.
Acrosorium decumbens
Ulva lactuca
Carpophyllum maschalocarpum
Carpophyllum plumosum
Carpophyllum flexuosum
Ecklonia radiata
Sargassum sinclairii
Cystophora torrulosa
Cystophora retroflexa
Ectocarpus indicus
Gloccophora kunthii

Pterocladia lucida
Myriogramme gattayana
Zonaria angustata
Cladhymenia oblongifolia
Schzymenia novaezelandiae
Grateloupia polymorpha

Takapuna Beach - soft substrate

On the upper beach, above all but the highest spring tides there is an area of clean white sand. Beneath drift algae, or burrowing in the sand about high water mark are found

Talorchestia sp. (a)
brown isopod (c)

Talorchestia extends for some distance down the sloping beach where it is the only common macrofaunal species.

About low water neap where the substrate appears to be more stable, is the upper limit of dense beds of Amphidesma subtriangulatum, the tuatua. Beds of this species are in a band about 30 metres wide between low water neap and low water spring. Small numbers of Cominella adspersa are found with the Amphidesma subtriangulatum, and occasional Glycera sp. Ovalipes punctatus is common at low water mark.

Low tidal substrates appear extremely mobile and there is no common macrofauna.

Narrow Neck Beach - A seawall truncates the upper beach and drift material tends to be collected in the one small high tidal patch of sand near the boat ramp. Amphipods and isopods of the upper beach, such as those which are common at Takapuna, are reduced at Narrow Neck.

Towards the foot of the sloping beach there are small numbers of Amphidesma subtriangulatum with the occasional Glycera sp.

In marked contrast with Takapuna Beach, there is a low spring tide flat at Narrow Neck. This flat supports a fauna which is similar to that found over large areas at a similar level at Cheltenham.

Dosinea subrosea (o)
Amphiura aster (o)
Balanoglossus australiensis (a)
Glycera sp. (c)
haustoriid isopod (o)

24.4 Fish

Little is known of the fish in this area. The rich fauna and flora of the rocky reefs are undoubtedly important sources of food for fish populations, and the reefs themselves important as protection for small species or juvenile populations.

High density shellfish beds of Takapuna Beach may be an important food source to demersal feeders such as schnapper.

24.5 Birds

The most common shore feeding birds in this area are red-billed and black-backed gulls which are widespread when feeding at low tide. Oystercatchers and blue herons occasionally feed on the low tidal rocky reefs.

Of the fish feeders, pied shags occur in small numbers, and there are often numbers of white-fronted terns and gannets feeding offshore.

24.6 Edible Invertebrates

The dense beds of tuatua, Amphidesma subtriangulatum on Takapuna Beach are exploited for food by small numbers of people. It appears that many local residents do not take these shellfish because they are frightened they are polluted.

Small numbers of Dosinia subrosea occur on the spring tide flat at Narrow Neck but it is unlikely that these are taken.

Small numbers of mussels, Perna canaliculus, and oyster-like bivalve, Cleidothaerus maorianus, are taken from the low tidal rocky reefs.

24.7 Natural Ecological Changes

There are no obvious ecological changes occurring, or expected to occur, in this area.

24.8 Ecological Interference by Man

Small areas of this shore have been altered by reclamation and the forming of retaining walls. Ecological impact outside these areas has been negligible.

24.9 Pollution

Most pollution of this area is caused by water-borne material, either from the Harbour or from the more open waters to the north. Quantities of glass occur in rocky areas, and plastics, wood, and cans accumulate near the high tide mark. The popular beach areas are cleaned.

A small area near the stormwater outfall at St Leonards Point is polluted by sediments and what appears to be small quantities of oil or tar.

24.10 Ecological Value

The rocky reefs of this area are some of the richest and therefore most valuable habitats in the Waitemata Harbour ecosystem. More exposed conditions enable colonisation by a number of animals and plants that are not common in more sheltered areas, and there are extremely high biomasses near the low water mark of rocky areas.

24.11 Improvement and Protection of Ecological Assets

At present the ecology of this area is natural and healthy. Water quality is potentially the most important factor in maintaining this condition. Deteriorating water quality in terms of heavier sediment burdens will affect algal survival by reducing light penetration. Toxic pollutants will affect the larval stages of invertebrates.

24.12 Potential Use of Ecological Assets

At present, direct use of the ecological assets of this area is made by recreational fishing and shellfish gathering. Large numbers of small craft are launched in this area to fish in the near vicinity offshore. Shellfish gathering occurs at a low level because large numbers of people believe the shellfish could be polluted.

This area is used to a small extent for educational purposes. Many excellent examples of reef and beach habitats are present, and further documentation of these could well lead to further educational interest. In the report on Intertidal Reserves, the possibility of establishing a reserve at St Leonards Point is discussed.

AREA 25 RANGITOTO ISLAND

25.1 General Description

Rangitoto Island is an almost circular dormant volcano. Included in the Waitemata Harbour Study Area is the southern part of the coastline from the Rangitoto Beacon in the west to the head of Islington Bay in the east.

Foreshores consist of natural larva flows with extensive areas of rough broken rock. Vegetation is sparse over much of the foreshore apart from the region near Islington Bay where finer soils have formed.

25.2 Intertidal Substrates

Intertidal substrates consist largely of larva flows of broken rock and loose boulders. The shoreline is strongly indented with small enclosed bays sheltered by projecting reefs. In the sheltered areas there has been considerable accumulation of fine silts on the rocky surfaces. Small beaches of broken rock and shell occur in exposed areas. In the vicinity of Rangitoto Beacon there are a series of reefs and rock outcrops extending from the shore with stretches of firm clean sand between the rock.

25.3 Intertidal Flora and Invertebrate Fauna

Most of the algae listed were recorded by Carnahan, 1952, in his paper, 'Intertidal Zonation at Rangitoto Island, New Zealand'.

The hard rock surface of Rangitoto shores is ideal for attachment of sedentary species, and the broken reefs and boulders provide a wealth of niches which are occupied by a wide diversity of animals and plants.

High tide level - Above high tide level the rock surfaces are colonised by a number of lichens

Lichina pygmaea
Bostrychia mixta

About high water mark where some sediment is present crusts of blue-green algae are common

Calothrix scopulorum
Lyngbya semiplena
Phormidium ambiguum
Oscillatoria nigroviridis

Small algae are found in shaded areas high on the shore

Ralfsia sp.
Placoma vesiculosa
Caloglossa leprieurii
Catenella nipae
Hildenbrandia protyopus

The periwinkle, Melarapha oliveri, is common about the high water mark where it is found in small damp crevices.

Below high water neap there is a variously developed barnacle zone with Elminius modestus in sheltered regions and Chamaesipho columna in more exposed areas. Common algae at this level are

Apophloea sinclairii
Gelidium pusillum

Mid tide level - Between mid tide level and low water neap there is a well developed oyster zone, with a typical and rich assemblage of associated invertebrates. (See Area 23 for common species).

Below the oysters a well developed zone of the tube work Pomatoceros caeruleus is formed on clean rock surfaces.

About low water neap several algae become common

Corallina officinalis
Hormosira banksii
Scytothamnus australis
Colpomenia sinuosa
Splachnidium rugosum

The green algae Codium adhaerens is found in shaded areas, while about low spring tide elvel and low a fringe of larger brown algae is well developed.

Sargassum sinclairii
Ecklonia radiata
Carpophyllum flexuosum

In more exposed areas typical low tidal algae include:

Carpophyllum maschalocarpum
Carpophyllum plumosum
Cystophora torrulosa
Cystophora retroflexa

The low tidal fauna is similar to that described for Area 23.

25.4 Fish

The rich fauna and flora of the intertidal zone are potentially important sources of food for fish populations. The projecting reefs and larger low tidal algae provide shelter for smaller species.

Large numbers of people fish immediately offshore from the Rangitoto coast, particularly in the vicinity of the Rangitoto Beacon. Most of the common Harbour species occur in this area.

25.5 Birds

Rangitoto Island supports several nesting colonies of black-backed gulls from which gulls spread over the whole Harbour area. Other birds which feed in the intertidal zone include small numbers of red-billed gulls, blue reef herons, white-faced herons, and kingfishers.

Fish feeders include pied shag, and occasionally little black shag, with Caspian tern, white-fronted tern and gannet often feeding offshore. Little blue penguins are often seen in the waters surrounding the Island and several of the offshore feeding shearwaters occasionally visit the area.

25.6 Edible Invertebrates

Rock oysters are abundant on the basalt shores of Rangitoto and are often taken in small quantities by boating parties. Mussels, *Perna canaliculus*, are common in some low tidal areas and are also taken in small quantities.

Sea urchins, *Evechinus chloroticus*, are found in small numbers in the more exposed low tidal areas, but are apparently not sought for food.

25.7 Natural Ecological Changes

Accumulation of fine sediments is occurring in some of the sheltered inlets on the southern shore of Rangitoto. Such accumulation is evidently at a slow rate and resultant ecological changes due to alteration of substrate nature, are also slow.

No other natural ecological changes are expected in this area.

25.8 Ecological Interference by Man

Man has caused little obvious interference with the ecology of this area.

25.9 Pollution

There is minor pollution of the high tidal strip in this area by the deposition of drift material, including timber dunnage, plastics and glass bottles. The ecological impact of this pollution is negligible.

25.10 Ecological Value

The rich fauna and flora of the rocky intertidal zone of Rangitoto Island is of considerable value to the Waitemata Harbour ecosystem. Biomass and diversity of species are both high compared with other Harbour areas, and the ecology is in a natural and healthy state.

25.11 Improvement and Protection of Ecological Assets

There is no need for improvement or added protection of the ecological assets of this area.

25.12 Potential Use of Ecological Assets

Direct use is made of the ecological assets of this area by the gathering of shellfish for food, and recreational fishing offshore. Gull colonies on the Island are being studied by university degree candidates.

AREA 26 MOTUTAPU ISLAND

The small part of the coastline of Motutapu Island which is included in the Waitemata Harbour Study Area extends from the causeway at Islington Bay to Emu Point.

This shore has not been inspected during the ecological survey.

Foreshores consist of soft sandstone cliffs in direct contrast to the hard volcanic rock of neighbouring Rangitoto. Intertidally there is a sandy shore towards the head of Islington Bay with sandstone outcrops and reefs towards Emu Point. It is expected that the ecology of this area is in a natural and healthy state with a flora and fauna similar to that of the West Tamaki Head - Glendowie Spit region. (Area 15.D)

AREA 27 BROWNS ISLAND

27.1 General Description

Browns Island is a small volcanic cone situated off the entrance to the Tamaki Estuary. Foreshores consist variably of cliffs and low-lying grassed land.

27.2 Intertidal Substrates

There is considerable variation in the nature of the intertidal substrates around the Island. In some parts, particularly on the southern and western sides larva flows of basalt and broken rock extend across the intertidal zone. Conglomerates of sand, shell and volcanic stones backed by the heat of volcanic activity occur in some regions. Accumulations of sand and shell form high tidal beaches in places and there are low tidal sand flats between the lava reefs.

On the west and north sides of the Island foreshores consist of sandstone cliffs with platforms and boulder accumulations in the intertidal zone. The largest beach on the island is on the north side beneath a high sandstone cliff. Considerable erosion of the soft cliffs is occurring in some places.

27.3 Intertidal Flora and Invertebrate Fauna

Hard shores - The rocky reefs of the intertidal zone support a healthy and prolific flora and fauna which is similar to that described for the Takapuna region, (Area 24) and the Devonport region (Area 23.B). A wealth of different habitats in the broken rock and beneath boulders and ledges makes this an ecologically rich area.

27.4 Fish

Strong tidal currents ebb and flow in the vicinity of Browns Island and a considerable amount of recreational fishing from small boats occurs in the area. The reefs extending from the Island on to a generally sandy bottom provide ideal feeding and shelter areas for fish populations.

27.5 Birds

Small numbers of red-billed gulls, black-backed gulls and oystercatchers occur on Browns Island. Blue reef herons habitually feed on the rocky reefs. Pied shags are common in the shallow waters around the Island and other fish feeders, white-fronted tern, and gannet feed offshore.

27.6 Edible Invertebrates

The rock oyster Crassostrea glomerata, is abundant on the hard basalt reefs, and is often taken in small numbers. Mussels, Perna canaliculus occur in small numbers on the low tidal reefs and are probably taken only occasionally. There is a possibility that the sea urchin, Evechinus chloroticus is also found in low tidal reef areas.

On the soft shores there are small numbers of Chione stutchburyi of edible size, although it appears that beds of this species were once far more abundant than they are at present. It is unlikely that Chione is taken for food at the present time, although if beds become re-established exploitation would probably increase.

27.7 Natural Ecological Changes

There are no predictable natural ecological changes occurring in this area.

27.8 Ecological Interference by Man

Apart from the wreckage of a small vessel on the southern side of the island Man has had little impact on this area.

27.9 Pollution

The only obvious intertidal pollution occurring in this area is by water-borne rubbish; glass, plastics and wood. The ecological impact of such pollution is negligible.

27.10 Ecological Value

The natural shores of Browns Island have considerable value because of the abundance of flora and fauna they support. This prolific intertidal life is important to the Waitemata Harbour ecosystem because it is of a type found only in a few parts of the study area, and is capable of interactions with the ecology of large surrounding areas.

27.11 Improvement and Protection of Ecological Assets

The intertidal ecology of Browns Island is in a healthy and natural state and requires neither improvement nor protection.

27.12 Potential Use of Ecological Assets

At present, direct uses of the ecological assets include fishing around the perimeter of the Island, and small scale gathering of shellfish from intertidal areas. These uses are unlikely to alter, although there may be an increase in the exploitation of shellfish, particularly if Chione beds regenerate.

THE WAITEMATA HARBOUR ECOSYSTEM

In this report there is a discussion of :

1. The Waitemata Harbour Ecosystem.
2. The Community Concept
3. Natural Ecological Changes

1. The Waitemata Harbour Ecosystem

An ecosystem may be broadly defined as a biological unit within which there are various interactions between populations of animals and plants. It is reasonable, then, to consider the Waitemata Harbour as one ecosystem, with the fauna and flora of different parts of the Harbour being able to interact through the common medium of tidal waters. The surrounding land and watershed of the Harbour, and particularly the foreshore, are also part of the Waitemata Harbour ecosystem because changes within these areas so often cause ecological changes within the tidal and subtidal regions.

Within an ecosystem several types of interaction are possible between the fauna and flora of different areas. These include :

(a) Trophic interaction.

(b) Transportation of nutrient from one area to another through the water

(c) Modification of water quality

(d) Provision of larvae

(a) Trophic interaction

Trophic interaction within an ecosystem such as the Waitemata are principally at the level of the larger mobile animals such as fish and birds which move from one area to another to obtain food. If food becomes short in one area a feeding population will move to another part of the ecosystem, thus establishing a balance in exploitation of suitable food resources. Food availability is one of the major factors determining the distribution and abundance of fish and birds.

(b) Transportation of nutrient material

Nutrient material derived from one part of the ecosystem is often utilised in other parts of the same ecosystem. In the Waitemata Harbour large quantities of organic detritus is produced in the mangrove marsh areas of the shallow Upper Harbour. This material is carried away by tidal currents and utilised in other areas by a variety of deposit and filter feeders.

Warm shallow waters with reduced salinities produce different species of phytoplankton than are found elsewhere, and production in such shallow waters is often high.

(c) Modification of Water Quality

Modification of water quality by natural processes in the Waitemata Harbour includes the deposition of water-borne silt in shallow upper reaches, and the potential re-oxygenation of oxygen-depleted waters. Such processes can have a widespread effect on the ecology of other areas.

The presence of various types of planktonic fauna and flora and their metabolites can also influence water quality to the extent where distributions of sessile fauna and flora are affected.

(d) Provision of Larvae

In the case of those animals and plants with planktonic larval phases the larvae to recolonise an area are seldom derived from that area. In this way, then, there is an interaction between different areas through the provision and dispersal of larvae.

Insofar as changes to the watershed area and foreshore of the Waitemata Harbour can have widespread influence on the ecology of the intertidal and subtidal areas, these regions must also be considered as part of the Waitemata Harbour ecosystem. Several influences of alteration of these areas are described in the 'Ecological Report on Harbour Waters' and 'The Ecological Impact of Reclamation'.

2. The Community Concept

It will be noted from the lists of common flora and fauna presented in the 'Report on Intertidal Ecology' that certain animals and plants are usually found together. Such recurring groups are often called 'communities'.

The separate identity of a community and the placing of a boundary between adjacent communities are often discussed aspects of descriptive ecology. The degree of isolation of different communities depends largely on the method of analysis, and some workers prefer to regard the situation as a continuum, rather than a number of separate communities.

The reasons for different animals and plant species being found in the same area are varied. In some cases there is a biological relationship between two or more species, e.g.

Trophic dependance - The distribution of herbivorous animals is determined by the distribution of food algae. The distribution of predators is determined by the distribution of suitable prey.

Commensalism - Some animal species are associated because of their sharing of a food resource in a co-operative manner.

Biological modification of the environment - In many cases the presence of animals or plants modifies the environment making it more or less suitable for colonisation of other animals and plants, e.g. the shells of molluscs such as oysters and mussels provide hard surfaces for the attachment of several species of animals and plants. The dead shells of bivalves in soft sediment environments provide hard surfaces for attachment by sessile organisms, grazing by herbivores and egg deposition by gastropods. Algal growth modifies the rock surface environment providing shelter for a number of smaller algae and animals. In soft sediments the burrows of invertebrates permit oxygenation of substrate beneath the surface; deposit feeders turn over the sediments; plants provide organic detritus.

Biological Competition - Competition between species, particularly between sessile organisms on hard substrates, limits the distribution of many species, and is one of the principal factors responsible for the zonation of intertidal organisms.

In other cases different organisms are often found together because they are reacting to similar or related properties of the physical or chemical environment, e.g. on soft shores the distribution of several bivalve filter feeding molluscs is related to the sediment grade. The distributions of deposit feeding animals including polychaetes and bivalves is also related to the grade but for a different reason. The filter feeding animals are unable to tolerate sediments finer than a certain grade because finer sediment clogs the filtering gills, whereas the distribution of deposit feeding animals is determined by the nature of the food within the sediment.

Rarely, except perhaps in cases of parasitism and commensalism, and occasionally with specialised predators, is the distribution of an organism solely determined by the distribution of another, and rarely do two or more different organisms react in precisely the same way to physical, chemical or biological properties of the environment. For the purposes of this study of the ecology of the Waitemata Harbour it was considered impractical to use a community analysis method because of the considerable diversity of fauna and flora and habitat type, which has necessitated the definition of a large and unwieldy number of communities. However, the information on distribution and abundance of common fauna and flora provided in the 'Report on Intertidal Ecology' is sufficient to be subjected to further analysis and derivation of major community types.

ECOLOGICAL REPORT ON HARBOUR WATERS

The Waitemata Harbour is a shallow, almost landlocked, extension of the south-western corner of the Hauraki Gulf. (Fig. 1). A typical example of a drowned river system, it has been considerably modified by wave and current action, and now contains extensive gently-shelving intertidal areas of soft sediment. The hydrological regime within the Harbour is varied and influences the distribution of both planktonic and sedentary fauna and flora.

This report contains a description of the following :

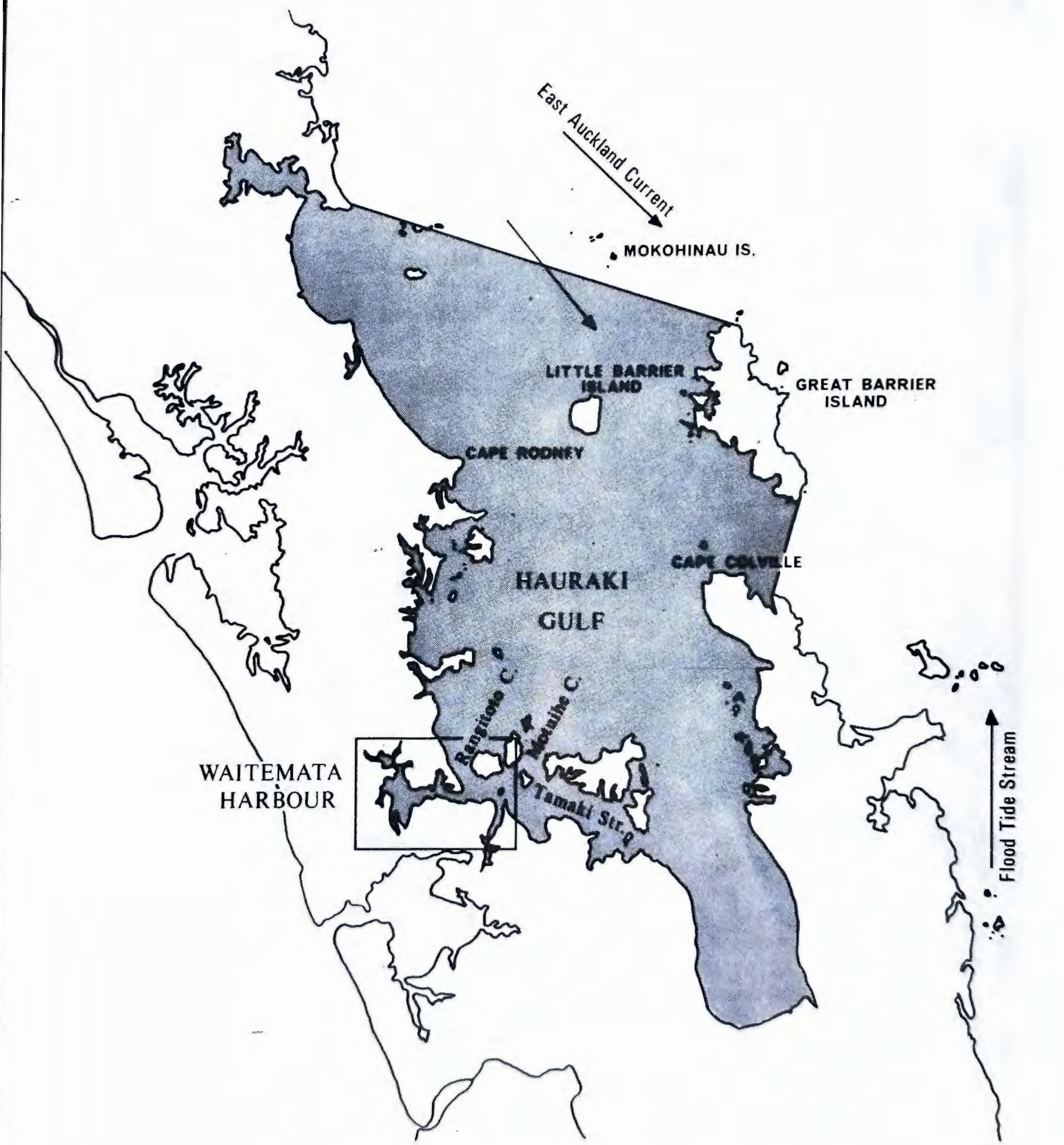
1. The derivation of Harbour waters.
2. Tides.
3. Currents.
4. Salinity.
5. Temperature.
6. Suspended sediment.
7. Nutrients, including oxygen.
8. Planktonic flora and fauna.
9. Pollution of Harbour waters.

This material should be considered in conjunction with the reports on 'Harbour Waters,' (A.H.B.) and 'Water Quality,' (A.R.A.) which also discuss several of the above parameters.

1. Derivation of Harbour Waters

Oceanic water enters the Hauraki Gulf from the north where it is moving slowly south-eastwards in the East Auckland Current. Oceanic waters are more stable in their physical and chemical properties than water closer to the land. Temperature and salinity variations are not as great, and there is the regular formation of a summer thermocline, usually at about 25 fathoms depth. This thermocline breaks up in the autumn when the surface waters cool, resulting in a mixing of the water mass to isothermal conditions, and an increase in nutrient concentrations in the surface layers. Surface temperatures increase to seawards in both summer and winter.

Gulf and oceanic waters mix in a region between Cape Rodney in the west and Cape Colville in the east. Seaward of the line between these capes, land influence is small and oceanic conditions prevail.



WAITEMATA HARBOUR AND HAURAKI GULF

Within the Gulf, the water mass assumes different properties. It becomes slightly less saline and usually cooler. A thermocline is formed in the deeper areas in summer, but in shallow areas this is either temporary or not formed at all because of mixing of the water column by current and wave action. Changes in physical water properties result in changes in the planktonic flora and fauna, with communities characteristic of the Gulf being present.

Towards the shallow region of the Gulf, including the Waitemata Harbour, the changes in physical and biological water characteristics are most pronounced. Variations in temperature and salinity are greater than elsewhere and there is a marked increase in the amount of suspended material in the water, which decreases light penetration. No permanent thermocline is present, although transient thermoclines are often observed on hot days when surface layers of water become heated.

2. Tides

The flooding tidal stream sets northwards along the north-eastern coast of New Zealand and turns southwards into the Hauraki Gulf. Inside the Gulf, the tide sets to the south and ebbs to the north, except for variations caused by the numerous small islands about the entrance to the Waitemata Harbour.

Water entering the Waitemata with the rising tide is derived from the north and east of the Harbour and flows via the Rangitoto Channel into the inner Harbour and Tamaki Estuary. Water from the Motuihe Channel to the east does not penetrate into the inner Harbour or Tamaki.

The tidal cycle is semi-diurnal with a vertical range between 1.5m (minimum neaps) and 3.5m (maximum springs) at Queens Wharf, with a slightly greater range towards the upper Harbour extremities. Low spring tides occur in mid afternoon - a factor of some ecological importance - when the sun may seriously desiccate low tidal animals and plants.

Tides are important in determining the zonation of intertidal plants and animals. The adaptation of plants and animals to restricted intertidal levels results in the formation of definite bands or zones, with different species dominant in each zone. This phenomenon is particularly well illustrated on the basalt block retaining walls in the Waitemata.

3. Currents

Within the Hauraki Gulf currents are largely generated by tidal movement. In the confines of the Waitemata Harbour tidal currents run at velocities up to 3 knots in the Rangitoto Channel, 2 knots in the narrow parts of the Harbour in the City region, and between 3 and 4 knots off Kauri Point (see Report on Harbour Water, A.H.B.).

The construction of two tidal deflectors on the southern side of the Harbour has tended to deflect the tidal stream to the north with a probable increase in velocity.

Strong tidal currents result in a vertically well-mixed water body in the outer Harbour area. Such currents are also responsible for transporting large volumes of suspended material from the Upper Harbour.

Currents are important to the flora and fauna because they transport fresh, nutrient-rich and food-laden water to the sedentary forms. They also remove waste products, and carry the larvae necessary for recruitment.

Currents are also instrumental in determining the nature of the substratum, and thus the types of organisms that colonise an area. Sorting action of moving water determines the grade of soft sediments and the degree of siltation on hard surfaces. Outgoing tidal currents from the Upper Harbour transport large quantities of fine sediment. This affects both planktonic and sedentary organisms. (see below)

4. Salinity

The waters of the Waitemata are variously diluted by freshwater land runoff.

Three main hydrological zones may be recognised on the basis of the degree of salinity variation. (Fig. 2)

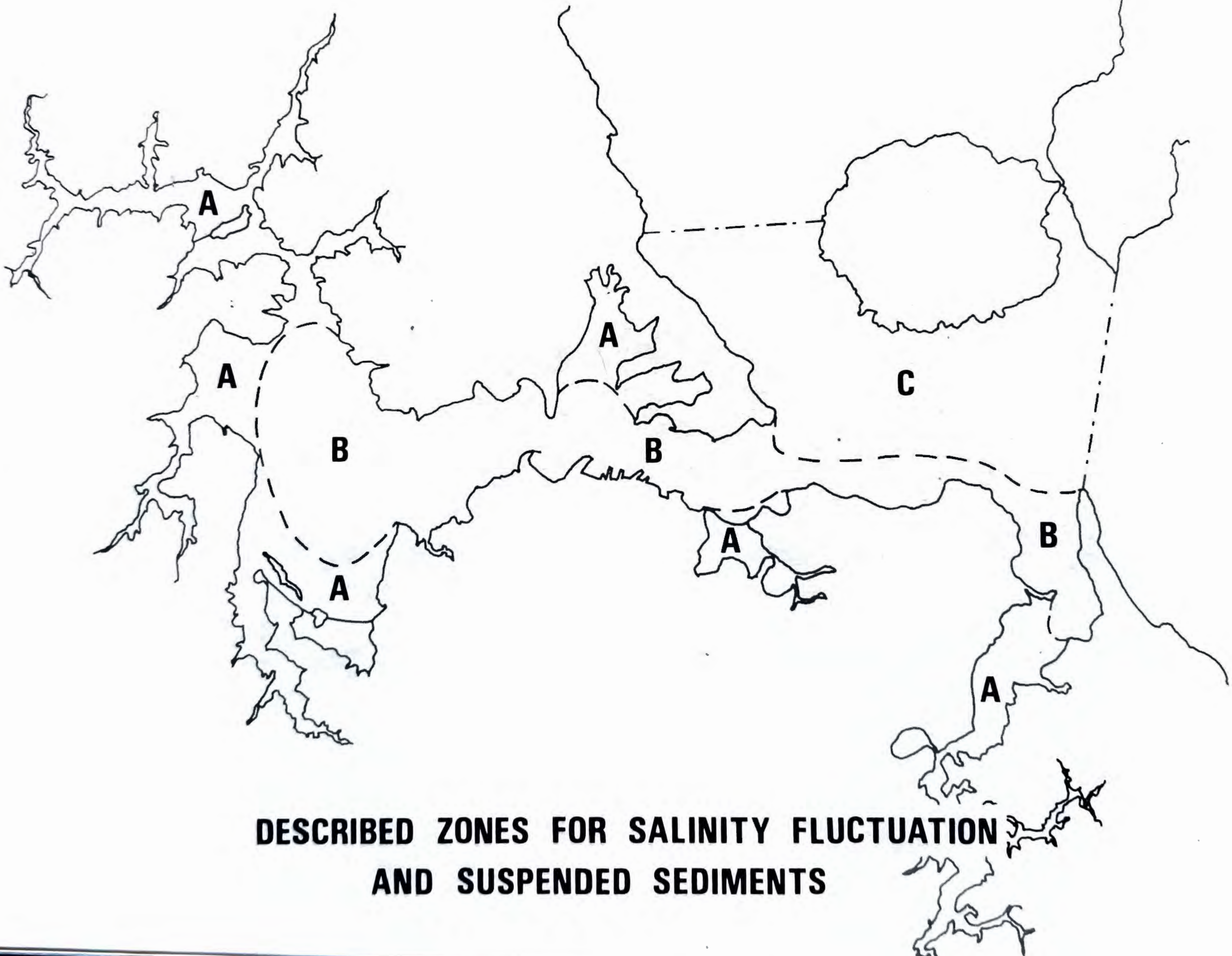
A. Areas subject to considerable salinity variation.

B. Areas subject to moderate salinity variation.

C. Areas subject to slight salinity variation.

A. Areas subject to considerable salinity variation

These areas include the shallow rivers and creeks of the Upper Waitemata and Tamaki, particularly those with a large watershed area in relation to intertidal volume.



DESCRIBED ZONES FOR SALINITY FLUCTUATION
AND SUSPENDED SEDIMENTS

After heavy rain in the watershed of such areas the tidal salinities are rapidly reduced, reaching minimum values at low tide when the fresh water is concentrated in narrow channels.

In wet periods, salinity fluctuations over a tidal cycle in a particular locality are often as great as 25 parts per thousand. On calm days, and particularly in the deeper channels, there is a salt wedge effect, with the incoming tidal water remaining on the bottom of the channel, and the less dense fresh water, 'floating' on the surface. At such times a marked vertical stratification in salinity occurs, of the order of 25 parts per thousand variation between surface and bottom. In dryer periods there is still some stratification under calm conditions, while in rough weather the water column becomes vertically mixed with little stratification.

Average salinities in areas of this type are lower than in other areas of the Harbour, and fluctuations are greater, both from day to day and with the tidal cycle. The seasonal variation in average salinities is between approximately 25 parts per thousand in the winter, and 32 parts per thousand in the summer, but short term variations are far greater than this.

Most common Harbour invertebrates show reductions in abundance and/or size towards the upper reaches of the Harbour, and several common species are absent from the most estuarine areas. Salinity variation is, however, only one of several factors determining such changes; substrate nature, the quantity of suspended material in the water, and the availability of food are also limiting in such areas.

There is a small group of animals that is adapted to reduced salinity conditions and is only found in regions with marked freshwater dilution.

B. Areas subject to moderate salinity variation

In the deeper water of the main channels of the Upper Harbour, and in the extensive Upper Harbour Basin, the salinity is less variable, and freshwater dilution less than in the shallow creeks and rivers which receive the land runoff directly.

After periods of heavy rain, however, there is moderate dilution of the seawater in this area. Short-term reductions to as low as 15 parts per thousand may be expected at low tide.

Under calm weather conditions, stratification occurs with lower salinities at the surface, and a variation of up to 10 parts per thousand in the water column. In rough conditions the water column becomes vertically mixed.

Seasonally, average salinity varies between 28 parts per thousand, (winter) and 35 parts per thousand, (summer) although short-term variations are much greater than this. Fig. 3 gives average surface salinity data for the Westmere Reef region.

There are no flora and fauna acclimated specifically to the salinity regime of this area, although it is possible that occasional low surface salinities may be instrumental in excluding some species, or reducing their numbers.

C. Areas subject to slight salinity variations only

Because of the considerable water volume of this area and the relatively small amount of freshwater entering the area directly, salinity fluctuations are only minor.

Short term variations are dependant on rainfall in the watershed of the entire Harbour. Vertical stratification is still evident, particularly in calm periods after heavy rain, with a variation up to 2 parts per thousand between surface and bottom being common in deeper areas.

There is a noticeable seasonal variation with maximum values up to 36 parts per thousand in summer and minimum values down to 32 parts per thousand in winter.

Salinity variations in this region have little apparent effect on the distributions of flora and fauna.

Changing Salinity patterns

In a harbour within a metropolitan area such as Auckland, the salinity regime might be expected to alter slightly as the surrounding land is developed. Such changes will arise through a more rapid channelling of rainfall into the Harbour and a greater contribution of freshwater to the Harbour from the Watershed. Major stormwater outlets will be located in areas where there was previously little freshwater influence, and the quality of the stormwater will probably deteriorate.

An increase in the quantity of freshwater released into the Harbour may have some local effect in the outfall area but will have no major ecological impact. The release of stormwater subtidally would minimise local effects.

Of greater concern is the quality of stormwater effluents. Water with heavy sediment loads and high organic content poses a threat to the ecology of large areas, particularly in sheltered regions with fine natural substrates. (see Pollution Report)

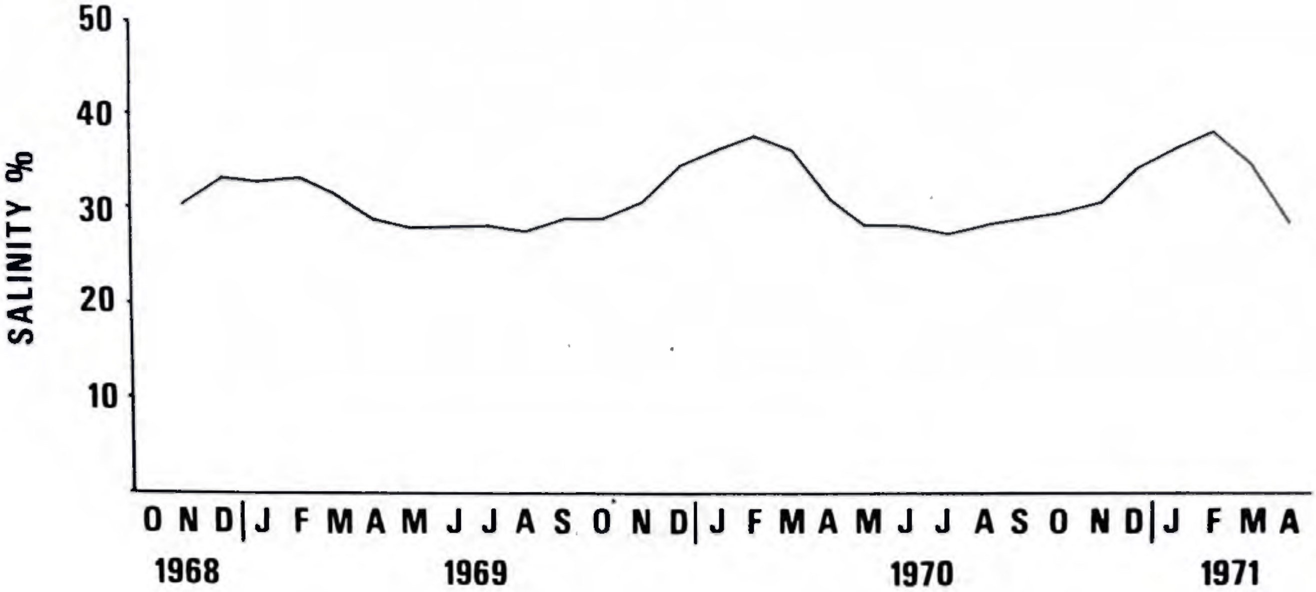
5. Water Temperature

Seawater temperatures in the Harbour Study Area have an annual range between extremes of 9°C in winter and 25°C in summer. The temperature curve for surface water at Westmere during 1968-1971 is given in Fig. 4.

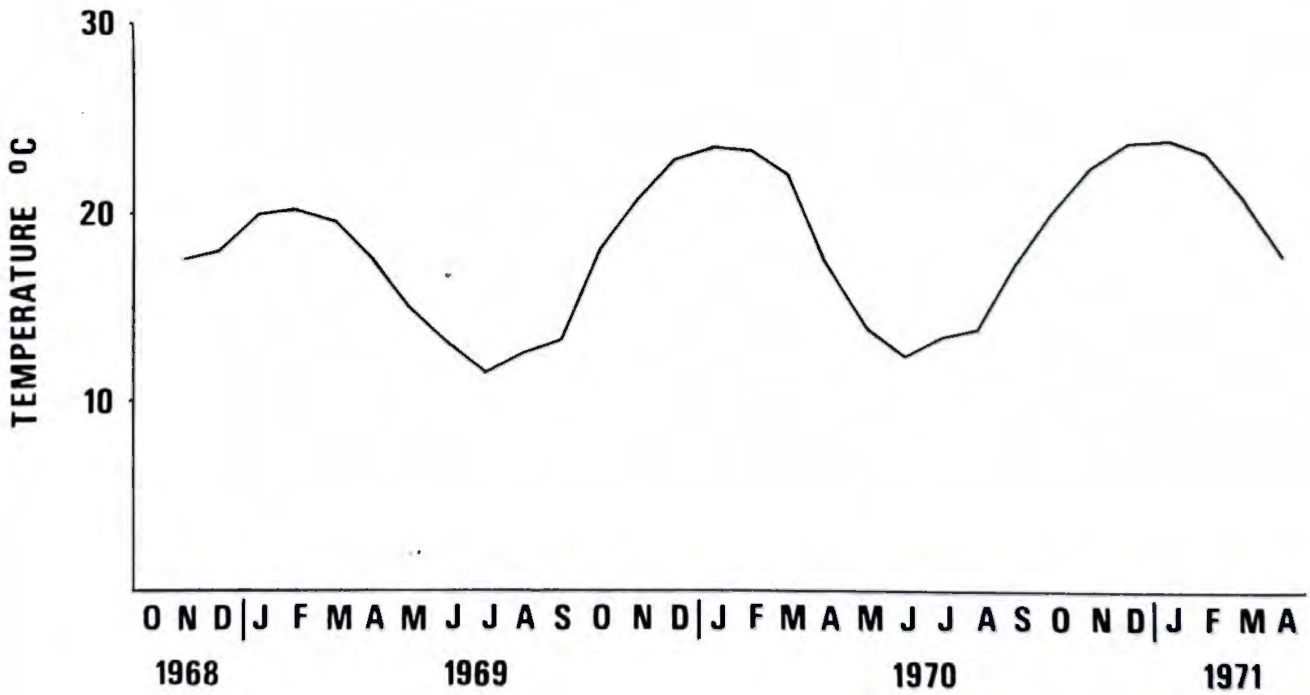
The annual range of seawater temperature in the Harbour is greater than that in the Gulf, with Harbour waters being colder in winter and warmer in summer. Gulf waters are cooler than oceanic waters in both summer and winter.

There is also a tendency towards higher summer temperatures and lower winter temperatures towards the head of the Harbour. This is largely caused by the heating effect of exposed intertidal flats on the incoming water in summer, and their cooling effect in winter. Incoming tidal water may be heated more than 5°C by this effect and on a cool morning in winter temperatures as low as 5°C have been recorded. Local variations may also be caused by freshwater inflow which is usually cooler than seawater.

A daily variation in water temperature also occurs. On sunny days the temperature increases 2° or 3°C during the day, reaching a maximum at about 4 p.m. and falling again during the night to a minimum at 4 a.m. In calm conditions there may be a temporary temperature stratification with a thermocline forming at 1 or 2 metres depth and



Surface salinities at Westmere.



Seawater surface temperature at Westmere.

surface waters reaching a temperature up to 5°C warmer than those beneath. The cooling effects of evaporation may cool surface waters up to 2°C on windy days.

There is little evidence of any limiting effect on flora and fauna distributions imposed by temperature variations other than the occasional mortality of mangroves when subjected to frosts.

It is also possible that some of the occasional mass mortalities of intertidal invertebrates is caused by exceptionally high or low temperatures when an area is exposed.

Increases in water temperature from hot water effluents can result in the replacement of normal fauna by those adapted to warmer water, or an increase in growth rates of common plants and animals, dependant on the degree of heating. At present there are no significant heated water effluents released into the Waitemata Harbour and no obvious ecological impact. The Otara Power generating station is not yet working at full capacity, however, and may have some effect in the future.

A survey of the ecology of the area of the heated water outfall from the New Plymouth power station has been commissioned by the D.S.I.R. This may indicate the nature of the effects of increased water temperature on some local invertebrates and algae.

6. Suspended Sediment

Considerable quantities of fine inorganic silts and clays are contributed to Harbour waters via freshwater runoff. In considering water properties determined by the quantities of suspended sediment, it is useful to describe the Harbour in three areas as was done for the description of salinity variation. (Fig. 2)

A. Areas with large quantities of suspended sediment.

B. Areas with moderate quantities of suspended sediment.

C. Areas with small quantities of suspended sediment.

Areas A

Most sediment is derived from land runoff, although some is put into suspension by wave and current action. The areas with highest sediment loads are generally the shallow creeks and rivers of the upper Waitemata and Tamaki which receive freshwater runoff directly, and also have large areas of soft substrate which is easily suspended in periods of rough weather.

In such areas the water is often dirty, particularly during periods of heavy rain when freshwater flow is increased. The water is only clear in calm dry spells, on the incoming tide.

When the weather is calm considerable deposition of fine sediments occurs in these areas through a variety of physical and chemical processes. Such deposited sediment is derived directly from the land and also from current-bourne material. In rough periods some of this may be re-suspended and carried elsewhere.

Areas B

In these areas the water is often discoloured with suspended sediment, particularly on the outgoing tide after periods of heavy rain. Local creeks within this region also contribute large quantities of sediment to the Harbour water, e.g. the creek at Barry's Point, Cox's Creek, and stormwater drains at Chelsea, in the Wharf area, and at Okahu Point.

However, the water mass in these areas is generally cleaner than that of Areas A. In calm dry periods the water is quite clear, particularly on the incoming tide. Active sediment deposition is restricted to the sheltered areas with little current.

There are often sharp discontinuities between different water masses in this area, these being easily distinguished by the different quantities of suspended sediment.

Area C

The water in Area C is cleaner with respect to sediment content than that of the other areas. There are, however, several local sources of considerable quantities of suspended sediment such as stormwater drains and the Milford Creek.

Sharp discontinuities are also common in this area - usually between water derived from the Harbour area on the outgoing tide and the cleaner, incoming Gulf water.

Effects of suspended sediment on flora and fauna

Water-bourne sediments have considerable influence on the distributions of flora and fauna. In most cases high sediment concentrations means a restriction in distribution and size of organisms.

High sediment loads reduce light penetration through the water and restrict the depth distribution of algae to areas close to the surface. The depth at which photosynthesis by phytoplankton may take place is also affected.

Filter feeding animals are unable to cope with large quantities of suspended inorganic material which they cannot utilise and must expend energy rejecting. Heavy sediment load results in reduced size and eventually absence of many species.

Effects on flora and fauna by modifying substrates

Deposition of fine sediments affects the distribution of organisms in several ways.

1. Making a rock surface unsuited for attachment. Thin layers of fine sediments over a hard surface prevent the attachment of algae, grazing animals, and sedentary filter feeders.

2. Smothering attached animals. Sedentary animals are often smothered in areas of the Upper Harbour where there has been deposition of fine sediments on previously hard substrates.

3. Changing the nature of the substratum in soft bottom areas. Many soft shore dwellers are restricted in distribution by certain sediment characteristics. The deposition of fine sediments on the surface can radically alter sediment properties and result in the disappearance of some invertebrate species.

4. Smothering of bottom dwellers. In some shallow protected areas the deposition of fine sediments has occurred on such a scale as to destroy the previously healthy invertebrate communities by smothering them.

5. Fine sediments of the type being deposited from the water are well suited to the retention of foreign matter such as organic material and other pollutants because of their large surface

area and other physical and chemical properties, which enable a variety of reactions to occur, resulting eventually in considerable further modification of the sediment nature.

Sources of sediment contributed to Harbour waters

In view of the serious impact of fine sediments, both in the water, and when deposited on the bottom, on the ecology of the Waitemata, the sources of sediment are discussed.

An attempt has been made below to list the major types of land use in the Harbour watershed, together with an estimate of the relationship between these in terms of their contribution of sediment to Harbour waters.

Sediment contribution per unit area. (increasing order)

1. Bush.
2. Developed farmland.
3. Developed suburban.
4. Developed urban.
5. Land in the process of being developed.
6. Reclamation.

Discussion

(1) Bush

Freshwater flows from bush areas are usually clear and contain little suspended sediment even after heavy rainfall. At present, the remaining areas of bush in the Waitemata watershed are on steep land - land which is most prone to erosion if developed.

(2) Developed farmland

Water derived from farmland contains some suspended material, particularly during winter when races and other areas become muddy with animal activity. In a developed and efficiently managed farm area, however, there is relatively little sediment contribution to the Harbour.

Little can be done to reduce the contribution of sediment from well-run farmland. No waste products should be permitted to enter Harbour waters.

(3) Developed suburban

Water from such areas is usually channelled through stormwater drains to the Harbour or a natural water course. A large proportion of the total area of such regions is road or roof and water retention is considerably reduced. Runoff from such regions is greater per unit area with the same amount of rainfall than from areas of types 1 and 2 above. The pattern of flow is also different, with a more rapid rise and fall, compared with a protracted flow from areas of types 1 and 2.

Sediments from suburban areas are derived from soils and material deposited on hard surfaces of roofs and roads. Considerable quantities of organic material from fallen leaves may also be derived from such areas.

There is little that can be done to reduce sediment contributions from such areas other than the regular upkeep of streets with collection of organic leaves and rubbish where possible.

(4) Developed Urban

In such areas the land is almost entirely covered with impervious materials. Rainfall is drained extremely rapidly into the Harbour and carries any material deposited on the hard surfaces.

Sedimentary material from such areas probably contains a variety of substances, some of which - greases, oils and rubber - are potentially harmful to the ecology of the Harbour.

Little can be done to reduce the contribution from such areas.

(5) Land in the process of being developed

The contribution of sediment from such areas is both spectacular and damaging. After one downpour on the North Shore half an inch of silt and clay was deposited over several thousand square yards of inter-tidal area in one tide - all derived from one subdivision on a fairly steep slope.

Contribution of sediment from areas that are being developed can be easily reduced. Present subdivision practise should be examined, particularly that of removing topsoil, landscaping large areas, and then leaving bare clay exposed for long periods. The rapid replacement of topsoil and planting of a fast-growing grass or other vegetation would reduce sediment flow from such areas considerably.

(6) Reclamation

Sediment is derived from intertidal reclamations by erosion of the outer perimeter and surface runoff.

Contribution of sediment to the Harbour from reclamations could be minimised by efficient development in facing the reclamation with stone, compacting fill, and planting vegetation as soon as is practicable. (See report on 'The Ecological Impact of Reclamations')

7. Nutrients, including oxygen

Table 1 gives the concentrations of common nutrient ions at Princes Wharf during 1963 (Slinn,1968). Figures given are monthly means for weekly samples taken at 1300 hours.

Further nutrient data from Harger, (1963) is given in Table 2.

Harger (1963) showed that percentage oxygen saturation at the naval paint raft averaged between 85% and 95% with extremes of 130% and 72% for weekly samples 1959-1963.

Further data on nutrients and oxygen concentrations of Harbour waters will be presented in the Water Quality Report. (A.R.A.)

Table 1 - Nutrients ug-at./l. Monthly means at Princes Wharf. (from Slinn, 1968)

Component	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Temp (°C)	21.7	22.5	20.8	18.5	15.8	13.9	12.3	12.2	14.2	16.1	17.2	18.9
Salinity (‰)	34.52	34.95	35.14	34.29	34.38	33.15	32.75	33.31	33.28	33.90	34.86	34.85
Nitrate	0.7	1.0	1.1	2.5	2.1	2.7	1.2	1.0	1.2	0.6	0.4	0.8
Nitrite	0.09	0.10	0.19	0.24	0.24	0.23	0.24	0.19	0.15	0.11	0.09	0.14
Phosphate	0.54	0.58	0.63	0.69	0.58	0.55	0.47	0.46	0.45	0.41	0.40	0.45
Silicate	4.5	6.6	11.6	12.5	9.6	11.9	17.1	13.9	11.8	9.0	10.4	8.1

Table 2 - Nutrients ppm (Harger)

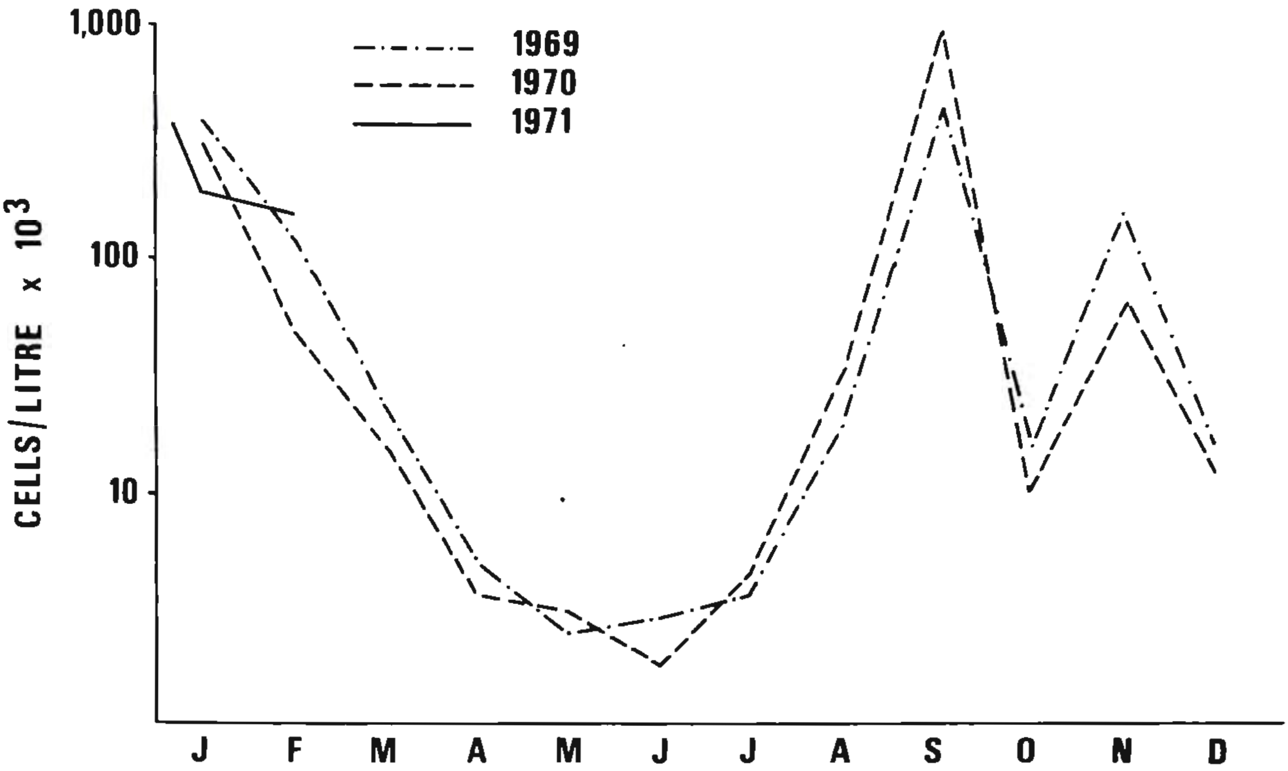
Date	NO_2	NO_3	Si	PO_4	PH	Temp. °C	Time Sample Taken	Time of High Water	Height of High Water
26/6/63	0.003	0.060	0.10	0.06	8.4	13.0	10.45 a.m.	11.16 a.m.	10.5
3/7/63	0.000	0.070	0.00	0.04	8.2	12.2	2.30 p.m.	5.08 p.m.	9.0
16/7/63	0.000	0.500	0.00	0.07	8.3	12.2	10.45 a.m.	3.02 p.m.	10.0
30/7/63	0.001	0.090	0.00	0.00	8.2	12.2	11.30 a.m.	2.30 p.m.	8.0
28/8/63	0.020	0.001	0.04	0.00	8.4	14.4	11.45 a.m.	1.46 p.m.	8.9

8. Planktonic Flora and Fauna

Of the flora and fauna living naturally in the water and not attached in any way, the fish are the group most widely known and utilised. Fish are mobile and able to avoid unsuitable environmental conditions.

Several parameters of the water mass are likely to affect fish distributions.

Salinity: Some species are intolerant of substantially reduced salinities, although other associated factors such as increased sediment load, and food availability are probably more important in limiting their distribution.



Phytoplankton numbers per litre of seawater at Westmere.

Suspended Sediment: Many fish are known to avoid areas with large quantities of suspended material in the water. Sediment interferes with vision and olfactory senses, and in extreme cases reduces the efficiency of gills.

Temperature fluctuations: Temperature variation in the Study Area is probably not an important factor in determining distribution of fish species, although prolonged heating or cooling is a potential source of change.

Oxygen reduction: Localised areas show sufficient reduction in oxygen concentration to preclude fish for short periods, and distress them for longer periods. Data from these areas will be presented in the 'Water Quality Report'. (A.R.A.)

pH Alteration: Fish are particularly sensitive to pH changes. There is no apparent large-scale alteration of pH in the Waitemata at present (Data is given in Water Quality Report).

Available food: Many fish rely on invertebrates from the Harbour bed for food. In areas where these invertebrates have been reduced by pollution or sedimentation, the distribution and abundance of fish species will be adversely affected.

Truly planktonic species

Unlike the fish truly planktonic species have only limited powers of movement and are essentially carried by the currents. Thus they cannot avoid unsuitable areas and are particularly susceptible to deterioration of water quality.

Harbour plankton varies from that of the more open waters of the Gulf. Species tolerant of, or adapted to, the fluctuations in salinity and other Harbour conditions are present.

Planktonic flora

Little is known of the planktonic flora of the Harbour. There is a seasonal cycle of abundance which is probably related to cycles in the concentration of nutrient ions and water temperature. (Fig. 5) Phytoplankton are variously affected by the factors listed above as affecting fish, and are particularly affected by the quantity of suspended material in the water which determines light penetration and the volume of water in which plants can photosynthesize.

Planktonic fauna

The most conspicuous zooplankton are the larger jellyfish, ctenophores and salps. The common jellyfish Aurelia aurita is present for much of the year and increases in size through the summer and winter.

A fauna of smaller crustacea, characteristic of inner Gulf and Harbour waters, is present, as well as the larvae of many of the invertebrates found on Harbour shores.

Again the increase in sediment is probably the most important factor affecting the survival of these animals and their abundance, particularly in the upper Harbour. Many rely on delicate filtering mechanisms which are easily clogged by suspended material with reduction in feeding efficiency.

9. Pollution of Harbour Waters

Pollution of the Harbour Study Area is dealt with in the Pollution Report and also in the Water Quality Report. (A.R.A.)

FISH OF THE WAITEMATA HARBOUR

The common fish found in the waters of the Waitemata Harbour Study Area are listed below, followed by a brief description of their abundance, distribution within the Harbour Study Area, and behaviour. Additional information on the exploitation of fish species for sport or food is provided.

A brief discussion describes some of the interactions that are occurring between fish populations and a changing Harbour environment.

Common fish of the Waitemata Harbour Study Area

Schnapper
John Dory
Kahawai
Kingfish (Yellowtail)
Koheru
Barracouta
Piper
Yellow-eyed Mullet
Grey Mullet
Blue Maomao
Paketi
Banded Parrot Fish
Parore
Red Moki
Blue Cod
Marblefish
Hiwihiwi
Drummer
Butterfish
Stargazer
Gurnard
Seahorse
Eel
Tommy Cod *Acanthoclinus quadridactylus*
Acentrogobius lentiginosus
Forsterygion nigripenne
Whitebait *Galaxias attenuatus*
Retropinna sp.
Argentea sp.
Yellow-bellied Flounder
Common Sole
Dab
Plaice
Short-tailed Sting Ray
Eagle Ray
Bronze Whaler
Hammer Head Shark
Dogfish
School Shark

Schnapper

The schnapper is the most widely sought eating fish found in the study area. It is found throughout the area in all seasons, with a possible increased abundance of larger specimens in the spring and autumn. Specimens over 5 kg in weight are occasionally taken, but the majority are between 0.5 and 1.5 kg with many under the minimum legal length of 10 inches.

Schnapper are demersal feeders and consume a large variety of invertebrates and occasionally small fish. Within the Harbour food includes bivalves, gastropods, chitons, echinoderms, polychaetes, crabs and fishes. Larger specimens feed on the bivalves *Chione stutchburyi* and *Amphidesma australe*, coming into the intertidal region with high night tides. Shallow pits are left in the substrate where the schnapper have excavated the shellfish. Schnapper caught in the Upper Harbour have normally been feeding almost exclusively on crabs - Helice crassa and Hemiplax hirtipes which are taken from the soft intertidal flats.

Recreational fishing for schnapper is usually with a rod and line or handline, with attached sinker and fish or shellfish bait. Large numbers of people fish from the shore with casting rods and handlines. When fishing from a boat the boat is normally anchored or drifting slowly.

Although the schnapper does not spawn in the Harbour juveniles occur in large numbers. The rich invertebrate fauna of the extensive mudflats of the Upper Harbour provide a valuable food supply for these fish.

John Dory

Occurring only occasionally in small numbers in the Harbour Study Area, this fish may be taken when line fishing. Specimens are usually between 0.5 and 1.5 kg, occasionally larger, and are found around rocky reefs and foul ground, or near wharves.

Trevalli

Trevalli are most common in the Outer and Middle Harbours but at times they penetrate the shallow reaches of the Upper Harbour. Larger specimens of this species - up to 3 kg - often occur individually or in small groups, while young fish occur in schools.

Trevalli are pelagic feeders in deep water areas, but in shallow waters such as the Waitemata Harbour, the juveniles more often consume a wide variety of small benthic invertebrates, including crabs, polychaetes, and small molluscs. From mid-water and surface waters, larger zooplankton are taken. Large trevalli feed mainly on benthic organisms in the Waitemata Harbour, and occasionally dig in intertidal sand flats for bivalves such as Chione stutchburyi and Amphidesma australe.

Trevalli are often caught on lines by small boat and shore fishermen. They are not usually eaten but are a favoured bait for schnapper and other fish.

Kahawai

Kahawai are present in the Harbour for the whole year but are particularly abundant in the spring when large schools of small specimens are often feeding near the surface. Specimens of up to 5 lb may be taken, with fish of this size occurring individually or in small groups. Smaller fish, between 0.5 and 1.5 kg are more common, and it is fish of this size range that are often seen schooling on the surface.

Whereas larger kahawai feed almost exclusively on fish, the smaller specimens feed on a wide variety of pelagic and benthic invertebrates, including crabs, polychaetes, shrimps, molluscs and isopods.

Kahawai are caught both for sport, on very light lines, and for consumption, on heavier gear. Trolling lures is a common method of fishing for surface schooling fish, and they are also taken on baited lines fishing near the bottom. Small fish may be baked or steamed, whereas larger specimens may be smoked.

Kingfish

Kingfish are found throughout the Harbour in all seasons. They usually occur in small schools of three to fifteen fish, with the individuals in a school normally being of similar size. Large individuals of up to 25 kg occur occasionally.

Kingfish are piscivores and within the Harbour Study Area feed mainly on yellow-eyed mullet, koheru, and kahawai. Feeding activity is often indicated by splashes and disturbances of the surface, sometimes in very shallow water.

Kingfish appear inquisitive and often approach boats and wharves. They may be caught on baited lines or with moving lures.

Koheru

Koheru occur throughout the Harbour in all seasons. They are particularly abundant in the proximity of wharf lights at night, where they wait in the shelter of the wharf for food organisms to be swept towards them by tidal currents.

Koheru are pelagic feeders, and consume large zooplankton organisms, juvenile fish such as smelt and whitebait, and occasionally benthic organisms. They may reach a length in excess of 40 cm and a weight of up to 1 kg, but Harbour populations are solely juveniles of between 7 and 20 cm in length.

Koheru are often caught from wharves both at night and in the day. At night they are taken with a lure made of white wool and twisted on the hook to resemble a juvenile fish. In the daytime they are found near the bottom and take bait of fish or shellfish. Larger specimens may be eaten.

Barracouta

Barracouta occasionally occur within the Harbour Study Area. Sizes vary considerably but most specimens taken are between 35 and 50 cm in length.

Barracouta are voracious fish feeders, and probably consume a variety of smaller fish species and juvenile fish. They are not sought but may be taken on baited lines or on moving lures.

Piper

Piper occur throughout the Harbour in surface swimming school, but appear to vary considerably in abundance. They reach a maximum length of 25 cm but are more usually 12 to 18 cm in the Waitemata Harbour.

Piper feed on a variety of planktonic organisms and also browse on algae and Zostera (sea grass) in mud flat areas. This species is considered a delicacy by some members of the public who obtain specimens by netting with beach seines. They may also be taken with a floating line and dough bait when fishing from the shore or from wharves.

Yellow-eyed mullet

The 'sprat' is one of the best known and widespread Harbour fish. It occurs throughout the Harbour in all seasons, usually in schools of considerable numbers.

Yellow-eyed mullet grow to 25 cm in length but in the Waitemata are usually much smaller than this. Small yellow-eyed mullet are caught with plastic traps, or nets; larger specimens being taken on a small hook with bread or shellfish bait. The fish are often used for bait for larger fish.

Yellow-eyed mullet are omnivorous consuming a wide variety of planktonic and benthonic organisms. In areas with richly organic sediments they are known to ingest the sediment. Upper Harbour mudlfats are valuable food sources for this species.

Grey Mullet

Grey mullet migrate into the Harbour Study Area in the spring when they may occur in considerable numbers in the shallow reaches of the Upper Harbour. Schooling fish are usually between 30 and 40 cm in length but individuals may be considerably larger.

Grey mullet feed on small invertebrates and organic detritus which they obtain from soft sediment areas by sifting the sediments with their specialised dental apparatus.

They are often taken by set nets and are considered good eating by some members of the public.

Blue Maomao

Juvenile blue maomao used to occur in the Waitemata Harbour in considerable numbers, particularly near rocky reefs and wharves in the middle and outer parts of the Harbour.

It is not known if this species is still present within the Harbour Study Area.

Paketi

The paketi or spotty is one of the most common of Harbour fishes. It is widespread throughout the Harbour in all seasons, particularly in rocky areas or near wharves. Large specimens are up to 20 cm in length, but within the Waitemata there is an abundance of fish of smaller size between 6 and 15 cm.

The spotty is an omnivore, and consumes almost any invertebrates of suitable size, particularly small bivalves and crabs.

Because of its abundance near wharves and its ready acceptance of fish or shellfish bait, this is one of the most common species taken by children fishing from the shore or from wharves with small rods and light lines. Spottys are not usually eaten.

Banded Parrot Fish

This species is probably present in the outer Harbour.

Parore

Parore occur throughout the Harbour Study Area in large numbers. They grow to 2 kg in weight but are usually between 500 g and 1.5 kg.

Parore are omnivores and feed mainly on weeds and rich organic growths on hard surfaces. Teeth marks may be seen almost up to the high water mark on shaded silty reefs in the Upper Harbour. They are also known to eat raw sewage and are attracted to outfalls discharging sewage.

Parore are not fished for but are often taken in nets by commercial or pleasure fishermen seeking flatfish and other species. They are also occasionally taken by line fishermen, particularly near wharves. They are not considered good eating.

Red Moki

Red Moki may be present in the outer part of the Harbour Study Area in rocky reef regions.

Blue Cod

Blue cod may be present in the outer part of the Harbour Study Area, particularly on foul ground and in rocky reef regions.

Marblefish

Marblefish may be present in the outer part of the Harbour Study Area in regions of considerable algal growth on rocky shores.

Hiwihiwi

Hiwihiwi are probably present in the outer part of the Harbour Study Area in shallow water on rocky reefs.

Drummer

Drummer probably visit the Harbour Study Area occasionally and are most likely to be found in the reef areas of the Outer Harbour.

Butterfish

Butterfish occur in small numbers in algal thickets on rocky reefs in the outer Harbour. Apparently this sought after, algal-grazing fish is becoming reduced in numbers.

Stargazer

Stargazers are widespread within the Harbour particularly in the shallow sandy areas of the Upper Harbour, although they are not numerous. Specimens are usually about 30 cm in length.

Stargazers bury themselves in the soft sandy sediments and attract prey organisms by exposing brilliant white flesh in the mouth region. Most common prey are small crustaceans.

Gurnard

Gurnard are not common within the Harbour Study Area but are occasionally caught on lines in sandy areas of the Outer and Middle Harbour. Specimens are normally adults between 30 and 45 cm in length.

Gurnard are benthic feeders in soft bottom areas and consume crabs and polychaetes. They may be caught on baited lines at the bottom, and are a good eating fish.

Seahorse

Seahorses were once widespread in the Outer and Middle Harbour in the vicinity of algae-covered rocky shores. It is not known if this species is still present in the Study Area.

Eel

Eels are fairly common in the Harbour at times, particularly in the winter when they may be migrating from freshwater.

While in the Harbour they appear to take a variety of invertebrate food. They may be caught on baited lines while fishing for other benthic species.

Tommy Cod (Acanthoclinus quadridactylus)

The tommy cod is found beneath intertidal boulders throughout the Harbour. It is often sought by children when the tide is out. Average length is 10-12 cm.

Tommy cod feed on small crustaceans and molluscs which are picked off intertidal algal mats at high tide. As the tide recedes they retire to a 'home' beneath a boulder where a small volume of water will remain.

Acentrogobius lentiginosus

This small sandy brown-coloured goby is extremely common in sandy areas, often remaining in shallow pools and streams on sand flats, where small specimens may easily be mistaken for shrimps. Large specimens reach up to 8 cm and usually occur individually whereas juveniles occur in large numbers.

Forsterygion nigripenne

This small fish is found beneath boulders on rocky and sandy shores. Pairs are usually found, and in the spring eggs are laid beneath the boulder and guarded by the adults.

Forsterygion nigripenne is found throughout the Harbour but is most common in clean sand situations.

Whitebait (Galaxias attenuatus)

Whitebait migrate through the Harbour in the spring in 'runs' the timing of which is determined by the lunar cycle.

Whitebait were once sought for eating and whitebait fishing was a popular pastime in the season. At present, however, the runs of whitebait are considerably reduced, and only small numbers are caught for consumption.

Retropinna sp.

Retropinna sp. is a small fish which apparently migrates into the Harbour to take advantage of the food supply offered by rich detrital deposits of the shallow reaches of the Upper Harbour. These small fish are often mistaken for whitebait.

Argentea sp.

Argentea sp. is a small fish which migrates into the Harbour to take advantage of the abundant food supply in the rich detrital deposits in the shallow reaches of the Upper Harbour. These small fish are often mistaken for whitebait.

Yellow-bellied Flounder

Yellow-bellied flounder are the most common flatfish in the Waitemata Harbour. They are found throughout the Harbour, particularly in the shallow bays and estuaries of the Upper Harbour. A large range of sizes is present, with juveniles of about 1 cm long being present in spring, and adults up to 45 cm being present all year.

Flounder feed on a variety of small invertebrates found in soft sediments. These include polychaetes, crabs and small molluscs. There is an abundant supply of suitable food for flatfish in the shallow flats of the Upper Harbour.

Yellow-bellied flounder are a popular food fish and are caught commercially by approximately four full time fisherman. Flounder netting is also a popular recreational pastime.

Common Sole

Small numbers of common sole occur in the Harbour. These are occasionally caught in set nets.

Dab

Small numbers of dab occur in the upper reaches of the Harbour. These are occasionally caught in set nets.

Plaice

Plaice are rare in the Waitemata Harbour, but are occasionally caught in set nets.

Short-tailed Sting Ray

Short-tailed sting rays are common in the Harbour at times, particularly in the wharf area, and on Upper Harbour sand flats. Individuals reach a large size - in excess of 1.5 m across and 100 kg in weight.

Stingrays consume a variety of soft sediment dwelling invertebrates, principally molluscs. They are caught on baited lines and often get caught in set nets.

Eagle Ray

Eagle rays are the most common ray in the Waitemata Harbour and occur throughout the Harbour in all seasons. Most specimens are less than 1 metre in span.

Eagle rays appear to consume bivalve shellfish when feeding in the Harbour area, and often leave large excavations in intertidal sand flats where they have been seeking *Chione stutchburyi* and *Amphidesma australe*.

They may be caught on a baited line, and also become trapped in set nets.

Bronze Whaler Shark

Bronze whalers are common in the Hauraki Gulf in the summer and occasionally enter the Waitemata Harbour. They are scavengers and consume any dead animal flesh. It is possible that bronze whalers enter Harbour waters to give birth to their young.

Hammer Head Shark

Hammer head sharks enter the shallow waters of the Hauraki Gulf and Firth of Thames to give birth to their young. The Waitemata Harbour was probably once used for breeding purposes by this species. However, hammer heads, and sharks in general are now less common than they were previously, and it is unlikely that the Harbour is still used for breeding.

Hammer heads are fish feeders and scavengers.

Dog fish

Dogfish are occasionally abundant in the Waitemata Harbour, particularly in the summer when large numbers of juveniles are present. It is not known if this species uses the Harbour for breeding purposes, or whether the juveniles migrate to the Harbour from the Gulf and the Firth of Thames.

Dogfish consume a variety of benthic invertebrates, including crabs, molluscs and polychaetes.

They are usually caught on baited lines when fishing for schnapper and other edible species.

School Shark

Small numbers of school shark occur in the Harbour at times. This species averages 130 cm in length, and is a general scavenger and invertebrate feeder.

Fishes of the Waitemata Harbour Study Area

Species	Use of Harbour f=feeding s=spawning	Feeding Area	Principal Food	Occupation p=permanent t=temporary w=winter s=summer	Population i=increasing d=cecreasing s=stable
Schnapper	f	widespread	inverte-brates	p	s
John Dory	f	Outer Hbr	fish	t	d?
Trevalli	f	widespread pelagic	planktonic and benthic inverts.	t	d?
Kahawai	f	widespread pelagic	fish and inverts.	p	s
Kingfish	f	widespread pelagic	fish	p	d?
Koheru	f,s?	widespread	planktonic organisms	p	s
Barracouta	f	Outer Hbr	fish	t	d?
Piper	f,s?	widespread	planktonic organisms	t	d
Yellow-eyed Mullet	f,s	widespread	planktonic organisms	p	s
Grey Mullet	f	Upper Hbr	small inverts in soft seds.	t,s	s
Blue Maomao	f	Outer Hbr	planktonic inverts.	p	d
Paketi	f,s	widespread	benthic inverts.	p	s
Banded Parrot Fish	f,s	Outer Hbr	benthic inverts.	p	d
Paroro	f,s	widespread	algae and detritus	p	s
Red Moki	f,s	Outer Hbr	algae	p	d
Blue Cod	f	Outer Hbr	benthic inverts.	p	d
Marble fish	f,s?	Outer Hbr		p	d
Hiwihiwi	f,s	Outer Hbr	benthic inverts.	p	d
Drummer	f	Outer Hbr	algae	t	d
Butterfish	f,s	Outer Hbr	algae	p	d
Stargazer	f,s	sandflats	inverts.	p	d?
Gurnard	f	sandy bottom	benthic inverts.	t	d

Species	Use of Harbour	Feeding Area	Principal Food	Occupation	Population level
Seahorse	f,s	rocky reef algae	crustacea	p	d
Eel	f	widespread	benthic inverts.	t,m	d
Tommy Cod	f,s	rocky reef	benthic inverts.	p	s
<u>Acentrogobius</u>	f,s	widespread	benthic inverts.	p	s
<u>Forsterygion</u>	f,s	rocky areas	benthic inverts.	p	s
<u>Galaxias</u>	f	water	planktonic organisms	t,m	d
<u>Retropinna</u> <u>sp</u>.	f,s?	mudflats & mangrove	benthic inverts.	t	d
<u>Argentea</u> <u>sp</u>.	f,s?	mudflats & mangrove	benthic inverts	t	d
Yellow-bellied Flounder	f,s	sand and mudflats	benthic inverts.	p	s
Common Sole	f	sand and mudflats	benthic inverts.	t	s?
Dab	f,s?	sand and mudflats	benthic inverts.	p	s?
Plaice	f	sand flats	benthic inverts.	t	s?
Short-tailed Sting Ray	f	sand flats	benthic inverts.	p	s?
Eagle Ray	f,s?	sand and mudflats	benthic inverts.	p	s?
Bronze Whaler	f,s?	widespread	scavenger	t,s	d
Hammer Head	f,s?	widespread	carnivore scavenger	t,s	d
Dogfish	f,s?	widespread	benthic inverts.	t,s	s
School Shark	f	widespread	benthic inverts. & scavenger	t	d?

Discussion

It can be seen from the table that populations of many species of fish are decreasing within the Waitemata Harbour Study Area. It is difficult to assess the rates of reduction of such populations, or whether population levels will stabilise at a lower level or keep falling until there are no individuals of a certain species remaining. There are many factors which may lead to reduction in fish populations and different species react in different ways to such factors. In some cases a definite cause may be attributed to the reduction of a certain species, but more usually it is a combination of several factors that adversely affects fish populations.

Some of the factors contributing to reductions in fish populations are :

(a) Reduction of spawning area

The decrease in whitebait runs over the years may almost certainly be attributed to the reduction in spawning areas in the rivers flowing into the Waitemata. Siltation, reclamation and deteriorating water quality are important in the upper reaches of the Harbour and freshwater streams and rivers flowing into these areas.

Deteriorating water quality, particularly in terms of increasing sediment burden is considered an important factor reducing the suitability of the Harbour as a spawning area. Other species potentially affected are the sharks, flatfish, Butterfish, Blue Maomao, and Red Moki.

(b) Reduction of feeding areas

Reduction of feeding areas may mean one or both of two things - a physical reduction of the area available for feeding, or a reduction of the area in which suitable food organisms are found.

The reduction in eel populations may be attributed to the reduction of feeding areas caused by reclamation and draining of wetland adjacent to the waterways leading into the Harbour.

Reductions of many of the other fish populations may be attributed to changing patterns of distribution and abundance of common food organisms. Large scale changes are described in the 'Report on Intertidal Ecology.'

One of the most important and widespread changes in this respect has been due to the siltation of wide areas in the Upper Harbour changing the sediment nature and the nature of the flora and fauna. In this Harbour finer sediments probably favour the flatfish populations which have remained stable, but the spread of such sediment has meant the decrease in feeding area available to other feeders on soft sediment benthic invertebrates such as schnapper, gurnard, trevalli and stargazer.

(c) Deterioration of Water Quality

Fish are generally sensitive to impurities in water and tolerant of only small degrees of contamination. In the Waitemata Harbour the changing pattern of freshwater flow (see 'Ecological Report on Harbour Waters') and increasing sediment burden of tidal waters are thought to be the two factors most important in affecting the distribution and behaviour of fish populations.

(d) Exploitation

Exploitation may be a contributing factor to reduction in population level of some fish species, e.g. whitebait, schnapper, John Dory, butterfish, but it is unlikely that exploitation within the Harbour area is having any effect at present rates. Reductions in populations of edible species such as schnapper, gurnard, John Dory, and some of the pelagic species may, however, be due to exploitation of populations outside the Harbour area.

(e) Noise

The increasing volume of underwater noise caused by increasing water traffic may be an important factor in reducing populations of some fish species. It is believed that some of the pelagic species, including sharks, show strong aversion to certain types of noise generated by fast pleasure craft.

Although many of the species of Harbour fish are diminishing in numbers there is still a large variety represented in Harbour waters. To preserve this variety of fish species it is important to protect the diversity of shore types and natural invertebrate communities within the Harbour area. Control of effluents leading to a reduction of pollutant material, (particularly fine sediments) entering the Harbour is important in this respect, along with the retention of natural shoreline wherever possible.

ECOLOGICAL REPORT ON BIRDS OF THE WAITEMATA HARBOUR STUDY AREA

The common birds which are in some way dependent on the shores and waters of the Waitemata Study Area are listed below. A brief description of the distribution, food and behaviour of each species is given, along with a discussion of the interaction of the species with the human population and activities.

A brief summary gives the main factors affecting bird populations in the Waitemata Harbour Study Area.

Common birds of the Waitemata Harbour Study Area.

- Northern Blue Penguin
- Australian Gannet
- Black Shag
- Pied Shag
- Little Black Shag
- Little Shag
- White-faced Heron
- White Heron
- Blue Reef Heron
- Mallard Duck
- Banded Rail
- Pukeko
- Pied Oystercatcher
- Banded Dotterel
- Wrybill
- Eastern (Pacific) Bar-tailed Godwit
- Eastern Knot
- Pied Stilt
- Southern Black-backed Gull
- Red-billed Gull
- Caspian Tern
- White-fronted tern
- Rock Pigeon
- Kingfisher
- Starling
- Giant Petrel

Northern Blue Penguin

This small penguin is abundant in the more open waters of the Hauraki Gulf and occasionally enters the outer part of the Study Area, particularly in the Rangitoto Island Region. It is only rarely seen inside North Head.

Northern Blue Penguins probably roost and nest on Rangitoto Island in small numbers. The numbers seen within the Study Area are probably decreasing as a result of increased boating activity and increased use and alteration of shore areas.

Australian Gannet

The gannet is abundant in coastal waters, and occasionally enters sheltered harbours. Gannets are often seen in the outer part of the Study Area, and enter the inner part of the Harbour in prolonged periods of easterly weather when they fish in the channels as far as Whenuapai.

Food in the Harbour area probably consists of small fish such as yellow-eyed mullet, koheru, and small grey mullet. Numbers occurring generally within the Study Area are probably decreasing as a result of increasing water turbidity. Gannets require clear water to sight fish swimming near the surface.

Black Shag

Occasionally seen in the Study Area during autumn and winter this species is immediately conspicuous because of its large size. Small groups of birds are seen most frequently in the Glendowie Spit and Te Atatu regions, when they rest on sandbanks at low tide.

Black Shags are probably piscivores, and are known to eat large quantities of eels in inland areas. This species appears to be extremely sensitive to the close proximity of human populations and activity. Presence within the Harbour Study Area will probably decrease with increasing development.

Pied Shag

Pied shags are common throughout the Study Area, and are particularly abundant in the tidal creeks of the Upper Harbour, where they are often seen fishing in the water or resting on the banks.

Food consists of small fish - in Upper Harbour areas mainly flatfish and yellow-eyed mullet; in the Outer Harbour a variety of small fish are probably taken.

Pied Shags are tolerant of the close proximity of human populations and activity, and numbers are probably fairly stable. Roosts and nesting colonies are commonly situated in tall trees adjacent to the Harbour shore.

Little Black Shag

This species is most common in winter when large flocks may be seen flying in formation, or resting or feeding in the Study Area. Up to 150 birds occur in a single flock, and when feeding, individuals in the flock co-operate, with the whole flock diving and surfacing simultaneously.

Large winter visiting flocks feed over much of the Harbour. There also appear to be small resident populations which are most often found in the upper reaches of the Harbour in areas such as the Whau River, Hellyers Creek, and towards Riverhead.

Food consists mainly of fish such as yellow-eyed mullet and small flatfish. Little Black Shags appear fairly tolerant of human populations and activity, and at present numbers appear stable.

Little Shag

Little Shags occur in small numbers, and are spread throughout the Upper Harbour where they are most often seen resting and drying their wings on the banks of tidal creeks at low tide.

Food is probably mainly fish.

Populations appear to be stable at present, and this species seems to be unaffected by changes caused by human activities.

White-faced Heron

The White-faced heron is common, particularly on the extensive sheltered sand and mud flats of the Upper Harbour area. They are normally seen in pairs or singly, with individuals spread over the intertidal area.

Food consists of larger crustacea such as the crabs, Helice crassa and Hemiplax hirtipes, and the snapping shrimp, Alpheus sp. and the herons utilise the abundant supplies of these species found in mangrove swamps.

White-faced herons roost and nest in large trees, often at some distance from the water. They are tolerant of human activity and numbers appear to be increasing rapidly.

White Heron

White herons are seen only rarely in the Waitemata Harbour Study Area. The Pollen Island - Waterview Inlet region is where they are most often seen, but individuals are also seen elsewhere. They appear to stay in the area only to feed for short periods before departing.

Blue Reef Heron

Only small numbers of this species occur in the Study Area, and they are most common on the rocky reefs of the Outer Harbour, where they occur singly or in pairs.

Food consists of small crustacea and fish, normally taken from rocky reef areas, but occasionally from pools and tidal streams in sandy areas.

Blue Reef Herons roost and nest in secluded cliff areas. They are extremely sensitive to the presence of human populations and activities, and are apparently decreasing in numbers.

Mallard Duck

Mallard ducks are common in some of the tidal creeks of the Upper Harbour - particularly in the Whau Creek, and also in Meola and Motions Creeks and the Tamaki Estuary.

In such areas the ducks are apparently feeding on rich organic detrital material deposited on the bottom sediments. They are tolerant of the close proximity of human activity and are probably relatively stable in numbers, although the availability of suitable nesting areas is probably being reduced.

Banded Rail

Banded Rails are occasionally sighted in areas fringing mangrove marshes.

Nests are located in scrubby areas adjacent to mangrove marsh.
This species is uncommon at present, and numbers are likely to decrease as suitable habitat is altered.

Pukeko

The Pukeko is common in some parts of the Upper Harbour, particularly in swampy regions with mangrove in the intertidal.

This species is tolerant of the close proximity of human populations and development, but because of a reduction of suitable habitat area, numbers are probably decreasing.

Pied Oystercatcher

This species feeds both on rocky reefs and on sandy flats. It is most often seen along the Tamaki Drive shore between Okahu Bay and St Heliers Bay, and in the entrance area to the Tamaki Estuary, including the Glendowie Spit.

Oystercatchers normally occur in small groups of up to 20 birds. They feed at low water on a variety of molluscs on hard shores, and on polychaetes and bivalves in soft shore areas.

This species shows little tolerance of the close proximity of human habitation or activity. Numbers are probably decreasing in the Study Area.

Banded Dotterel

This species occurs seasonally in winter, in some numbers on shelly and sandy areas, particularly in the entrance area of the Tamaki Estuary where there are extensive flats at Farm Cove and Glendowie Spit.

They feed actively at low tide, probably on small crustacea and polychaetes. Individuals spread over wide areas of intertidal flats.

These birds favour remote open areas, and appear intolerant of the close proximity of human development or activity. Population levels are probably fairly stable at present.

Wrybill

Occurring in small numbers in the winter months, particulaly in the entrance area of the Tamaki Estuary on the Glendowie Spit.

Feed on open sand flats, probably on small crustacea - amphipods and isopods.

Require remote areas for feeding and roosting. The numbers wintering in the Study Area are probably decreasing.

Eastern (Pacific) Bar-tailed Godwit

Godwits occur in the Study Area in considerable numbers in the summer, (October to March), and migrate back to Siberia or North-western America in the winter.

The largest concentrations occur on the open flats near the entrance to the Tamaki Estuary. Godwits feed at low water by probing in the substrate with their long slender bill. Principal food organisms appear to be small crustacea and polychaetes.

Godwits require remote areas for roosting and feeding, and with the increase of human activity and decrease of suitably remote roosting areas, numbers will probably decrease.

Eastern Knot

Knots often occur with Godwits and have a similar distribution within the Study Area. These birds are also migratory from Siberia and North-western America.

Knots also require remote feeding and roosting areas, and appear to be restricted in distribution to the extensive flats of the entrance area of the Tamaki Estuary, particularly surrounding Glendowie Spit.

Numbers will probably decrease as shoreline and water activity increase.

Pied Stilt

The Pied Stilt is one of the most widespread waders in the Study Area. It occurs on soft shores, from the muddy inlets of the Upper Harbour to firmer sand flats near the Harbour entrance, and is one of the few birds which are common in the soft muddy intertidal environments of sheltered Upper Harbour areas.

Pied Stilts feed on small crustaceans and polychaetes. They roost in secluded areas such as the shell bars of Pollen and Traherne Islands or inland in pastureland.

Pied Stilts utilise a habitat which is little used by man. They are tolerant of considerable development of the shoreline, and the principal limiting factor in the Study Area appears to be the availability of suitable roosting areas.

Southern Black-backed Gull

Black backed gulls occur throughout the Harbour, with the largest numbers being found in refuse disposal areas and around the wharves.

This species is a scavenger and feeds on any organic animal material. In some areas, however, the diet consists almost solely of marine invertebrates, particularly molluscs.

Black-backed gulls are tolerant of most human activity and development. Numbers have increased with the ready availability of food in the form of organic wastes.

Roosts occur at Te Atatu (south of Harbour View Road), on the wharf sheds, on Rangitoto Island, and in the Upper Manukau Harbour.

This is one of the few species that has shown an increase in numbers as a result of human activities.

Red-billed Gull

Red-billed gulls are common throughout the Harbour. This species obtains food from a variety of sources, including scavenging at rubbish tips, feeding on small invertebrates on sandy and rocky shores, and feeding on planktonic organisms in Harbour waters.

Large aggregations are found in areas where there has been enrichment of soft sediments such as in Shoal Bay, where they are apparently feeding on small crustacea and polychaetes.

This species is well adapted to the presence of human populations and numbers have probably increased considerably since the arrival of man, and subsequent development of the Harbour area.

Caspian Tern

Caspian terns are often seen in the sheltered waters of the Upper Harbour where they feed on fish caught by diving.

This species rests in small aggregations of up to 26 birds at low tide, and commences feeding as the tide rises. Common intertidal resting areas at Te Atatu, north-east of Harbour View Road and at the Glendowie Spit.

This species may have been reduced in number within the Study Area by increasing water turbidity which would make the sighting of fish prey more difficult.

White-fronted tern

White-fronted terns are more common in the open waters of the Hauraki Gulf than in enclosed Harbour waters. However, there appears to be a small resident population in the Waitemata Harbour which feeds in the Upper Harbour channels in the vicinity of Hobsonville and Whenuapai. Considerable numbers of white-fronted terns enter the Harbour occasionally in winter.

Food is almost solely fish, which is caught by diving. The most common species taken is probably yellow-eyed mullet.

The numbers of this species in the Waitemata Harbour Study Area is probably being reduced as suitably remote roosting areas become fewer.

Rock Pigeon

Rock pigeons feed intertidally in several parts of the Harbour, mainly in shelly waterfront regions. (It is possible that pigeons are merely gathering suitable material for their crops.)

Kingfisher

The kingfisher is the most common intertidally feeding bird of the Upper Harbour. It is particularly common where there are extensive mangrove marshes with adjacent vegetation on the shoreline.

Food consists almost solely of crabs - Helice crassa and Hemiplax hirtipes, which are plucked from the surface of the mud whilst the bird is in flight.

Kingfishers roost and nest in steep, inaccessible areas near the shore. Numbers have probably been reduced in some areas where the shoreline has been altered by human activity, but generally population levels appear to be stable.

Starling

Stalings occasionally feed in intertidal areas where food seems to consist almost solely of small gastropods such as Melarapha oliveri and Risselopsis varia.

Giant Petrel

Giant petrels are well known as scavengers and are often seen patrolling the sewage effluent off North Head.

Sooty Shearwater

Sooty Shearwaters frequently occur in the Outer Harbour, particularly towards the Rangitoto Light.

They are more typically an open-water species and are abundant in the Hauraki Gulf and further north.

Food appears to consist largely of small pelagic fish. Numbers have probably been reduced within the Harbour Study Area as a result of increased water turbidity.

Several other species of birds occasionally enter the Harbour Study Area - particularly members of the migratory wading group, and the pelagic fish feeding group (petrels and shearwaters). However, when such species do enter the Study Area it is only in small numbers and for a short period of time.

Birds of the Waitemata Harbour Study Area

Abbreviations used in Table

Use of Harbour
f = feeding
r = roosting
n = nesting

Occupation (period spent within the Harbour Study Area)
p = permanent
t = temporary
m = migrant
w = winter
s = summer

Population level
i = increasing
d = decreasing

Species	Use of Harbour	Feeding Habitat	Principal Food	Occupation	Population Level
Northern Blue Penguin	f,r,n	open water	fish	p	d
Australian Gannet	f	open water	fish	t	d
Black Shag	f,r	water	fish	t	d
Pied Shag	f,r,n	water	fish	p	s
Little Black Shag	f,r	water	fish	t,w	s

Species	Use of	Feeding	Principal	Occupation	Population Level
Little Shag	f,r	water	fish	t	s
White-faced Heron	f,r,n	int. sand and mud	crustacea	p	i
White Heron	f,r	int. sand and mud	crustacea and fish	t	d
Blue Reef Heron	f,r,n	rocky reefs and pools	crustacea and fish	p	d
Mallard Duck	f,r,n	shallow water	rich org. sediment	p	s
Banded Rail	f,r,n	mangrove marsh	small crustacea?	p	d
Pukeko	f,r,n	mangrove marsh	vegetation	p	d
Pied Oystercatcher	f,r	rocky reefs & clean sand	molluscs crustacea	m,w	d
Banded Dotterel	f,r	shelly sand flats	small crustacea	m,w	d
Wrybill	f,r	sand flats	crustacea polychaetes	m,w	d
Eastern Godwit	f,r	sand flats	crustacea polychaetes	m,s	d
Eastern Knot	f,r	sand flats	crustacea polychaetes	m,s	d
Pied Stilt	f,r	mud flats & sand flats	small crustacea	p	s
Southern Black-backed Gull	f,r,n	widespread	scavenged animal waste & gastropods	p	s
Red-billed Gull	f,r	widespread	small crustacea	p	s
Caspian Tern	f,r	open water	fish	p	d
White-fronted Tern	f,r	open water	fish	p	d
Rock Pigeon	f	shelly and gravel areas	?	t	s
Starling	f	rocky shores	small gastropods	t	s
Kingfisher	f,r,n	mangrove marsh	crabs	p	s
Giant petrel	f	open water scavenger	waste animal matter	t	s?
Sooty Shearwater	f	open water	fish	t	d

Summary

Several factors are important in determining distribution and abundance of species of birds reliant on the Waitemata Harbour Study Area.

1. Food

Changes in the abundance of various types of invertebrate food organisms may well have a limiting effect on the distributions of some local bird species. Widespread alteration of soft shore communities in the Upper Harbour by sedimentation has effectively destroyed the feeding grounds of some wading species and enabled other birds to replace them.

The increase in organic animal wastes made available by rubbish tipping and waste discharge has certainly caused an increase in populations of Southern Black-backed Gull and Red-billed Gull.

In the case of pelagic fish feeding birds it appears that populations are being reduced not as a result of less food being available, but because of an increase in water turbidity making the food less easily seen.

2. Roosting Areas

Most species of Harbour birds require secluded roosting areas. Some species are more adaptable than others to the close proximity of human developments and activities. The reduction of suitably secluded roosting sites is perhaps the most important factor instrumental in reducing numbers of Harbour bird species. Important roosting areas at present are Glendowie Spit, Pollen Island-Traherne Island, and the sand banks near the entrance to the Henderson Creek and in the Upper Harbour.

3. Nesting areas

Most bird species require more secluded areas for nesting than they need for roosting. Only a small number of bird species nest in the Waitemata Harbour Study Area, and some of these are probably under considerable pressure as a result of the increasing rarity of suitable sites.

4. Competition

Competition by different species for the same resources may be instrumental in controlling the size of some bird populations. However, there is no direct evidence of such a case in the Harbour Study Area.

The table suggests that the population levels of many of the Harbour birds are decreasing. In most cases it appears that a combination of several factors is important in causing such decreases. It is suggested that some of the more secluded areas used by birds for roosting purposes be preserved for this purpose. (See Ecological Report on Intertidal Reserves.)

REPORT ON EDIBLE SHELLFISH OF THE WAITEMATA HARBOUR

The shores of the Waitemata Harbour support a number of shellfish which are traditional foods of the Maori and are also taken for food by large numbers of the Pakeha population. Generally, it can be stated that wherever an edible species attains sufficient size and density it is taken for food.

The Ecological Report describes the distribution of edible shellfish within each of the 27 divisions of the Study Area. In this report a brief description of each edible species is given together with a brief discussion of the effects of human exploitation and natural changes on the species within the Study Area.

Common edible shellfish found in the Harbour are listed below with the minimum size at which they are normally taken for human consumption and the common maximum length to which they grow in the Study Area.

		min. edible length (mm)	common max. l. (mm)
Chione stutchburyi	cockle	30	40
Amphidesma australe	pipi	50	70
Amphidesma subtriangulatum	tuatua	45	60
Dosinia subrosea		40	60
Mactra ovata	trough shell	45	75
Macomona liliana	wedge shell	40	65
Perna canaliculus	mussel	70	140
Crassostrea glomerata	rock oyster	50	90
Pecten novaezelandiae	scallop	100	180
Lunella smaragda	cat's eye	20	35
Amphibola crenata	mud snail	20	28

Chione stutchburyi

Chione is one of the most popular of the edible species. It is found intertidally on soft shores throughout the Harbour, being excluded only from shores where the substrate is too soft or muddy.

Generally, the largest individuals are found towards the entrance area to the Harbour about the low water mark - as at Cheltenham and on the Glendowie Spit - although populations of edible size occur in many areas. There is a gradation in the maximum length attained dependant on the height at which populations occur on the shore, and the quantity of food they receive.

Chione is not spread evenly over a shore but typically occurs in beds. Such beds often contain large numbers of individuals of similar size and age with adjacent beds having populations of different size and age. This type of distribution is the result of patchy recruitment which is normal for this species. Juveniles are often found in quite small beds with densities up to 4,000 per square metre.

In ideal growth situations such as at Cheltenham, Chione reaches an edible size of 30 mm in the third year. In less suitable areas a length of 30 mm may only be reached after 5 or 6 years.

Human exploitation has had little long term effect on Chione populations within the Harbour. Recruitment occurs on a satisfactory scale to maintain population levels; the sole effect of concentrated exploitation being to temporarily deplete populations in an area until subsequent recruitment again provides an edible population.

Of considerable importance in reducing the total area available to Chione populations in the Study Area has been the alteration of substrate nature by the deposition of fine sediments. In several regions of the Harbour there has been substantial mortality of Chione populations by burial and suffocation. Sedimentation has undoubtedly decreased population densities over a wide area.

Amphidesma australe

The pipi is found both intertidally and subtidally in dense beds in regions with a coarse, sandy or shelly substrate. Although common in the Waitemata Harbour it does not form the extensive beds of large individuals found near the entrances of many northern harbours, because of the lack of a suitable substrate over wide areas. Within the Harbour two distinct habitats may be recognised; first, at the foot of sloping beaches such as Cheltenham, Mission Bay, Kohimarama, and Bucklands; and second in subtidal channels as on the end of the Glendowie Spit. On sloping beaches recruitment of A. australe appears to be constant along the beach, whereas in subtidal areas there are often distinct beds based on areas of suitable substrate.

Recruitment of the pipi is variable from year to year with one or two year classes often being dominant in a population. In ideal growth conditions animals take 4 or 5 years to reach edible size.

Human exploitation has noticeably reduced the density of pipi beds in some areas - notably the end of the Glendowie Spit, although it is possible that these will regenerate in the future.

The deposition of fine sediments derived from land runoff has also adversely affected populations of this species. Complete mortality of populations is rare, but there has been considerable reduction in growth rates and densities in some areas.

Amphidesma subtriangulatum

Restricted in the Study Area to Takapuna and Narrow Neck beaches, this species is common on semi-exposed sandy shores; these two beaches being the inner end of the exposure spectrum tolerated by *A. subtriangulatum*.

Dense beds of several hundred individuals per square metre are found between low water neap and low water spring at Takapuna. When the sand is exposed the animal is found just beneath the surface, and may often be detected by small depressions in the sand.

Recruitment appears to be fairly regular with several year classes being present at the moment. *A. subtriangulatum* takes 3 to 4 years to attain edible size.

Although the tuatua is popular for eating the populations at Takapuna do not appear to be heavily exploited. At present, however, most of the animals are fairly small in size and exploitation will probably increase as they grow. Exploitation in the Study Area is unlikely to affect future recruitment which is probably derived from populations further to the north.

There are no predictable natural changes which will affect the populations of *A. subtriangulatum* in the Study Area.

Dosinia subrosea

This species is found only in clean sand at the low tide mark at Cheltenham, Mission Bay, and Kohimarama.

Dense beds are not formed, and in maximum concentrations individuals are 15 to 20 cm apart. They can be detected by siphonal marks on the surface and live about 15 cm down.

Little is known of recruitment other than the fact that there are only small numbers of juveniles present at the moment. Growth rates are slow, animals of edible size being 5 or 6 years old.

This species is selectively exploited, mainly by Maoris and Islanders who recognise the surface mark. This exploitation is probably having little effect on the total populations.

Little is known of the sensitivity of this species to alteration of the natural environment. However, the habitat is unlikely to change appreciably in the near future.

Mactra ovata

This species is widespread on the softer and muddy shores of the Harbour, being most common between half tide and low tide levels in soft wet substrates.

Occasionally Mactra is found in dense beds with the shells of individuals almost touching, but more usually animals are 15 to 20 cm apart. It can be detected by siphonal holes in the mud, and by strong exhalant occurrents when covered by shallow water. Adults live 15 to 30 cm below the surface.

Little is known of recruitment of this species. There are few juveniles in the Harbour at present. Specimens of edible size are probably between three and six years old.

Exploitation of this species is most intensive in areas towards the clean or firm substrate end of its habitat spectrum, e.g. Mission Bay and Kohimarama. It is probably taken only in small numbers from other areas, possibly because of a lack of knowledge of its abundance. Such exploitation as occurs is unlikely to have any detrimental effect on Harbour populations.

The numbers of Mactra have been considerably reduced within the Harbour, probably as a result of substrate changes and the disappearance of Zostera beds.

Macomona liliana

Macomona is abundant on all sandy shores in the Study Area. In most situations it attains a maximum adult length of about 35 mm and is not sought for food.

Macomona lives up to 18 cm below the surface with individuals spaced out, usually 10-15 cm apart. A wide tidal range is tolerated with the lower limit being below low tide mark. Being a deposit feeder, there is no significant variation in size with the period of intertidal exposure. A characteristic 'birds foot' mark is left on the surface at low tide where substrate has been removed by the siphon.

Recruitment of Macomona appears regular and sufficient to maintain normal population levels.

Macomona is only taken for food from a few areas of the Outer Harbour where it reaches a large size - Cheltenham, Mission Bay and Kohimarama. Only small numbers of people selectively seek this animal.

Macomona is unable to tolerate heavy sedimentation and has been killed in some areas where this has occurred.

Perna canaliculus

The green mussel is widespread within the Study Area, being found below low tide neap on any hard clean substrate. Previously occurring in bands in the lower part of the intertidal the mussel is now common only on shaded wharf piles or in regions unfrequented by the public.

Perna is found up to about half tide level, but at that level reaches only a relatively small size. The largest specimens are found about the low tide mark or subtidally. In suitable bottom areas the mussel occurs in several fathoms of water.

Recruitment on Harbour shores appears to be low, although high densities of young individuals often occur on submerged mooring chains or on the submerged part of floating objects. The failure of this species to re-establish itself in any quantity in the intertidal zone is probably due to constant removal of those individuals which do settle before they can modify the environment to suit further successful settlement.

In optimum growing conditions (permanently submerged) Perna attains a length of about 15 cm in two years.

Perna is a popular food being taken from intertidal areas at low water and from sublittoral areas by diving. Constant exploitation keeps populations at a low level in the Harbour area.

The distribution and abundance of Perna has also been affected by siltation of reefs in the Harbour - fine layers of sediment preventing settlement at the larval stage.

Crassostrea glomerata

The rock oyster is found throughout the Study Area and occurs on any hard rock surface or on the roots, trunks and pneumatophores of mangroves where these occur at the appropriate level. This species is most abundant on the hard larva flows of Rangitoto, North Head and Westmere Reef, as well as on the constructed basalt walls in the Harbour area. Densities are reduced somewhat on the natural sandstone shores, the softer rock providing a less stable surface. In optimum conditions a solid band of oysters is formed between mid tide level and low water neap.

Recruitment of Crassostrea is variable from year to year but is sufficient to maintain present population levels. In most areas with suitable substrate high densities result in reduced growth rates. Under optimum conditions the rock oyster may reach a length of 8 cm in two to three years. However, such growth rates are seldom realised in the Harbour area, the average time taken to reach 8 cm being about 5 years.

Although the taking of rock oysters is forbidden by law, they are taken in small quantities wherever they occur. Exploitation levels at present have little effect on population levels.

Increasing sedimentation in the Study Area has resulted in some areas becoming unsuitable for rock oyster colonisation, but the greatest effect of human activity on this species has been to increase the suitable area for colonisation by the construction of basalt retaining walls along considerable lengths of the Harbour foreshore.

Pecten novaezelandiae

The scallop is now almost completely absent from the Waitemata Harbour. Previously common on low tidal flats, a combination of the disappearance of Zostera, human exploitation for food, and perhaps deterioration of water quality have been responsible for the disappearance of this species. It appears unlikely that it will become re-established.

Lunella smaragda

The common cats-eye reaches considerable size on some of the more sheltered rocky shores in the Harbour. It is widespread in distribution and occurs below half tide level on all rocky shores.

The largest specimens of Lunella are found in mangrove marshes where they eat a rich film of algae growing on the hard surfaces of trunks and pheumatophores. In such areas, however, the population density is fairly low. In more exposed open reef situations population density is much higher but the maximum size of individuals is much smaller.

Recruitment of this species appears regular in open reef situations of the lower reaches of the Harbour, but irregular on reefs of the Upper Harbour and in mangrove marshes. Under average conditions a diameter of 20 mm is reached in about three years.

This species is exploited by only small numbers of the human population and is most often taken from open reef situations of the lower region of the Harbour. Such exploitation has only a temporary local effect in reducing population density.

Lunella is another species which has gained considerable territory in the basalt walls constructed along the foreshore.

Amphibola crenata

The mud snail is abundant on sheltered sand flats of the Upper Harbour region and also amongst mangrove. An almost uniform maximum size of 25 mm is reached with vast numbers of individuals being about that size.

Recruitment of this species appears regular and sufficient to maintain present population levels. Under average conditions a length of 25 mm is reached in three to four years.

Although the Maoris used this species for food exploitation at present is only at a low level and is having a negligible effect on population levels.

Amphibola is one species which may gain territory by increased sedimentation on Harbour flats. The mud snail is generally restricted to the upper half of the intertidal zone and will colonise new areas as the sediment builds up to that level. It is also able to utilise the environment produced by the spread of mangrove as a result of sedimentation.

Other species

Several other species of shellfish which occur in the Study area were utilised in small numbers by the Maori. These included the gastropods *Neothais scalaris*, *Haustrum haustorium*, *Alcithoe arabica*, *Penion adusta*, and *Cabestana Spengleri*, and the bivalve *Atrina zelandica*. *Neothais* and *Haustrum* are the only species which are still common in the Harbour, and it is unlikely that any of the above species are still taken for food.

Discussion

Present rates of human exploitation of shellfish populations in the Waitemata Harbour are generally having little deleterious effect on those populations. The green mussel has shown the greatest reduction in numbers although these are probably stable at present. The disappearance of scallops cannot be attributed to exploitation alone.

Of some concern is the effect on shellfish populations of the deposition of fine sediments. In some cases large areas of intertidal substrate have been made unsuitable for continued colonisation by common species, while sedimentation of a lesser degree has reduced population densities and growth rates.

Also of some concern is the potential contamination of shellfish by pollutants and bacteria. Traditional shellfish gathering areas such as Okahu Bay are close to the port and discharge points of sewer overflows. Shellfish are taken for eating from the port area itself. Generally, wherever a suitable species grows to edible size it is likely to be taken for food.

THE CHANGING ECOLOGY OF THE WAITEMATA HARBOUR

In this report the various types of natural ecological change that may occur within the Waitemata Harbour are discussed, along with a description of some of the changes that have occurred to date.

Short-term Fluctuations

In any ecosystem there is a natural variation in the abundance of organisms determined by various physical and biological factors.

Physical factors include :

(a) frosts
(b) heat mortality
(c) storms
(d) low salinities

Biological factors include :

(e) predation
(f) fluctuating recruitment
(g) competition
(h) disease

Known influences of these factors include :

(a) Frosts
Mangroves are known to be intolerant of frost and some mortality of mangrove trees in the Waitemata Harbour area has been attributed to frost.

(b) Heat
High temperatures coinciding with low water spring tide in early and mid-afternoon have been responsible for the mortality of several types of marine invertebrates in the Waitemata Harbour. In spring the 'burning off' of intertidal algae is a common phenomenon.

(c) Storms
Rough water conditions generated in storms remove sessile organisms from hard surfaces and may bury, or remove soft shore organisms.

(d) Low Salinities

Prolonged salinity reduction in wet periods may cause mortality of some animals, particularly those that are unable to seal themselves off from the external medium. Reduced salinities are also important in restricting the distribution of fish species.

Biological factors

(e) Predation

Heavy predation may result in the complete removal of prey organisms from an area, with the consequent disappearance of predators. Such cycles occur locally with the predation of young bivalves such as Chione stutchburyi and Amphidesma australe by Cominella species, and the predation of the small barnacles Elminius modestus and Chamaesipho columna by Lepsiella scobina.

(f) Fluctuating Recruitment

Many marine invertebrates, and the algae, have planktonic larval forms which are carried in the water for a variable time before they seek a site for development to the adult stage. This system leads to dispersal of the species, but at the same time provides an unpredictable recruitment to any particular area. Many harbour species of animals and plants have a variable recruitment from year to year. Some of the common shellfish, including the cockle, Chione stutchburyi, the pipi, Amphidesma australe, and the rock oyster, Crassostrea glomerata, have considerable variation in the population age, and size structure in different areas. In some cases there may be a period of several years between recruitments.

(g) Competition

Varying recruitment success for a competitively superior organism determines the amount of space available for other organisms with similar environmental requirements. The variable recruitment of some of the hard shore 'zoning organisms' may result in noticeable ecological changes because of this competition.

(h) Disease

Mass mortalities of organisms may sometimes be attributed to disease. The best documented example in the Waitemata Harbour has been the disappearance of Zostera or eel grass.

Long Term Changes

As well as the factors causing temporary fluctuations in abundance of organisms there are several natural processes which lead to a predictable long term change in the ecology of an area.

A. Alteration of Substrate Nature
B. Increase in height of substrate
C. The spread of a biological influence
D. Exploitation

A. Alteration of Substrate Nature

The most widespread cause of alteration of substrate nature in the Waitemata Harbour is the deposition of fine sediments. Although this is a natural process, the sediment burden of Harbour waters, and consequently the rates of sediment deposition in protected areas have been considerably increased as a result of development of the watershed area. (See 'Ecological Report on Harbour Waters' and 'The Ecological Effects of Pollution in the Waitemata Harbour')

Under natural conditions sediments are derived in small quantities from land runoff, from erosion by rivers and streams, and wave action on the shoreline, and by suspension of fine bottom sediments both inside and outside the Harbour, by current action, and during storms.

The deposition of fine, water-borne sediments in areas which previously had coarser or cleaner substrates results in a number of ecological changes. In soft sediment areas, fauna that are intolerant of finer sediment grades are gradually replaced by those able to tolerate the finer silts and muds, while on hard shores deposited sediment often makes a rock surface unsuited for the attachment of sessile organisms.

B. Increase in Substrate Height

As a result of the deposition of fine sediment from the water, the level of intertidal and subtidal regions is slowly built up, with the consequent longer exposure of intertidal regions, and the appearance of intertidal banks in previously submerged areas.

Many animals and plants are adapted to a certain submergence period, and on an accreting shore are able to colonise new areas as the substrate reaches a suitable height. Ecological changes of this nature are generally fairly slow, e.g. the spread of mangrove and salt marsh.

C. The spread of a biological influence

The spread of mangrove provides an enlarging habitat suitable for those organisms found in mangrove marsh.

Another example of spreading biological influence is the accumulation of dead mollusc shells, whether it be into an intertidal shell barrier, or a subtidal channel area. The dead shells of molluscs which collect in the current exposed channels of the Harbour provide a suitable surface for colonisation by a wide variety of animals and algae, with the resultant formation of a rich environment.

D. Exploitation

Exploitation of marine invertebrates and algae may lead to long term changes in the ecology of an area. Within the Waitemata Harbour considerable exploitation of edible species of shellfish and invertebrates has occurred, and some of the less common species are now all but absent.

Sea eggs, Evechinus chloroticus, paua, Haliotis iris, and crayfish, Jasus edwardsi, have had their numbers in the outer Harbour reduced. The green mussel, Perna canaliculus, rarely reaches an edible size on Harbour shores. Exploitation may also have played a part in the reduction of some fish species.

Some Noticeable Ecological Changes

Besides the ecological changes described in the Report on Intertidal Ecology the reduction in population levels of several large molluscs deserves mention.

With the disappearance of large areas of eel grass or Zostera, it appears that widespread reduction of several species of molluscs occurred. These included :

Mactra ovata
Pecten novaezelandiae
Atrina zelandica
Struthiolaria vermis

Mactra ovata is the only one of these that remains in the Harbour in any numbers.

Struthiolaria papulosa was once more common than at present in clean sand habitats of the outer and middle Harbour.

Of the hard shore gastropods, Cookia sulcata has become noticeably less common, and the distribution of rock boring pholads has become less widespread.

Further ecological changes that have occurred are described above, and an assessment of the changes occurring at present is given in the Report on Intertidal Ecology.

THE ECOLOGICAL IMPACT OF RECLAMATION

The intertidal area of the Waitemata Harbour is limited to 41 square miles. Any reduction in this area will affect the nature of the remaining Harbour environment. Reasons for reclamation of tidal land must therefore be considered from the environmental point of view, as well as from the more traditional aspects of economic or other advantage. Ideally, from an ecological point of view, the maximum amount of foreshore, intertidal and subtidal area should be retained in its natural state.

The impact of a reclamation may be considered in two parts:

1. The ecological impact of removal of the particular area to be reclaimed from the Harbour ecosystem.

2. The impact on the ecology of the area surrounding the reclamation created by the presence of the reclamation.

Ecologically speaking, a good reclamation will have minimum impact in both respects.

Considering 1

It is apparent that different regions of the Harbour have different 'ecological value' per unit area, in terms of the parts they play in the Harbour ecosystem. Some areas are of a common type, e.g. mangrove swamp, and very similar; some types of area, e.g. salt marsh, are less common than others; some areas are more productive, some have been affected by man. The determination of a precise ecological value for each area or type of area within the Harbour would be a complex and lengthy task. However, by considering some ecologically-orientated parameters one can gain some idea of the ecological value of an area.

Such parameters are:

(a) the abundance of that type of area.

(b) the stability of the particular area. (Are the ecological features likely to change?)

(c) the type of flora and fauna present.

(d) biomass and productivity.

(e) interactions with neighbouring and distant areas. (e.g. contribution to food webs, supply of larval animals, etc).

In this way then, we might say that mangrove marsh has less ecological value than low tidal sand flats in the Waitemata Harbour ecosystem. Low tidal sand flats would in turn have less ecological value than an equivalent area of rocky reef shore.

We must be careful here to differentiate between the 'ecological value' of an area and the impact that removal of the area might have. For example the reclamation of a low ecological value area could have widespread ecological repercussions, and conversely the reclamation of a high ecological value area might have minimal ecological repercussions. The impact of a solid reclamation in place of a natural tidal environment is discussed below.

We must also beware of forming rigid set of rules for determining suitable reclamation sites. The continued reclamation of a low ecological value type of area would steadily increase the value of the remainder of that type of area, and in time could create a serious imbalance in the ecosystem.

Considering 2

The impact of a reclamation on the ecology of surrounding areas is determined by several factors:

(a) interference with currents and tidal movement resulting in:

- (i) siltation
- (ii) scouring
- (iii) changes in rates of transportation of food and larvae into the area

(b) leaching of material from the reclamation:

- (i) sediments
- (ii) toxic materials

(c) establishment of a changed environment on retaining walls. This effect is particularly noticeable in subtidal areas where a profusion of sedentary plants and animals attaches to rock walls.

(d) changing the exposure of surrounding areas to wave action.

Interference with water movement in the surrounding area is perhaps the most serious problem associated with the siting of a reclamation. The impact of such interference can be minimised by studying current patterns and rates of

alteration of the natural environment principally by the deposition of large quantities of fine sediments resulting in an increase in level of intertidal substrates and the formation of soft muds.

The crossing of bays and inlets should be avoided where possible, and consideration given to the placing of necessary routes across such areas on pillars. The use of foreshore for roadways is ecologically inadvisable because of the large area of foreshore interfered with. When crossing tidal streams it would be preferable to place the whole road on pillars rather than putting a causeway across the intertidal area with only a small bridge in the centre, as is common practice at present.

2. Reclamation for port facilities

Further reclamation for the servicing of port areas will be necessary in the Waitemata Harbour.

Although the ecology of a port area is unavoidably altered - the natural shoreline is destroyed, and areas of sea floor substantially changed by dredging - the impact of port reclamation on surrounding areas can be minimised by enforcing high standards of water quality and siting reclamations so as not to interfere unduly with water circulation patterns.

If water quality is maintained at a high level the concrete and hardwood surfaces of pilings and walls will support a prolific fauna which will be a real asset to the Harbour ecosystem.

3. Reclamation for marinas

Reclamation for the purpose of sheltering marina areas and perhaps in some cases for servicing boats will be necessary in the Waitemata Harbour.

It should be the aim of marina developers to provide space for the maximum number of boats in the minimum area with the siting and shape of the development designed to have minimal environmental impact.

The Half Moon Bay Marina is ecologically acceptable although the reclaimed parking and servicing area might be considered rather large, whereas residential marinas of the type proposed for Ngataringa Bay would be definitely unacceptable.

At present there are two areas capable of being further developed for marina type boat facilities: Westhaven has a considerable area remaining for development and the large area of Okahu Bay would be suited for this purpose. It is ecologically preferable to concentrate boats in larger areas near the entrance of the Harbour than to have smaller marinas scattered throughout the region.

4. Reclamation for Industry

As a means of providing cheap industrial land reclamation is ecologically unacceptable.

However, reclamation to provide facilities for water-dependant industries such as commercial fishing and barging, transport and boat-builders will probably be necessary. Such reclamation should not be permitted for any function that could be equally well provided for on dry land.

5. Recreational reclamation

The promise of a recreational facility is often used to justify a foreshore reclamation for which the real purpose is to dispose of fill or refuse. Such reclamations are often relatively large in size and are unusable for their purported purpose for several years after reclamation has been completed.

Minor reclamations to provide a facility such as a boat ramp need not interfere unduly with the ecology, but larger reclamations for car-parks, clubhouses, etc, are not ecologically acceptable.

6. Residential Reclamations

Residential reclamations are ecologically unacceptable because of the large area of intertidal land required for the benefit of a relative few. Residential marinas are unacceptable for the same reason.

7. Reclamation for the disposal of waste

The disposal of waste in intertidal areas is ecologically unsound particularly in view of present practices which result not only in removal of the area reclaimed from the Harbour ecosystem, but also in the contribution of pollutant material to the water and sediments away from the reclaimed area.

Disposal of refuse and spoil is an increasing problem, and dumping into intertidal areas, no matter how convenient or economically advantageous this might be, is not the answer.

(The pollution aspect of organic refuse tipping into intertidal areas is discussed in the Pollution Report.)

8. Reclamation for private purposes

Private individuals with properties bordering the Harbour foreshore often want small reclamations for purposes such as providing areas of flat land, building boatsheds, or filling in 'unsightly' mangroves. The collective threat of such small reclamations should not be underestimated.

Discussion

As a general principle, reclamation of foreshore and tidal areas can be considered detrimental to the natural environment of the Harbour. Some reclamations will cause less damage than others, but all are harmful to some extent, in that they are destroying a resource that is strictly limited and non-replaceable.

Policies governing reclamation should determine the reasons for which reclamation will be authorised and those for which it will be refused. The policies should then provide for the consideration of specific applications for reclamations of an approved 'type'. It is at this stage that the determination of ecological impact is important in determining the location, size, and shape of a reclamation development.

THE ECOLOGICAL EFFECTS OF POLLUTION OF THE WAITEMATA HARBOUR

1. Introduction
2. Pollution by the General Public
3. Pollution by Local Authorities
4. Sewage Pollution
5. Pollution from Intertidal and Foreshore Rubbish Tipping
6. Pollution Associated with Port Activity
7. Pollutants in Stormwater
8. Industrial Pollution
9. Pollution during Land Development

1. INTRODUCTION

As a general rule, water may be considered polluted when it is overburdened with :

(1) Organic wastes contributed by domestic sewage, industrial animal and plant wastes, and naturally occurring organic material such as dead plant material, or dead plankton blooms, which remove oxygen from the water during the process of decomposition.

(2) Infectious agents contributed by domestic sewage and by certain types of industrial wastes that may transmit disease.

(3) Plant nutrients which promote nuisance growths of aquatic plant life such as algae and weeds.

(4) Synthetic-organic chemicals such as detergents and pesticides which are toxic to aquatic life and potentially to humans.

(5) Inorganic chemical and mineral substances resulting from mining, manufacturing processes, oil plant operations, and agricultural practices which interfere with natural water purification, destroy fish life, and change chemical properties of the water.

(6) Sediments which fill streams, channels and harbours; cause erosion of pumping equipment, affect fish and shellfish populations by blanketing natural bottom sediments and food supplies.

(7) Temperature increases which result from the use of water for industrial cooling purposes and which have harmful effects on fish and aquatic life, and reduce the capacity of receiving water to assimilate waste.

In considering pollution of the Waitemata Harbour we are concerned not only with the water but also with physical and chemical alteration of substrates, and the effects of such changes on the fauna and flora. Pollution of the Harbour waters is often quite transient, and conditions revert rapidly to normal as soon as the pollutant is carried away or dispersed. Pollution of substrates, however, and particularly the alteration of fine, soft, sediments, is often a slow and cumulative change. The rate, or degree, of change in soft sediments gives perhaps the most accurate information on the extent of pollution of an area.

2. POLLUTION BY THE GENERAL PUBLIC

Although individual acts of pollution by members of the public are usually of no great impact, collectively they have an obvious detrimental effect on the ecology and aesthetics of the Harbour.

In an area such as Auckland where the population is increasing, and the Harbour foreshore is becoming increasingly utilised for high density suburban development, pollution by the general public can be expected to increase. In contrast, pollution from other sources will probably decrease as better practices are introduced to control the disposal of waste products.

Pollution by the general public deserves considerable attention, because it is affecting the immediate environment of the human population. In many instances it is a cumulative type of pollution, with many small pollutant acts leading over a period of time to noticeable ecological effects.

It is however, a type of pollution that can be inexpensively prevented. Education is necessary to ensure that the public treats all parts of the Harbour as an asset, and to point out the effects of pollutants, not only on the aesthetic environment, but also on ecology and water quality.

Pollution by the public has been divided into five categories :

A. Pollution by Casual Visitors

B. Disposal of Refuse

C. Dumping from Waterfront Properties

D. Pollution from private boats

E. Pollution from chartered craft.

A. Pollution by casual visitors

The litter situation on popular beaches has improved over recent years, largely due to the work of local bodies in active beach cleaning, and the provision of rubbish receptacles.

In less frequented areas there is still a problem with normal types of litter - paper, plastic, and bottles. Particularly obvious is the quantity of broken glass at the foot of cliffs, and on foreshores adjacent to areas where cars can park at night.

The environmental impact of this type of pollution is not great, although the accumulation of plastics in low tidal and sub-littoral areas is noticeable at present, and is not likely to decrease.

B. Disposal of Refuse

Included in this category is the dumping of any waste material on the foreshore or intertidal, other than at an authorised tip.

The dumping of all types of rubbish - from car bodies to lawn clippings - on foreshore and intertidal areas is a common practice around the Waitemata Harbour.

Most activity of this type is found in less frequented suburban or rural areas, particularly in the upper reaches of the Waitemata Harbour and Tamaki Esturary where mangroves are dominant. In some areas there appear to be semi-official tips where large quantities of rubbish are dumped.

The environmental impact of this type of refuse disposal can be locally serious, and noticeable over a wide area. With a variety of organic and inorganic materials being added to salt water a number of biological and chemical reactions are encouraged. The decomposition of organic wastes such as grass clippings and tree prunings, leads to the formation of anaerobic environments in the soft mud in which such waste material is usually deposited. A common by-product of decomposition of organic wastes in soft mud environments is hydrogen sulphide which has a strong pungent odour.

Besides the detrimental effects on the immediate environment into which rubbish is dumped, the decomposition process of organic wastes requires large quantities of oxygen and may reduce the oxygen content of overlying water. Floating rubbish and dissolved material also influence the environment in areas away from the site of deposition of the rubbish.

C. <u>Dumping from Waterfront Properties</u>

Several types of interference with the intertidal and foreshore areas are caused by the owners of land adjacent to the Harbour.

Retaining walls are built of a variety of materials, and fill is often spread over the intertidal outside the private property. In some cases landowners appear to have made illegal reclamations by progressively dumping rubbish and fill into the intertidal.

In Harbour areas with cliffs and steep banks large quantities of rubbish are deposited in the intertidal and on the foreshore by adjacent landowners.

The owners of boatsheds situated on the foreshore or in the intertidal area, often discard waste materials such as old timber and roofing iron by dumping in the tidal zone.

The environmental impact of these polluting practices is variable, but all are detrimental, and the collective impact is of considerable consequence in some areas.

D. <u>Pollution from Private Boats</u>

(i) <u>Sewage</u> - Considerable quantities of sewage must be derived from private craft, particularly in the summer season. While possibly not as important as the sewage derived from the land, sewage from boats will cause increased bacterial levels, and may on occasions constitute a health hazard. Although the Waitemata Harbour is probably not affected to the same extent as some of the more popular anchorage areas further afield, because there is only a small resident population on pleasure craft, it is felt that this problem deserves more attention.

Sewage derived from pleasure craft is of little apparent ecological significance at present levels.

(ii) Fuel - Unburnt fuel in exhaust gases, and spilt fuel, form noticeable slicks on the water surface when large numbers of motor boats are on the Harbour.

Ecological impact of such pollution is hard to determine or predict. Planktonic organisms are probably affected to some extent, and the nature of the surface film is affected meaning changes in the rates of diffusion of gases.

(iii) Rubbish - Considerable quantities of floating rubbish are derived from private pleasure craft, and much of this is washed ashore. Paper and plastics are a problem when they become partially buried in soft sediments, and glass occurs in large quantities where bottles have been washed against rocky shores and smashed. Beer, and other cans have a considerable local effect when they rust in proximity to soft sediments. This substrate becomes anaerobic for some distance, and hydrogen sulphide is released.

(iv) Fish remains - Fish frames are often left in intertidal areas by recreational fishermen. In lower intertidal areas the meat is rapidly removed by a variety of scavenging animals, but at higher levels it decomposes slowly. Bones of fish are also a hazard.

E. Pollution from Chartered Craft

Craft chartered for sightseeing, fishing, and 'moonlight cruises' are the source of considerable quantities of floating rubbish.

Of some concern is the large quantity of glass dumped in to the Harbour during some of these cruises.

3. POLLUTION BY LOCAL AUTHORITIES

Many local authorities can be criticised for their apparent lack of regard for foreshore and intertidal areas. Not only are foreshores often unkempt with weeds and gorse, but local authorities appear to regard the foreshore strip as a site for the disposal of a variety of waste materials including spoil, felled trees, and other vegetation, cable drums and unwanted construction materials.

Such practices, while contributing to pollution themselves, should also be viewed in respect of the example they provide to the local populace.

4. SEWAGE POLLUTION

Sewage acts as a pollutant in several ways. It increases turbidity of the receiving water and requires large quantities of oxygen for oxidation. It carries pathogens which are harmful to fish, invertebrates, and man. The deposition of fine organic material in sheltered areas leads to long lasting environmental changes and ecological effects.

The release of sewage at present levels into the Waitemata Harbour is having little immediately obvious ecological impact, apart from several localised areas where discharge rates are relatively high.

The only permanent untreated sewage flow in the Waitemata Harbour is that at North Head. This effluent is having an obvious impact on the ecology of the rocky shores in the outfall area. On either side of the discharge point the band of rock oysters, Crassostrea glomerata, is absent for a distance of approximately 100 metres and becomes gradually more dense at a greater distance. Green algae flourish over much of the intertidal area and some species of grazing molluscs occur in high densities and thrive on the algal growth. Below low water neap there is a band of large green mussels, Perna canaliculus, which are apparently tolerant of sewage and have not been taken for consumption because of their obvious proximity to a sewage outfall.

Sewage overflows are widespread in the Waitemata Harbour Study Area. Their frequency of overflows, whether as a result of overloading of the sewage system, or infiltration of stormwater into sewage reticulation, and the volume of sewage released in this manner, is sufficient to have some adverse ecological effects.

At Cox's Creek, which receives regular overflows, there has been a general deterioration of the soft sediment environment over a considerable intertidal and subtidal area. At higher intertidal levels the pollution is restricted to the vicinity of the stream which flows across the sand flats. The sediments in the bottom and on the banks of the stream are anaerobic to the surface and in places smell strongly of hydrogen sulphide. A surface layer of micro-organisms - probably euglenoids - is present at times. Near low tide level, where the stream enters the Harbour waters there is a considerable area of sand flat with an accumulation of organic material on the surface. Quantities of comminuted toilet paper occur in shallow pools and small depressions in the sand. A crust of paper fibres and filamentous algae covers the surface for some distance at low water level. It appears that the formation of this crust has been responsible for the deterioration of the sediment environment beneath the surface and there is evidence of mortality of common shellfish in this region.

The long term cumulative effects of sewage pollution are of more ecological significance than a temporary presence of a large concentration of sewage. In areas such as Cox's Creek it is apparent that the regular contribution of relatively small volumes of sewage can have a detrimental and lasting effect on the ecology of soft sediment areas. In rocky shore areas, such as North Head, the ecological impact is obvious but once the flow of sewage ceases the ecology should rapidly revert to a natural condition. Of greatest potential ecological significance is the possibility of incorporation of sewage derived organic material into the sediments of soft bottom sublittoral areas.

In a harbour such as the Waitemata, which is extensively used for recreation, the health implications of the release of raw sewage deserve consideration. (See Water Quality Report, A.R.A.). The degree of sewage contamination of harbour waters is sufficient to increase the faecal coliform levels above those held to be acceptable for swimming and shellfish consumption over large areas, and for considerable periods. Because of this, it is felt that a study should be made of shellfish areas in the vicinity of sewage outfalls. Of particular importance are the concentrations of cockles, *Chione stutchburyi*, at Cheltenham, and tuatuas, *Amphidesma subtriangulatum*, at Takapuna. The effluent from North Head is carried along this shore on the outgoing tide, and on low spring tides accumulations of toilet paper fibre occur in shallow pools on the Cheltenham sand flats.

5. POLLUTION FROM INTERTIDAL AND FORESHORE RUBBISH TIPPING

The practice of tipping organic and inorganic rubbish directly into the intertidal areas is having a severe adverse effect on the ecology of parts of the Waitemata Harbour.

Much of the problem arises from a failure to isolate tipped material from the tidal waters. Incursion of seawater into inadequately consolidated rubbish, and the percolation of rain water through a tip area, lead to the contribution of considerable quantities of organic and inorganic pollutant material to Harbour waters.

Fine particulate matter derived from intertidal tips may be carried away from the tip site and deposited in sheltered parts of the Harbour. In this way there has been considerable pollution of fine sediments by the incorporation of partially decomposed organic matter, much of which is apparently derived from organic rubbish tips. (See Areas 22E and 11A). Inorganic rubbish, particularly ferrous metals, is also a problem with a variety of chemical and bacterial reactions resulting in the pollution and deterioration of soft sediment environments.

The disposal of fill is a common practice which occurs both in designated intertidal tips, and in many other foreshore areas as well. Dumping of soft clays and soils into areas where they come into direct contact with tidal water has resulted in the spreading of fine inorganic material over large areas and a general deterioration in water quality by increasing the sediment burden. (See also 'Ecological Report on Harbour Waters - 6')

6. POLLUTION ASSOCIATED WITH PORT ACTIVITY

(i) Sewage - Sewage is released from ships while they are in the Port of Auckland. From some of the larger passenger liners the volume of sewage is sufficient to be visible over a wide area, and to be smelt at some distance.

It is understood that sewage from many of the watersiders toilets is released directly into the Harbour.

Sewage from these sources is probably sufficient on occasions to raise the faecal coliform counts of large volumes of sea-water above accepted levels for bathing or shellfish consumption.

(ii) Oil Spills - Minor oil spills are a common occurrence in the Port area and oil is often carried ashore.

Detergent sprayed on oil spills to disperse them is potentially more harmful to the ecology of the Harbour than the oil itself, particularly in shallow water or intertidal regions.

Wherever feasible, oil should be removed by mechanical means even if this means removing quantities of beach sand, or additional expenditure in terms of boat time.

Sinking oil is not a good ecological practice - accumulations of oil in sheltered regions on the sea floor decompose extremely slowly and have considerable ecological impact.

(iii) Dunnage and floating rubbish - Large quantities of dunnage and other floating refuse are carried ashore in the Waitemata Harbour, particularly in the outer Harbour and at Rangitoto.

Such pollution is more a hazard to boating and aesthetically undesirable than a threat to the ecology, except when water-logged material becomes buried in soft sediments.

7. POLLUTANTS IN STORMWATER

Considerable quantities of foreign materials are carried into the Harbour with stormwater drainage.

Of particular ecological importance is the large quantity of fine inorganic material which increases water turbidity and is deposited in sheltered areas where it affects the natural substrate. (See 'Ecological Report on Harbour Waters')

Large quantities of organic material are also contributed to the Harbour in stormwater runoff, and with increasing urbanisation the quantity of such material is likely to increase. Leaves are found in sublittoral areas throughout the Harbour, and in some places decomposing leaves are considerably affecting the bottom substrates. (See Report on Sublittoral Ecology)

8. INDUSTRIAL POLLUTION

(i) Ship Maintenance - Boatyards are the source of foreign material in the form of oil, paint chips, and waste metal and wood.

On occasions, large quantities of pollutant material enters the Harbour from Calliope dock when it is flooded to refloat a ship.

(ii) Hot Water Effluents - The two major users of Harbour waters for cooling purposes are the Colonial Sugar Refinery at Chelsea, and the Otara Power Generating Station.

The Chelsea effluent is quite warm but the volume is small compared with the volume of the receiving water. Adverse ecological effects in the vicinity of the outfall are attributed to organic pollutant material rather than the temperature of the water.

At Otara, the warm water effluent is released into a cooling pond, and thence into an enclosed arm of the Tamaki Estuary which has a weir at just above half tide level. There is no noticeable ecological impact attributable to the warm water effluent, either within the enclosed Otara Creek, or in the Tamaki Estuary.

(iii) Farm Wastes - Considerable areas of the watershed of the upper Waitemata Harbour are still farmland. Although no direct evidence of pollution from this source has been noted, every effort should be made to minimise the contribution of organic wastes from any source.

(iv) Others - Isolated cases of industrial pollution become obvious from time to time.

The Henderson Creek (particularly the freshwater region) was considerably polluted by winery discharges.

Complaints have been heard of discharges from a timber mill at Riverhead.

9. POLLUTION DURING LAND DEVELOPMENT

Pollution caused by the contribution of large quantities of inorganic silts and clays to the Harbour via stormwater runoff from land in the process of being developed is discussed in the 'Ecological Report on Harbour Waters - 6'.

THE VALUE OF ECOLOGICAL RESOURCES

An area may have an ecological value in several different senses. It may be an area that is used for ecological research, it may contain a rare species of animal or plant, it may possess a valuable natural resource which is exploited by the human population, or perhaps form part of a recreational complex.

For the purpose of this study, however, a method of defining the ecological value of an area in terms of the part it plays in the Waitemata Harbour Ecosystem is required. No absolute definition of ecological value in this sense is possible, but the ecological value of any area is related to :

(a) the diversity of fauna and flora in the area

(b) the productivity of the area

(c) the abundance of that type of area

(d) the degree of interaction between the flora and fauna of the area under consideration and the rest of the ecosystem of which the area is a part.

Consideration of any one of the above parameters will give some indication of the relative ecological value of an area compared with the ecological value of other areas in the same ecosystem. Consideration of all four parameters will give the trained ecologist an accurate assessment of the relative ecological value of an area.

Although it is possible to quantify each of the above parameters there is little interaction between them, and the derivation of a numerical 'ecological value' is impractical. Generally, however, high productivity, and considerable interaction with the fauna and flora of other areas, will have maximum ecological value. Conversely, areas of great extent with low faunal and floral diversity, low productivity, and little interaction with the ecology of other areas, may be considered to have minimum ecological value.

It should be noted that the 'ecological value' of an area to an ecosystem may well change with time. The value may increase as the total similar area is diminished, or decrease as ecological changes result in a reduction in diversity or productivity.

It is impractical at this stage to attempt to assess an 'ecological value' for all areas within the Waitemata Harbour. The 'Ecological Report on Intertidal Reserves' indicates some areas which are considered valuable for purposes such as education, conservation, research, and recreation, and most of the areas described would have a high 'ecological value' as defined above.

On the assumption that all parts of the Waitemata are valuable to the Waitemata Harbour Ecosystem, the only situation demanding a more precise assessment of the ecological value of an area should be when a proposed development of an approved nature has possible alternative sites, and the final site selection is dependant on ecological considerations. Further discussion of means of assessing the ecological impact of proposed development is given in the report, 'The Ecological Impact of Reclamation'. Sufficient ecological information is contained in the 'Report on Intertidal Ecology' to enable the trained ecologist to assess either the 'ecological value' of an area, or the ecological impact to the Waitemata Harbour Ecosystem, if an area was altered.

RESERVES OF ECOLOGICAL IMPORTANCE

Over and above the general need for conservation and planned, co-ordinated development of the Waitemata Harbour, there are strong ecological arguments for requiring stronger protection for some areas.

The placing of a reserve designation over areas of foreshore and intertidal land will afford them some measure of protection, particularly in terms of restricting the types of activity permitted in such areas, and removing them from consideration for other development purposes.

The reasons for suggesting that some areas of the Waitemata Harbour be protected by such designation are :

1. To preserve areas that are important within the Waitemata Harbour ecosystem because of their ecological diversity and richness.

2. To provide areas for education, which admirably illustrate principles of marine and foreshore ecology.

3. To preserve some areas in a relatively undisturbed state to encourage the presence of uncommon animals in the midst of urban Auckland.

4. To conserve examples of intertidal communities that have become rare in the Waitemata Harbour Study Area.

For some of the areas described below only one or two of the above ecological reasons for protection apply. However, it should be remembered that other arguments, particularly those from the aesthetic and recreational viewpoints, can be arrayed alongside the ecological reasons in most cases.

Several areas that deserve reservation in view of their ecological attributes are described below. The boundaries of these areas are flexible, but it is considered important that some area in the region of the defined area, be preserved.

Development plans are already in existence for several of the described areas. It is not suggested that such developments be discontinued; rather, that if the present planned development does not proceed, that the area receive the appropriate protection.

Henderson Creek (Fig. 1)

An extensive area of mangrove marsh and salt marsh in the region to the north of Rutherford High School is ecologically healthy, and supports a normal variety of animals and plants associated with mangrove and salt marsh communities. The area is easily accessible, and with minor developments to provide access within the intertidal region, it could become a valuable educational asset to the schools of the district.

Pollen Island, Traherne Island, and the end of Rosebank Peninsula (Fig. 2)

These areas may be considered separately or as a unit.

In the Pollen Island-Traherne Island region there has been considerable accumulation of sediment in the intertidal area with a resultant rising of the substrate level and colonisation by communities of mangrove and salt marsh. Pollen Island itself, is a stabilised shell bar, with the higher parts of the island now supporting increasing quantities of land vegetation.

There is no other similar area in the Waitemata at present, although a large part of the upper area of Hobson Bay once had similar attributes.

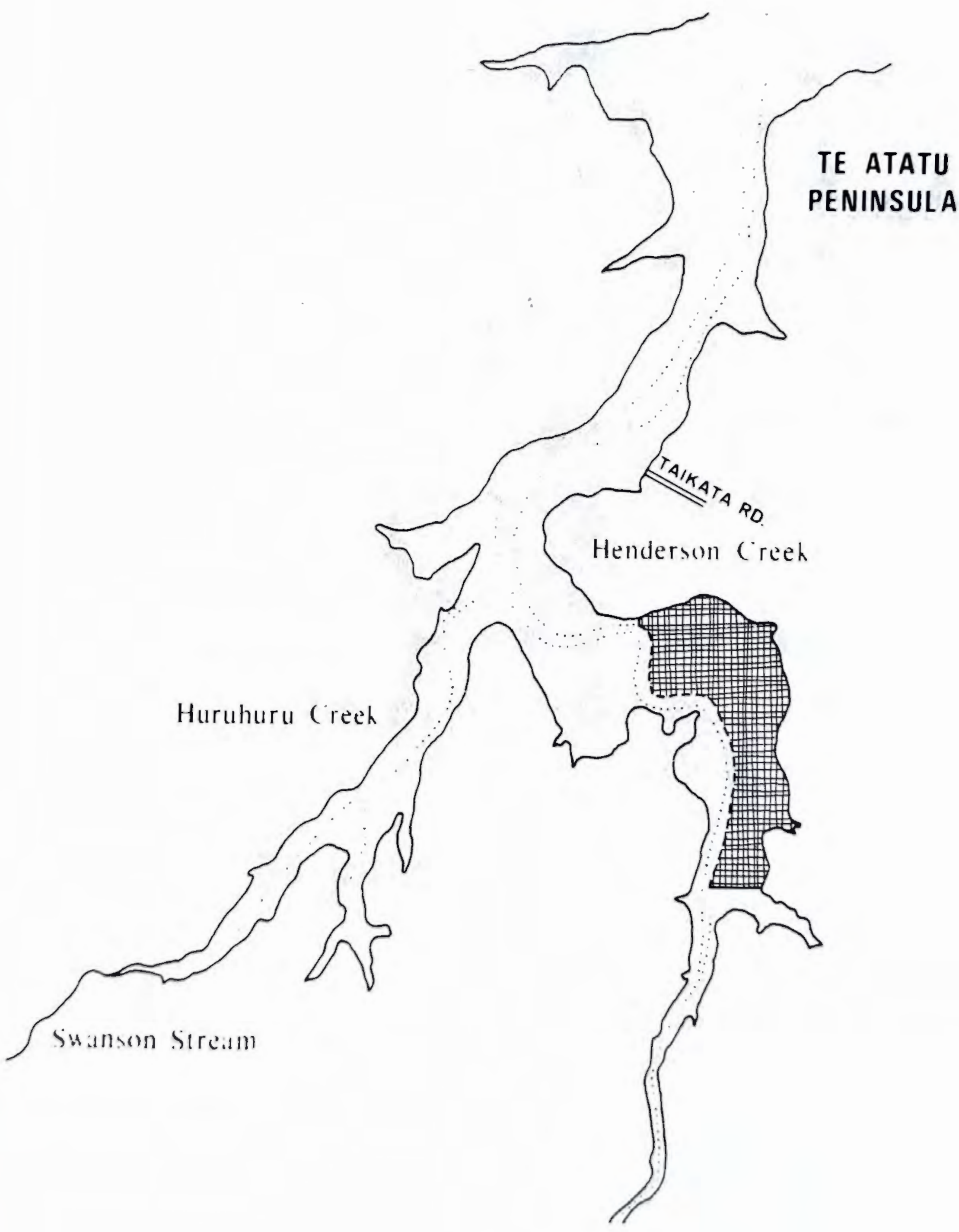
The region supports healthy examples of mangrove, salt marsh, and shell barrier communities. It is also ecologically important as a roosting area for birds.

Pollen Island has been used for botanical research, and there is potential for further research work and educational use, particularly at the secondary school level.

In view of the diminishing abundance of areas of this nature within the Waitemata Harbour, and also because of its size and relative isolation, it is considered that Pollen Island deserves the status of a wildlife reserve.

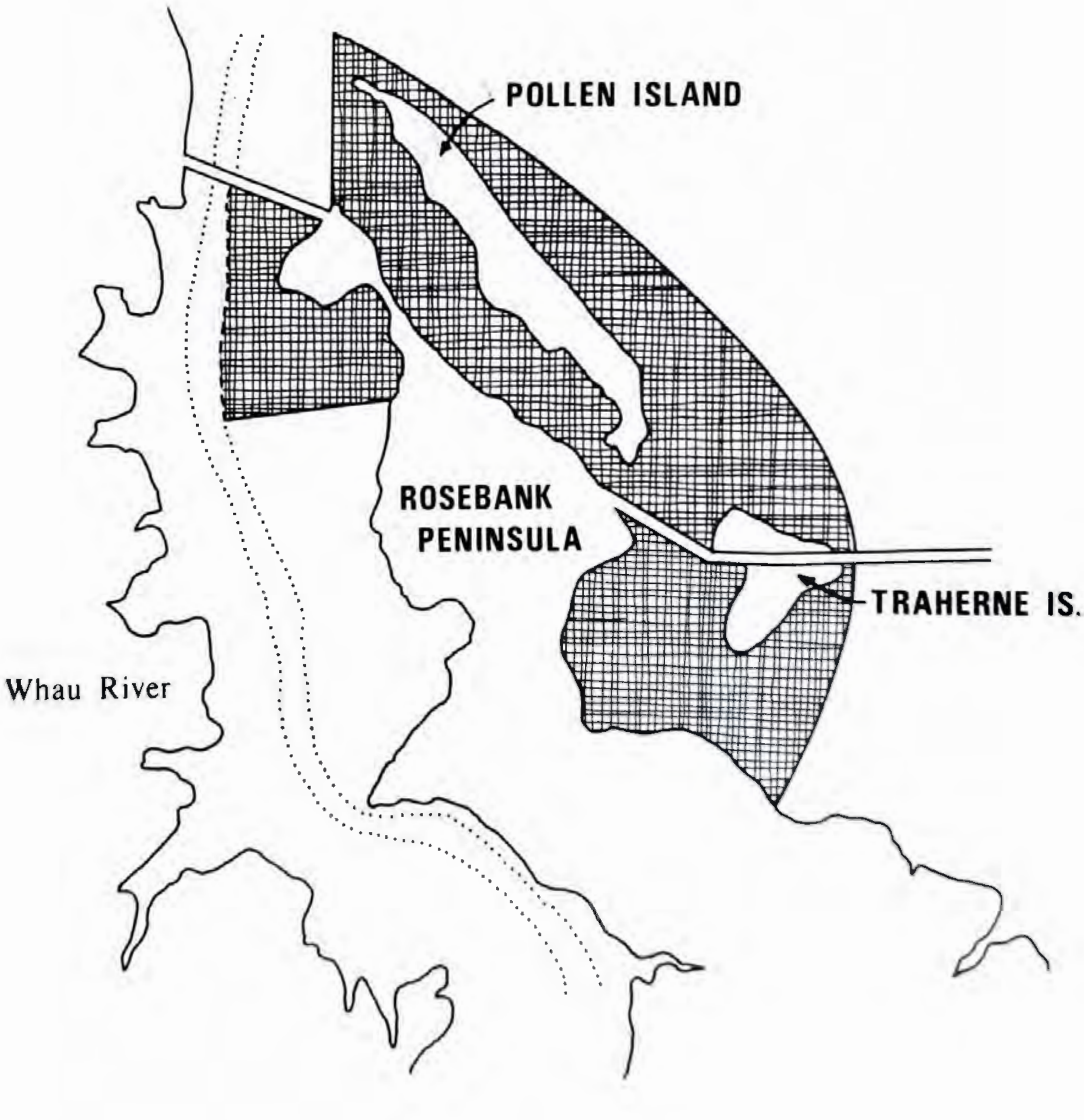
If the Pollen Island-Traherne Island region is developed as at present proposed, for port purposes, it is suggested that the intertidal area immediately south of the bridge across the Whau River and adjacent to the end of the Rosebank Peninsula be preserved. Although rather poor in comparison with the area mentioned above this region does support healthy examples of high intertidal salt marsh and mangrove communities, and in

FIGURE 1



HENDERSON CREEK

FIGURE 2



POLLEN ISLAND, TRAHERNE ISLAND,
AND ROSEBANK PENINSULA

view of the diminishing quantity of this type of area in the Waitemata Harbour ecosystem it is important that some examples be preserved.

Te Atatu (Fig. 3)

The area to be considered here, lies between Harbour View Road in the north, and the Whau River bridge in the south. At present this area may become part of a port development.

In this region there are extensive, clean, high-tidal sand flats, healthy mangrove marsh, a prominent shell barrier, and a high-tidal salt marsh along the shoreline. Black-backed gulls roost in some numbers on the high tidal sand flats.

As well as possessing healthy examples of high intertidal communities, the isolation of this area is important to the birds. To preserve the ecological attributes of the region, particularly the marsh zone along the shoreline, the land behind the area should also be reserved, even if only in a protecting belt.

This region is one of the few deserving a wildlife reserve status, and could also be used extensively for education.

Soldiers Bay (Fig. 4)

This area includes a number of habitats with a natural and healthy flora and fauna. Of particular interest are the firm sand flats, the high-tidal mangrove marsh, shell barrier, salt marsh and flax swamp. In association with the land reserve to the south, this bay could be part of an important recreational and educational area.

Kauri Point (Fig. 4)

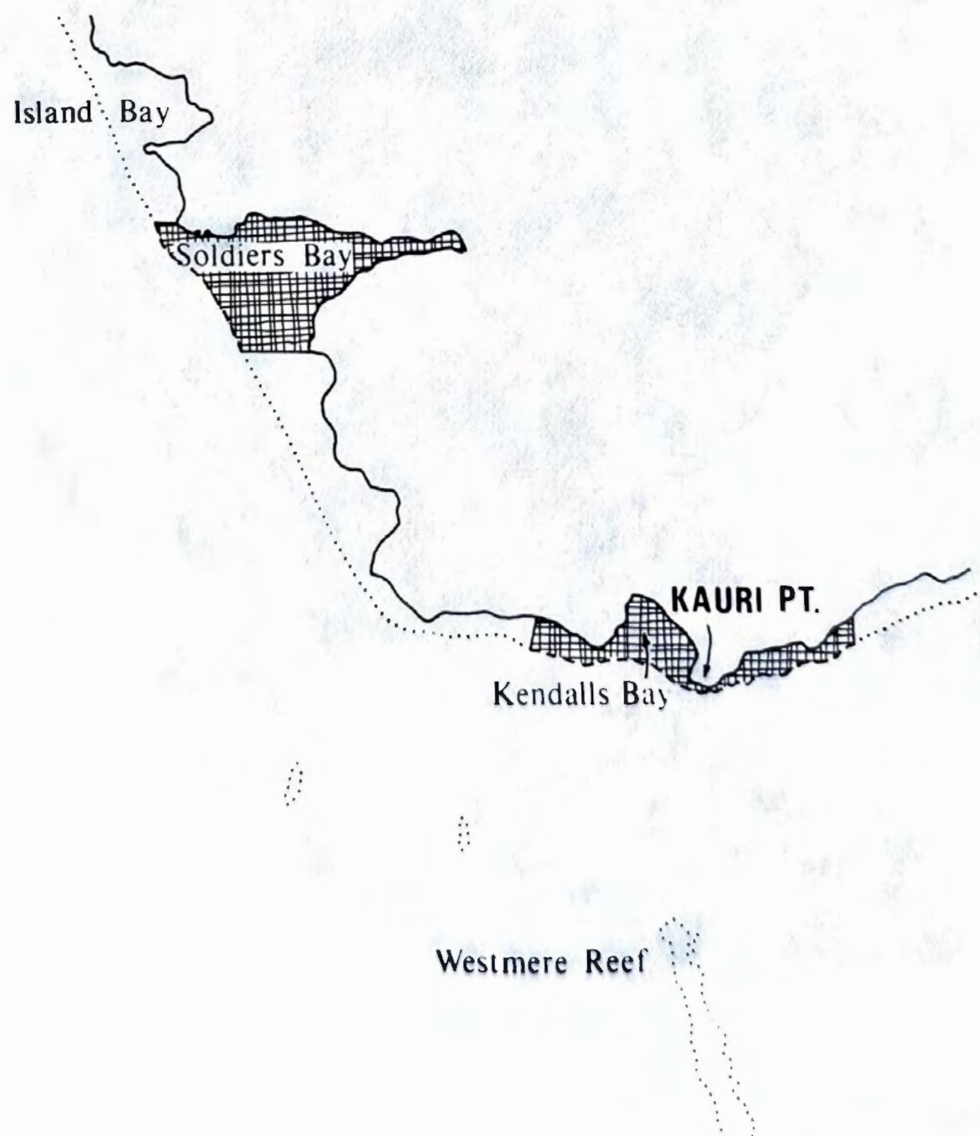
Kauri Point is the most prominent tree clad headland remaining in the Waitemata Harbour Study Area. It is visible from a large part of the suburban area of Auckland and is aesthetically important as part of the Waitemata Harbour environment.

The foreshore and intertidal areas are an interesting ecological unit; the natural state of the foreshore being particularly important to the intertidal environment. In association with a land reserve in this region,

FIGURE 3

TE ATATU

FIGURE 4



ISLAND BAY TO KAURI POINT

the foreshore and intertidal areas would assume considerable importance as part of a recreational and educational complex. The fostering of areas of native bush would enable land based ecological study areas to be formed in close proximity to the shore. The availability of a diverse range of habitats in one area could well prove attractive for educational purposes.

Westmere Reef (Fig. 5)

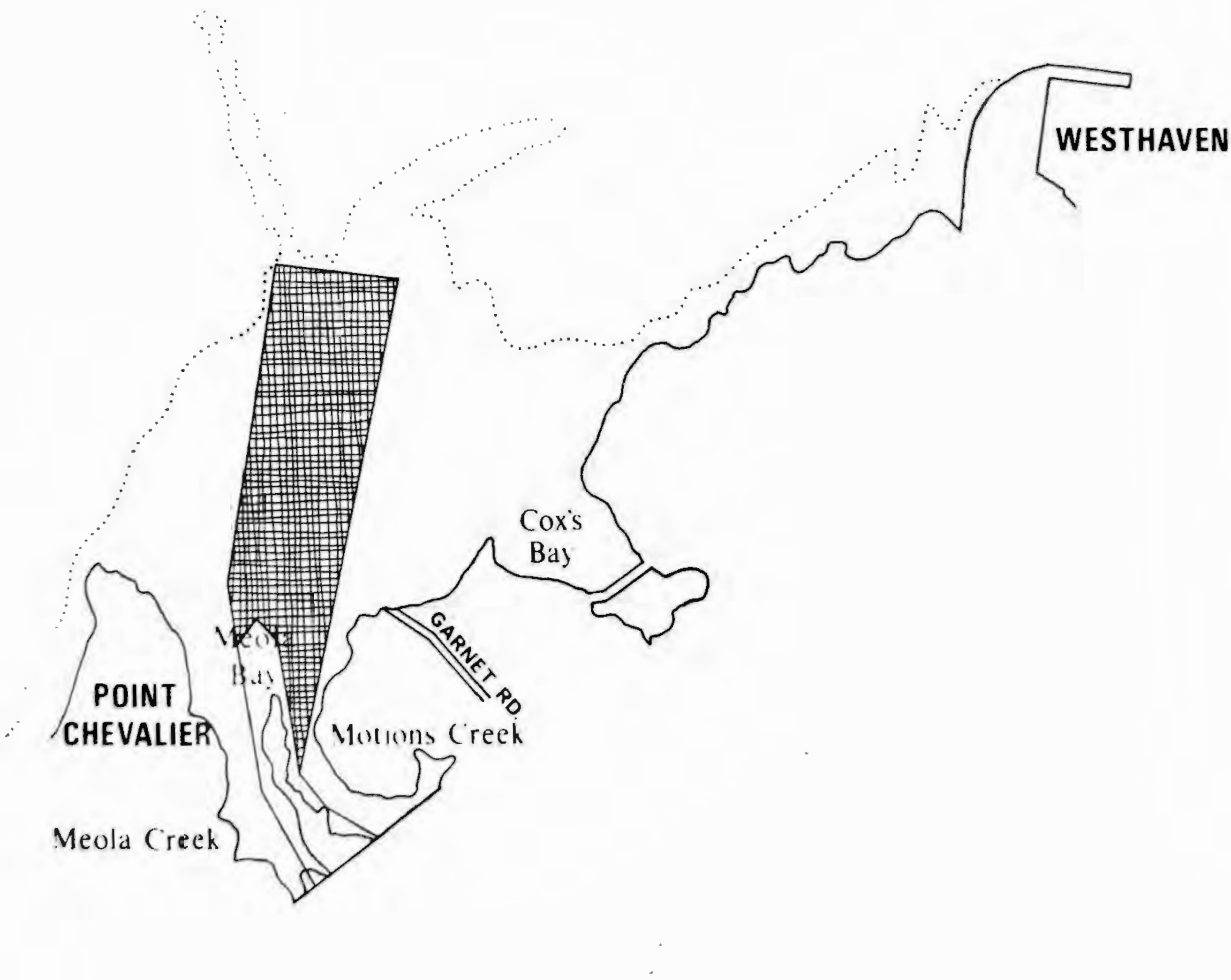
The basalt lava flow of Westmere Reef provides an extremely rich ecological unit within the Waitemata Harbour ecosystem. The presence of this hard substrate in the sheltered part of the Harbour provides an important attachment surface for a large variety of animals that are not otherwise common in the Harbour. The broken rock and presence of boulders are other factors adding to the diversity of available habitats, and increasing the variety of attached and mobile fauna.

From an ecological point of view this reef provides a range of habitats and flora and fauna which is unique both within the Waitemata Harbour and throughout New Zealand.

Of considerable interest is the inner part of the reef adjacent to the Meola Tip reclamation. About the high tide level there are examples of salt marsh vegetation in the sediment which has accumulated between the basalt blocks of the reef. An extensive area of mangrove is established in the upper intertidal zone outside the tip. The attraction of this area is the easy access to these habitats, and the ability to walk through the area on firm rock, instead of floundering through the soft muds more typically associated with mangrove marsh. A reserve of some considerable ecological and educational importance could be made in this region, while the attraction of the area to the general public will be largely dependant on the eventual use of the reclaimed tip area.

The area of reef outside the mangrove is already used considerably by the university, both for class instruction and individual thesis research. Further educational use could well be made of this region, particularly in association with the development of the inner part of the reef and tip reclamation.

FIGURE 5



POINT CHEVALIER – WESTHAVEN

Shoal Bay (Fig. 6)

The shell barrier on the eastern side of Shoal Bay is a fine example of this type of structure. It is also an example of a natural habitat that is under considerable threat within the Waitemata Harbour. (The only other similar areas of any extent are at Pollen Island, and in the region suggested for reservation at the base of the Te Atatu Peninsula.)

This high tidal shell barrier is in a healthy ecological state and supports a large number of plants adapted to the rigorous conditions of a coarse mobile substrate. Areas of salt marsh and mangrove in the lee of the shell barrier are also healthy and are good examples of high tidal communities of this nature.

The relative isolation of this area is of some importance to bird populations which use the shell barrier as a roosting area.

Besides the ecological value of this area it is important for recreational and aesthetic purposes. It has been used for educational purposes by the University, and, if the range of habitats was documented, could well be used for ecological teaching by schools.

North Head (Fig. 7)

Although the ecology of this region is somewhat affected by sewage discharge at present, it is, nevertheless, an example of a hard natural basalt shore, under conditions of mild exposure, and provides a wide range of habitats which support a diverse range of fauna and flora.

The value of this area is increased considerably the reservation of the surrounding land, which should provide protection by maintaining the foreshore in a relatively natural state.

This region is used for ecological instruction by the university, and is well suited for educational use at a lower level.

St Leonards Point (Fig. 8)

The sandstone reefs and platforms of this area provide a substrate which is markedly different from that of the hard basalt at North Head.

FIGURE 6

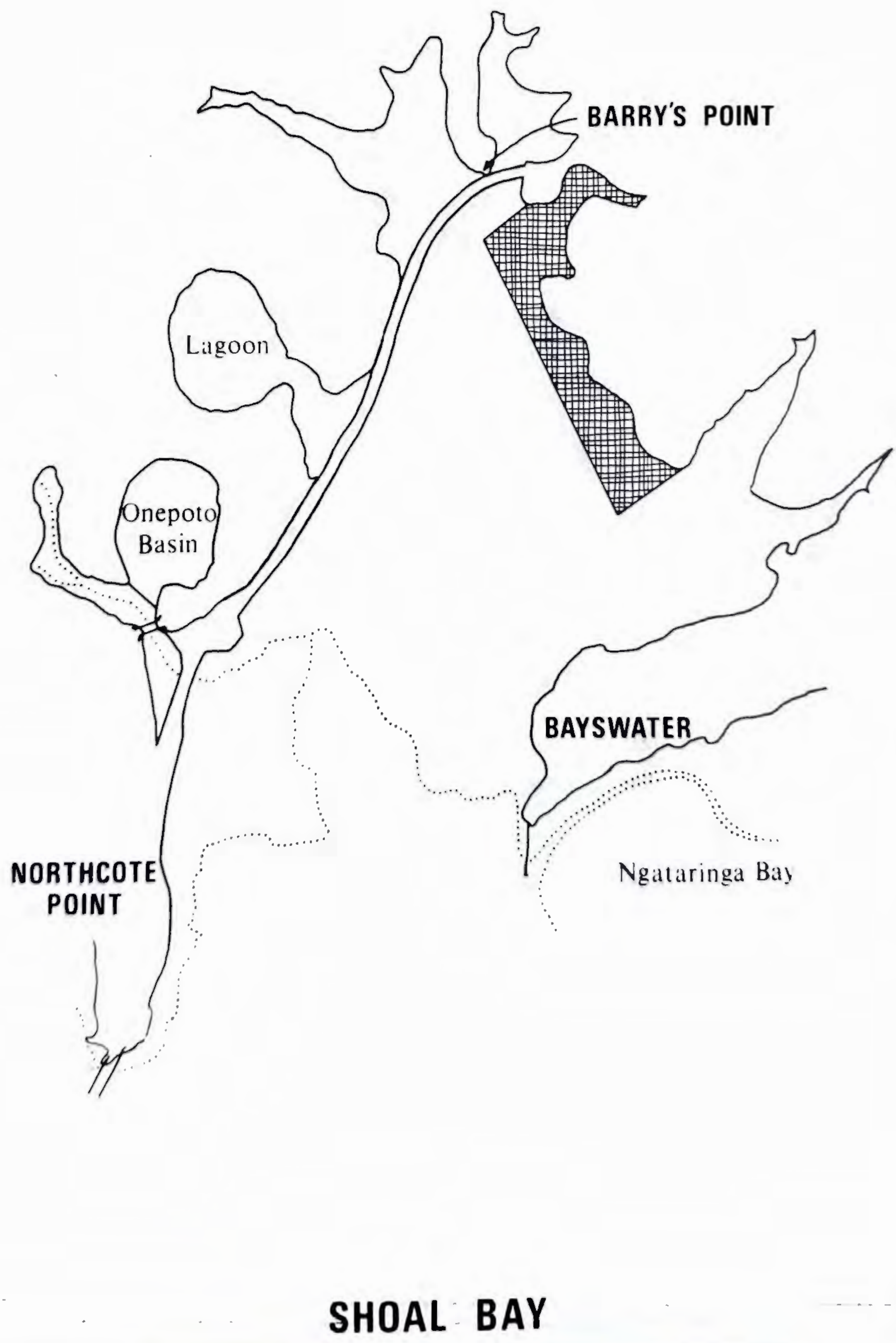
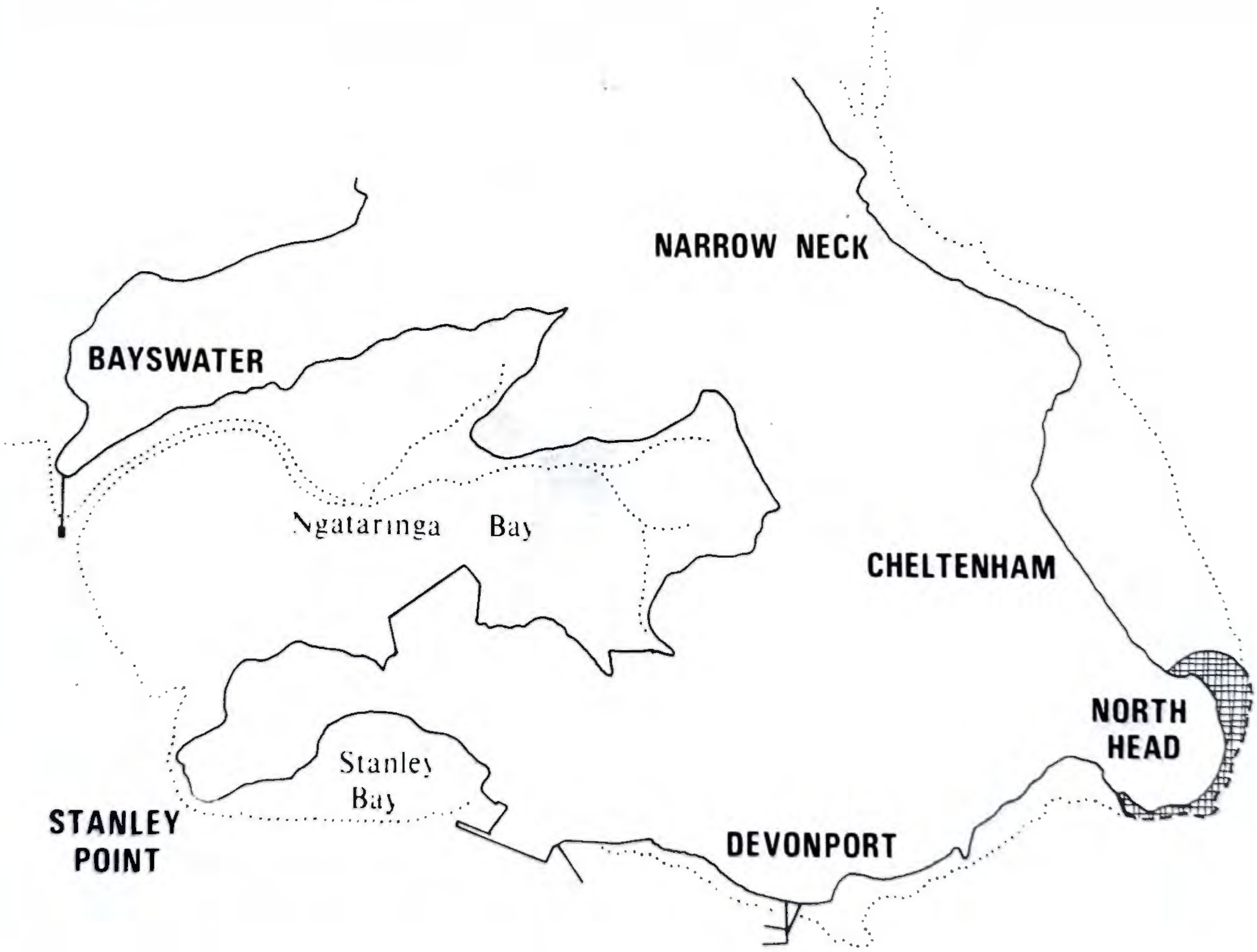
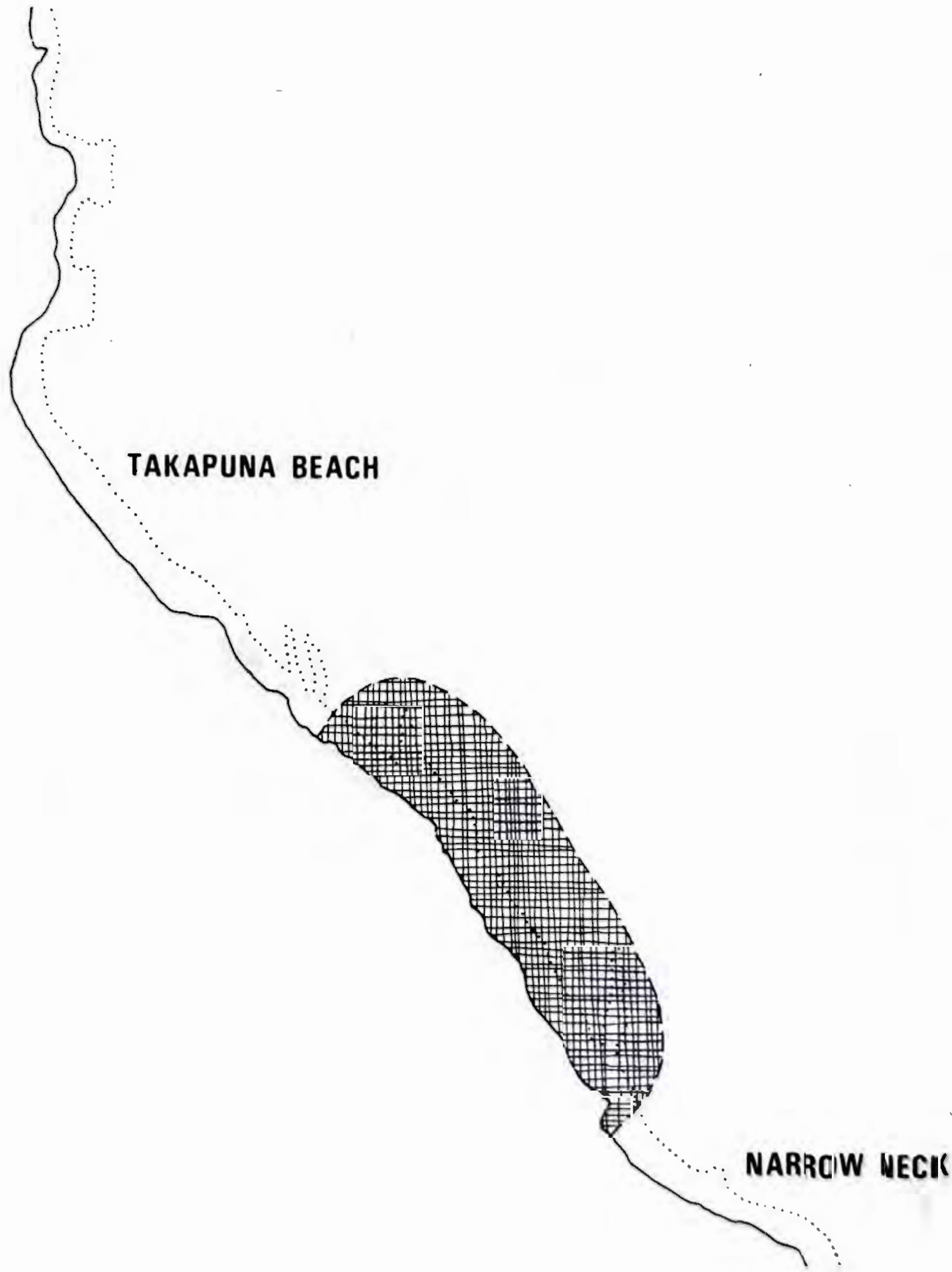

BARRY'S POINT
Lagoon
Onepoto
Basin
BAYSWATER
NORTHCOTE
POINT
Ngataringa Bay
SHOAL BAY

FIGURE 7



NGATARINGA BAY — CHELTENHAM

FIGURE 8



NARROW NECK TO TAKAPUNA

Differences in the ecology are interesting from a scientific and educational point of view.

Although this area is unlikely to be interfered with, it is considered that it deserves recognition as a rich example of a particular type of shore that is characteristic of large areas within the Waitemata Harbour Study Area, and in other protected regions of the Hauraki Gulf.

Water St. (Fig. 9)

This area contains a variety of intertidal habitats, and is well suited for educational use at school level. It is accessible from a large area of south-eastern Auckland, and is the best area for educational purposes in the upper Tamaki River.

Glendowie Spit (Fig. 10)

The extensive intertidal area in this region supports an extremely rich fauna which provides food for several species of birds which are otherwise uncommon within the Waitemata Harbour. Combined with the high tidal marsh, the consolidated shell barrier, and the land vegetation of the above tidal region, the intertidal sand flats are part of an area of considerable extent which is ecologically important because of the relative isolation, the physical size, and the variety of intertidal and maritime communities.

This area deserves the status of a wildlife reserve. Educational and recreational use are also to be encouraged.

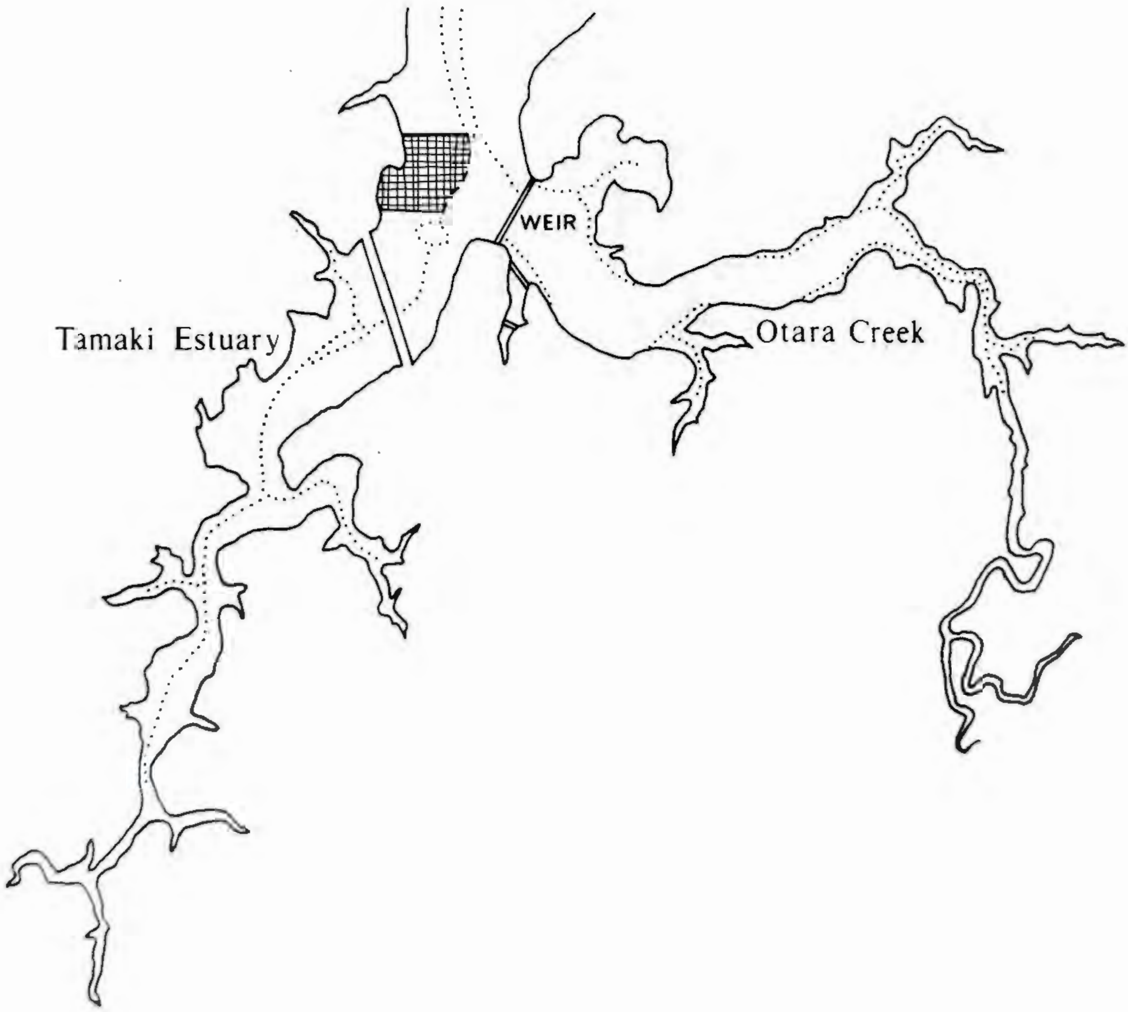
Development of Intertidal Reserves

Some of the reserves described above require little development other than some form of recognition, and a definition of the reasons for which they are to be reserved.

For educational purposes it is proposed that the ecological assets of the different areas be described, together with some sort of framework defining the relationship between the different areas in terms of the ecological assets they possess.

Those areas reserved for the conservation of uncommon habitats or species will require a closer definition of the types of activities that are to be

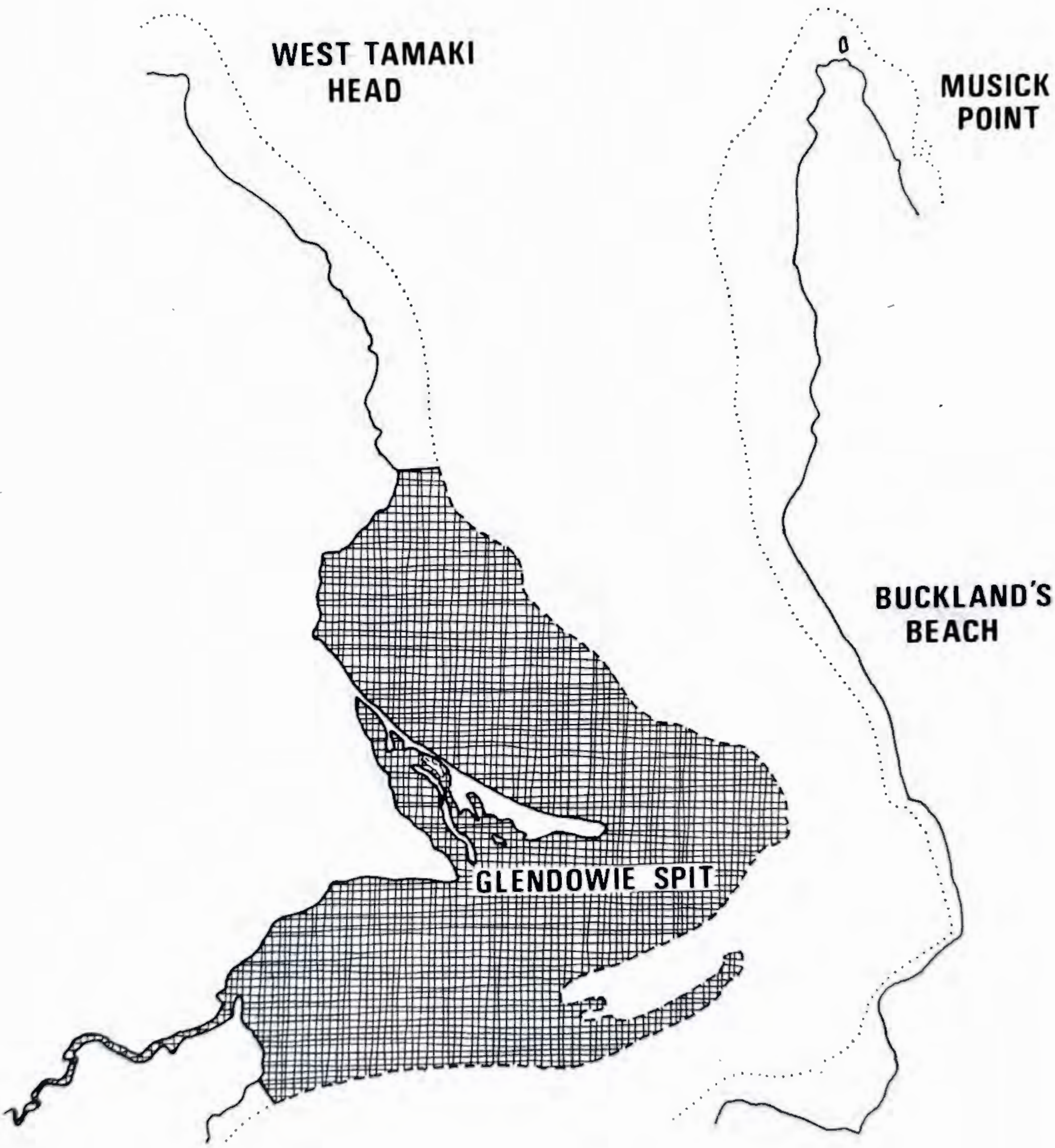
FIGURE 9



OTARA CREEK AND UPPER TAMAKI ESTUARY

permitted. Potential wildlife reserve areas such as Pollen Island and Glendowie Spit come into this category. At present it is envisaged that such areas should be open to the public and disruptive factors such as firearms, motor vehicles (including motor bikes) and fires, be prohibited.

FIGURE 10



ENTRANCE TO THE TAMAKI ESTUARY

SUBLITTORAL ECOLOGY

The sublittoral ecology of the Waitemata Harbour Study Area and the inner Hauraki Gulf, has been well described by A.W.B. Powell in his paper, 'Animal Communities of the Sea-bottom in Auckland and Manukau Harbours'. (Transactions of the Royal Society of N.Z. Vol. 66, pp 354-401.)

Powell described three major communities in the Waitemata Harbour based on the distribution of three common invertebrates. These were :

1. *Echinocardium* formation
2. *Maoricolpus* formation
3. *Tawera* + *Glycymeris* formation

He further subdivided these communities into 'associations' of animals, based on the distributions of other common species, and in some cases a further division of associations into groups called 'associes' was given.

The distribution of different communities was related to sediment grades. He also found a succession of communities based on the coarser sediments which were almost entirely derived from the dead shells of molluscs, with a community based on shell material being able to extend gradually as more shell became available for colonisation.

In 1972 the sublittoral ecology of the Waitemata was similar to that described by Powell. Sampling was undertaken with a cone dredge of 30 cm mouth diameter, with sufficient samples being obtained in a number of areas representative of the communities described by Powell to establish that the distributions of common fauna were basically similar.

Trends in Sub-littoral Ecology

1. Upper Harbour

   Sediments in the Upper Harbour channels are somewhat coarser than those exposed intertidally. In the low tidal channels of Brighams Creek and the Riverhead branch of the Upper Harbour there are dense beds of *Chione* in fine sand sediments, whereas in the intertidal area *Chione* has been considerably reduced by the deposition of fine sediments.

Of some concern in the Upper Harbour area is the accumulation of large quantities of both organic and inorganic rubbish in sublittoral areas. Plastics are particularly common, and in some areas there are patches with anaerobic conditions close to the surface where there has been an accumulation of organic material - mainly leaves and twigs from trees.

In the narrow parts of the channel towards Hobsonville substrates become shelly as described by Powell.

2. Middle Harbour

In the current-exposed regions of the Middle Harbour, particularly in the main channel between Kauri Point and the Wharf area, conditions are similar to those described by Powell. In the more sheltered regions of bays and inlets in this area, there has been considerable accumulation of fine sediments with a consequent destruction of previous communities. This effect is particularly noticeable in the entrance to Shoal Bay. In places the accumulation of organic material - principally leaves - is leading to a deterioration of the sediment environment, and an apparent reduction of macrofauna density.

3. Outer Harbour

In the Outer Harbour, sublittoral ecological conditions appear to be similar to those described by Powell. It is noticeable, however, particularly in sheltered regions with finer sediment grades, that there is a considerable accumulation of dead organic material in places with an apparent deterioration of the sediment environment.

Discussion

The sublittoral regions of the Harbour Study Area remain rich in both number of species and biomass, and ecological changes in this area seem minor compared with some of the changes in intertidal regions. At present, however, the accumulation of both inorganic and organic material in the soft sediments of sheltered regions is considered a problem. The deposition of fine sediments in some sheltered areas is also leading to ecological change in sublittoral regions.

The particularly rich fauna of coarse shell substrate in current swept channels is important in providing food for schnapper and other demersal fish. The area occupied by this rich fauna is expected to increase slowly as dead mollusc shells accumulate, although a reduction or change in water flow patterns could cause considerable ecological change in such areas.

APPENDIX 1 THE ABUNDANCE INDEX

It is part of the aim of this ecological study to provide sufficient information to enable large-scale ecological changes to be detected and monitored.

Under normal conditions population densities of animals are constantly fluctuating. There is also considerable spatial variation in the population density of any particular species. Recording, and accounting for, such natural fluctuations is often desirous in studies of the biology of one or a few species, but in a wide ranging, general study such as this, the recording of exact densities, and monitoring of small-scale natural variation is neither practical nor desirable.

In order to provide sufficient information to enable future detection of large scale ecological change an abundance index has been used. This defines four categories of abundance, with a range of population density assigned to each category.

1. abundant
2. common
3. occasional
4. rare

These are abbreviated to (a), (c), (o), (r) in the text of the general ecological reports.

The meaning of the Abundance Index

The abundance index for a species population in an area gives the range within which the population density occurs at the present time. The index refers to the population density over a fairly large area, and takes into account the natural variation in density within that area.

The range of densities assigned to each category in the abundance index was decided following study of the range of density of each species in the Waitemata Harbour Study Area. The 'abundant' density range was determined by reference to areas in which the species was most abundant, and usually set somewhat below the maximum density observed. The other categories were defined in relation to the 'abundant' category, and using knowledge of the range of population density for the species within the Harbour.

In a few cases, species did not occur in 'abundant' or 'common' categories within the Waitemata Harbour Study Area, and the population densities for these categories were decided using knowledge of the density distributions of the species in other similar areas. It is possible that such species will increase within the Waitemata Harbour, and allowance has been made for such an event in this abundance index.

The abundance index considers only the range of population density of a species in a certain area. It provides no information on the factors which determine the density. Generally, such factors fall into two groups:

(a) Limits of population density determined by the biological history of the species in the area - recruitment, predation, disease;

(b) Physical and other environmental factors determining the suitability of the area for colonisation by the species - substrate, water quality, available food.

Further information on the factors determining population densities in certain areas may be obtained from other sections of the Ecological Report. Species descriptions, (Appendix 2) gives adult size, feeding type, intertidal distribution, and substrate preference, while additional information may be obtained from the various sections of the general report for an area.

Included in the following index are the common solitary macrofauna of the Waitemata Harbour Study Area. Colonial forms such as sponges, colonial ascidians, and polyzoa are excluded because they require a definition of density based on the area covered. Algae have been excluded because the common algae show considerable fluctuations in density from year to year.

Species have been listed in alphabetical order in phyla. Densities are given in numbers of individuals per square metre.

'm'	means 'more than'
'L'	means 'less than'
1/10	means '1 individual per 10 square metres'
1/100	means '1 individual per 100 square metres'

Mollusca : Gastropoda

	Abundant	Common	Occasional	Rare
Acanthochiton zelandicus	m10	2-10	1 or 2	L1
Aglaja cylindrica	m1	1/10	L1/10	
Alcithoe arabica	1/100	1/1000		
Amaurochiton glaucus	m20	2-20	1 or 2	L1
Amphibola crenata	m20	2-20	1 or 2	L1
Baryspira australis	m1	1/10	1/100	L1/100
Baryspira novaezelandiae crystallina	m1	1/10	1/100	L1/100
Buccinulum heteromorphum	m10	1-10	1	L1
Cabestana spengleri	1/10	1/100	L1/100	
Cellana ornata	m5	1-5	1/10	L1/10
Cellana radians	m10	2-10	1	L1
Cominella adspersa	m5	1-5	1/10	1/100
Cominella glandiformis	m20	2-20	1 or 2	L1
Cominella maculosa	m5	1-5	1	L1
Cominella virgata	m5	1-5	L1	L1/10
Cryptoconchus porosus	1	1/10	1/100	L1/100
Dardinula sp.	m200	20-200	1-20	L1
Dendrodoris citrina	1	1/10	1/100	L1/100
Dendrodoris nigra	1/10	1/100	L1/100	
Estea sp.	m1000	100-1000	10-100	L10
Glossodoris sp.	1/10	1/100	L1/100	
Haustrum haustorium	m2	1	1/10	L1/10
Haminoea zelandica	m2	1 or 2	1/10	L1/10
Ischnochiton maorianus	m20	2-20	1 or 2	L1
Lepsiella scobina	m20	2-20	1 or 2	L1
Leuconopsis obsoleta	m100	10-100	1-10	L1
Lunella smaragda	m20	2-20	1 or 2	L1
Maoricolpus roseus	m10	2-10	1	L1
Maoricrypta costata	m5	1-5	1	L1
Maoricrypta monoxyla	m10	1-10	1	L1
Melagraphia aethiops	m10	2-10	1	L1
Melarapha oliveri	m100	10-100	1-10	L1
Micrelenchus huttoni	m10	1-10	1	L1
Murexul octogonus	m2	1 or 2	1/10	L1/10

	Abundant	Common	Occasional	Rare
Neothais scalaris	m2	1	1/10	L1/10
Nerita melanotragus	m10	2-10	1	L1
Notoacmea daedala	m20	2-20	1	L1
Notoacmea helmsi	m10	1-10	1	L1
Notoacmea parviconoidea	m50	10-50	1-10	L1
Onchidella nigricans	m10	2-10	1	L1
Onithochiton neglectus	m5	1-5	1	L1
Ophicardelus costellaris	m10	2-10	1	L1
Paratrophon stangeri	5	1-5	L1	
Perion adusta	1/10	1/100	L1/100	
Pervicacia tristis	m5	2-5	1	L1
Potamopyrgus antipodum	m1000	100-1000	10-100	L10
Risselspsis varia	m100	10-100	2-10	1
Rostangia rubicunda	m5	1-5	1	1/10
Scutus breviculus	1	1/10	L1/10	
Sigapatella novaezelandiae	m10	2-10	1	L1
Siphonaria zelandica	m5	2-5	1	L1
Struthiolaria papulosa	1/10	1/100	L1/100	
Struthiolaria vermis	1/5	1/100	L1/100	
Sypharochiton pelliserpentis	m10	2-10	1	1/10
Taron dubius	m5	1-5	1	L1
Teredo				
Terenochiton inquinatus	m10	2-10	1	L1
Tugali elegans	m2	1 or 2	1/5	L1/10
Xymene plebejus	m5	1-5	L1	
Zeacumantus lutulentus	m20	2-20	1 or 2	L1
Zeacumantus subcarinatus	m50	10-50	1-10	L1
Zediloma atrovirens	m10	2-10	1	L1
Zediloma subrostrata	m10	2-10	1	L1
Zegalerus tenuis	m10	1-10	1	L1
Zemitrella chaova	m20	2-20	1-2	L1

Mullusca Pelecypoda

	Abundant	Common	Occasional	Rare
Amphidesma australe	m100	10-100	1-10	L1
Amphidesma subtriangulatum	m100	10-100	1-10	L1
Anchomasa similis	m20	5-20	1-5	L1
Angulus gaimardi	m5	1-5	L1	
Anomia walteri	m50	5-50	1-5	L1
Arthritica crassiformis	m100	10-100	1-10	L1
Atrina zelandica	1/5	1/100	L1/100	
Chione stutchburyi	m100	10-100	1-10	L1
Cleidothaerus maorianus	m5	1-5	1	L1
Crassostrea glomerata	m100	10-100	1-10	L1
Diplodonta striatula	m10	2-10	1	L1
Diplodonta globa	m5	1-5	L1	
Dosinia subrosea	m5	1-5	1	L1
Dosinula zelandica	m2	1 or 2	L1	
Hiatella australis	m20	2-20	1 or 2	L1
Lasaea maoria	m100	10-100	1-10	L1
Leptomya retiaria	m10	1-10	1	L1
Mactra ovata	m5	1-5	1/10	L1/10
Macomona liliana	m20	5-20	1-5	L1
Modiolus fluviatilus	m100	10-100	1-10	L1
Modiolus neozelanicus	m200	50-200	1-50	1
Myadora striata	m5	2-5	1	L1
Mytilus edulis aoteanus	m10	2-10	1	L1
Notirus reflexus	m5	1-5	1	L1
Notocorbula zelandica	m20	5-20	1-5	L1
Notopaphia elegans	m5	1-5	1	L1
Nucula hartvigiana	m200	50-200	5-50	L5
Offadesma angasi	m1	1	L1	
Ostrea sp.	m100	10-100	1-10	L1
Paphirus largillierti	m5	2-5	1	L1
Pecten novaezelandiae	1/100	L1/100		
Perna canaliculus	m100	10-100	1-10	L1
Pholadidea spathulata	m20	2-20	1 or 2	L1
Pholadidea tridens	m10	1-10	1	L1
Protothacca crassicosta	m5	1-5	1	L1

	Abundant	Common	Occasional	Rare
Scintilla stevensoni	m5	1-5	L1	
Solemya parkinsoni	m5	1-5	L1	
Soletellina nitida	m10	2-10	1	L1
Trichomusculus barbatus	m10	2-10	1-2	L1
Zelithophaga truncata	m50	5-50	1-5	L1

Polychaetes

Acrocirrus sp.	m5	1-5	1	L1
Aglaophamus macroura	m10	2-10	1 or 2	L1
Asychis theodori	m20	2-20	1-2	L1
Axiothella quadrimaculata	m20	2-20	1-2	L1
Dasychone sp.	m5	2-5	L1	
Eulalia microphylla	m10	2-10	1-2	L1
Filograna sp.	m1000	100-1000	10-100	L10
Flabelligera affinis	m20	2-20	1-2	L1
Galeolaria histryx	m5	1-5	1	L1
Glycera sp.	m10	2-10	1-2	L1
Hermella spinulosa	m100	10-100		
Idyanthrysus quadricornis	m5	1-5	L1	
Lepidonotus jacksoni	m20	2-20	1-2	L1
Lepidonotus sp.	m10	2-10	1-2	L1
Lumbriconereis sphaerocephala	m100	10-100	1-10	L1
Marphysa depressa	m20	2-20	1-2	L1
Nicon aestuariense	m500	10-100	L10	
Orbinia papillosa	m1000	100-1000	10-100	L10
Onuphis aucklandensis	m2	1-2	L1	
Owenia fusiformis	m20	5-20	1-5	L1
Pectinaria australis	m20	5-20	1-5	L1
Perinereis novaehollandiae	m500	100-500	10-100	L10
Pomatoceros caeruleus	m1000	100-1000	10-100	L10
Prionospio aucklandica	m1000	100-1000	10-100	L10
Scolelepis sp.	m1000	100-1000	10-100	L10
Spirorbis sp.	m1000	100-1000	10-100	L10
Stylarioides parmatus	m20	5-20	1-5	L1
Terebella sp.	m10	2-10	1-2	L1
Timarete sp.	m10	2-10	1-2	L1

Crustacea

	Abundant	Common	Occasional	Rare
Alpheus sp.	m10	2-10	1 or 2	L1
Balanus amphitrite	m200	20-200	1-20	L1
Balanus trigonus	m500	50-500	5-50	L5
Callianassa filholi	m10	2-10	1 or 2	L1
Cancer novaezelandiae	1	1/5	L1/5	
Chamaesipho columna	m1000	100-1000	10-100	L10
Chamaesipho brunnea	m500	50-500	5-50	L5
Cirolana cooki	m5	1-5	1	L1
Cyclograpsus lavauxi	m20	5-20	1-5	L1
Elminius modestus	m10000	1000-10000	100	L100
Elminius plicatus	m200	20-200	2-20	L2
Halicarcinus cooki	m5	2-5	1	L1
Halicarcinus varius	m10	2-10	1	L1
Helice crassa	m50	5-50	1-5	L1
Hemigrapsus crenulatus	m10	2-10	1	L1
Hemigrapsus edwardsi	1	1/10	1/100	L1/100
Heterozius rotundifrons	m5	1-5	1	L1
Hymenicus pubescens	m10	2-10	1	L1
Isocladus armatus	m1000	100-1000	10-100	L10
Leptograpsus variegatus	m1	1	1/10	L1/10
Lysiosquilla armata	m5	1-5	L1	
Notomithrax minor	2	1	L1	
Ovalipes punctatus	1/5	1/10	L1/10	
Palaemon affinis	m20	2-20	1 or 2	L1
Petrolisthes elongatus	m200	20-200	2-20	L2
Pilumnopeus serratifrons	m2	1 or 2	L1	
Pontophilus australis	m10	2-10	1 or 2	L1
Plagusia capense	1	1/10	L1/10	
Sphaeroma quoyana	m100	10-100	1-10	L1
Talorchestia quoyana	m100	10-100	1-10	L1
Tetraclita purpurascens	m50	5-50	1-5	L1

Echinoderms

	Abundant	Common	Occasional	Rare
Coscinasterias calamaria	m1	1	1/5	L1/5
Evechinus chloroticus	m2	1 or 2	1/5	L1/5
Patiriella regularis	m2	1 or 2	1/5	L1/5
Trochodota dendyi	m5	2-5	1	L1

Coelenterates

Actinia tenebrosa	m5	1-5	1	L1
Actinothoe albocincta	m50	10-50	1-10	L1
Anthopleura aureoradiata	m50	10-50	1-10	L1
Diadumene neozelanica	m10	2-10	1 or 2	L1
Isactinia olivacea	m10	2-10	1 or 2	L1
Paractis ferax	m10	2-10	1 or 2	L1
Tubularia larynx	clumps			

Simple Ascidians

Asterocarpa coerulea	m10	2-10	1 or 2	L1
Asterocarpa cerea	m5	1-5	1	L1
Ciona intestinalis	m10	2-10	1 or 2	L1
Corella eumyota	m50	5-50	1-5	L1
Microcosmus claudicans	?			
Microcosmus kura	m100	10-100	1-10	L1
Pyura rugata	m10	1-10	1	L1
Styella plicata	m5	1-5	1	L1

Hemichordate

Balanoglossus australiensis	m30	5-30	1-5	L1

APPENDIX 2 SPECIES DESCRIPTIONS

In this appendix a brief description is given of each of the Harbour macrofauna species, including the average adult length, the feeding type, intertidal distribution, type of shore, and a general indication of their abundance within the Waitemata Harbour Study Area.

Mollusca : Gastropoda

Acanthochiton zelandicus - 25 mm, algal and detrital grazer.
Between mid and low tide levels on hard shores throughout the Harbour.

Aglaja cylindrica - 25 mm, carnivore eating small bivalves.
Found in clean sand in protected areas. Rare in the Waitemata.

Alcithoe arabica - 140 mm, carnivore eating bivalves.
Clean sand near low tide. Rare in the Waitemata.

Amaurochiton glaucus. 30 mm, algal grazer.
On hard substrates including shell and particularly under boulders on sand throughout the Harbour. Abundant.

Amphibola crenata - 25 mm, deposit feeder.
High tidal soft sediments particularly in mangrove marsh. Sheltered areas. Abundant.

Baryspira australis - 30 mm, carnivore.
Clean low tidal sands. Widespread and common.

Baryspira novaezelandiae crystallina - 15 mm, carnivore?
Clean low tidal sands sheltered areas. Rare.

Buccinulum heteromorphum - 25 mm, carnivore.
Low tide beneath boulders in unsedimented areas. Common central and outer Harbour.

Cabestana spengleri - 75 mm, carnivore eating ascidians.
Sheltered reefs, lower shore, middle Harbour, rare.

Cellana ornata - 30 mm, algal grazer.
Mid-tide on rocky shores more exposed. Abundant Outer Harbour occasional Middle Harbour.

Cellana radians - 35 mm, algal grazer.
Mid-tidal rocky shores, sandstone. Common outer Harbour.

Cominella adspersa - 45 mm, carnivore and scavenger.
Low tide soft shores throughout Harbour. Abundant.

Cominella glandiformis - 22 mm, carnivore and scavenger.
Mid-tide to low tide soft shores throughout Harbour. Abundant.

Cominella maculosa - 30 mm, carnivore and scavenger.
Mid - low tide hard shores and shelly areas, Outer and Middle Harbour. Abundant.

Cominella virgata - 28 mm, carnivore and scavenger.
Mid - low water hard shores, Outer and Middle Harbour.

Cryptoconchus porosus - 50 mm, carnivore.
Low water, clean rocky shores, Outer and Middle Harbour occasional.

Dardanula limbata - 5mm, algal grazer.
Low tide level, rocky shores, mid-outer Harbour, common.

Dendrodoris citrina - 50 mm, carnivore?
Mid - low tide rocky shores, sheltered areas, middle Harbour occasional.

Dendrodoris nigra - 40 mm, carnivore.
Low tide, rocky shores, sheltered areas. Rare.

Haminoea zelandica - 25 mm, detritus feeder.
Low tide, sandy to muddy area, middle Harbour. Common.

Ischnochiton maorianus - algal grazer.
Mid - low tide, beneath boulders, middle and outer Harbour, common.

Lepsiella scobina - 20 mm, barnacle and oyster carnivore.
Mid-tide rocky shores, middle and outer Harbour, abundant.

Leuconopsis obsoleta - 7 mm, algal grazer?
High water, beneath boulders, Outer Harbour occasional.

Lunella smaragda - 50 mm, algal grazer.
Mid-low tide, rocky shores, throughout Harbour, abundant.

Maoricolpus roseus - 45 mm, filter feeder.
Extreme low water, sandstone reefs, middle Harbour, rare.

Maoricrypta costata - 40 mm, filter feeder.
Low water beneath boulders, clean areas, middle and Outer Harbour. Common.

Maoricrypta monoxyla - 20 mm, filter feeder.
Low tide beneath boulders and on shells of Lunella smaragda, middle and outer Harbour,abundant.

Melagraphia aethiops - 20 mm, algal grazer.
Upper intertidal, hard shores, intolerant of silt widespread, abundant.

Melarapha oliveri - 10 mm, algal grazer.
High tide, hard shores, exposed areas. Middle and outer Harbour. Intolerant of silt or soft rock, abundant.

Micrelenchus huttoni - 7 mm, algal grazer and detritus feeder.
Lower intertidal, soft shores, shelly areas, middle Harbour, rare.

Murexul octogonus - 25 mm, carnivore.
Low tide beneath boulders, middle and outer Harbour, uncommon.

Neothais scalaris - 70 mm, mollusc carnivore.
Low tide, hard shores, middle and outer harbour, common.

Nerita melanotragus - 35 mm, algal grazer.
Upper intertidal, hard shores and beneath boulders. Outer Harbour, common.

Notoacmea daedala - 8 mm, algal grazer.
Mid tide, on shells and stones, Middle Harbour, common.

Notoacmea helmsi - 9 mm, algal grazer.
Mid - low tide on living and dead bivalve shells and stones, near soft substrate. Middle Harbour, abundant.

Notoacmea parviconoidea - 5 mm, algal grazer.
Mid-tide, hard shores, outer Harbour. Common amongst barnacles and Modilus.

Onchidella nigricans - algal grazer and detritus feeder.
Upper intertidal to low water rocky shores, particularly on algal films or in areas of sediment accumulation. Throughout Harbour, abundant.

Onithochiton neglectus - 25 mm, grazer.
Low water, beneath boulders, outer Harbour, occasional.

Ophicardelus costellaris - 8 mm, detritus feeder and algal grazer.
High water sedge marsh and mangrove marsh. Abundant.

Paratrophon stangeri - 20 mm, carnivore.
Lower shore, sandstone reefs, clean situations beneath stones, occasional.

Penion adusta - 80 mm carnivore.
Low water neap, rocky shores, often near sand, occasional.

Pervicacia tristis - 20 mm, polychaete carnivore.
Below mid tide on clean sand shores, occasional.

Potamopyrgus antipodum - 5 mm, detritus feeder.
High water spring in sedge and mangrove marsh, abundant.

Risselopsis varia - 5 mm, algal grazer.
Mid-tide level, amongst oysters and barnacles, rocky shores, common.

Rostangia rubicunda - 15 mm, sponge carnivore.
Low water neap to low water spring, shaded areas, rocky shores on sponge prey. Occasional.

Scutus breviculus - 100 mm, ascidian grazer.
Shaded places below mid-tide level, rocky shores, occasional.

Sigapatella novaezelandiae - 15 mm, filter feeder.
Beneath boulders and near low tide level, protected rocky shores, common.

Siphonaria zelandica - 20 mm, algal grazer.
Mid-tidal level, more exposed rocky shores, common.

Struthiolaria papulosa - 80 mm, filter feeder.
Low water neap to low water spring, clean sand, rare.

Struthiolaria vermis - 45 mm, filter feeder.
Low water neap to sublittoral, sandy areas, occasional.

Sypharochiton pelliserpentis - 40 mm, algal grazer.
Mid-tide neap on rocky shores, abundant.

Taron dubius - 10 mm, carnivore.
Low water neap to low water spring, rocky shores, beneath boulders, occasional.

Teredo spp. - wood borers.
Intertidal and sublittoral, boring into waterlogged wood, dead mangrove, and wharf pilings, etc, common.

Terenochiton inquinatus - 10 mm, grazer.
Low water neap to low water spring, benath boulders, also common sublittorally, common.

Tugali elegans - 20 mm, ascidian grazer.
Low water spring, beneath boulders in clean situations, rare.

Xymene plebejus - 12 mm, bivalve carnivore.
Mid tide to low tide level, clean sand associated with common bivalves, occasional.

Zeacumantus lutulentus - 25 mm, detritus feeder.
Mid-tide level, sandy and firm muddy shores, abundant.

Zeacumantus subcarinatus - 15 mm, detritus feeder.
Sandstone reefs and shelly areas, mid-low tide. Common.

Zediloma atrovirens - 12 mm, algal grazer and detritus feeder.
High water neap, beneath boulders, occasional.

Zediloma subrostrata - 10 mm, algal grazer.
Mid tide level on dead bivalve shells, in sandy areas, also on sandstone reefs, abundant.

Zegalerus tenuis - 8 mm, filter feeder.
Low water spring on shells, rocky areas, occasional.

Zemitrella chaoya - 5 mm.
Low water neap amongst Corallina and beneath stones, common.

Mollusca : Pelecypoda

Amphidesma australe - 75 mm, filter feeder.
Low water neap to sublittoral, clean sand and shelly substrate, abundant.

Amphidesma subtriangulatum - 65 mm, filter feeder.
Low water neap to low water spring, clean sand, more exposed areas - Takapuna Beach. Abundant.

Anchomasa similis - 75 mm, filter feeder.
Mid tide level to low water neap, rock borer in sandstone reefs, common.

Angulus gaimardi - 45 mm, surface deposit feeder.
Low water spring, clean fine sand, Cheltenham, rare.

Anomia walteri - 40 mm, filter feeder.
Low water neap to subtidal, beneath boulders and in shaded areas, rocky shores, abundant.

Arthritica crassiformis - 3 mm.
Commensal with Anchomasa similis, common.

Atrina zelandica - 200+ mm, filter feeder.
Low water spring and sublittoral, clean fine sand, rare.

Chione stutchburyi - 35 mm, filter feeder.
Mid tide level to low water spring, sandy and firm muddy shores, abundant.

Cleidothaerus maorianus - 50 mm, filter feeder.
Low water neap to sublittoral, clean sandstone reefs, occasional.

Crassostrea glomerata - 75 mm, filter feeder.
Mid tide level to low water neap, on rocky shores, abundant.

Diplodonta striatula - 8 mm, filter feeder.
Mid tide level to low water spring in coarse sand and shell, occasional.

Diplodonta globa - 8 mm, filter feeder.
In holes excavated by pholads, occasional.

Dosinia subrosea - 45 mm, filter feeder.
Low water spring in clean fine sand, occasional.

Dosinula zelandica - 45 mm, filter feeder.

Low water neap to low water spring, coarse shelly substrate and in holes in sandstone, rare.

Hiatella australis - 10 mm, filter feeder.

Mid tide level to low water spring. In algal holdfasts, and pholad holes, rocky reef areas, common.

Lasaea maoria - 3 mm, filter feeder.

High water neap, beneath boulders in clean damp situations, occasional.

Leptomya retiaria - 12 mm, surface deposit feeder.

Fine, firm muds, rare.

Mactra ovata - 70 mm, filter feeder.

Mid tide level to sublittoral in soft sands and muds, occasional.

Macomona liliana - 35 mm, surface deposit feeder.

Mid tide level to sublittoral, sands and muds, abundant.

Modiolus fluviatilus - 30 mm, filter feeder.

Low water neap to sublittoral, hard substrates in areas with reduced salinity, common.

Modiolus neozelanicus - 20 mm, filter feeder.

Mid tide level, clean rock surfaces, common.

Myadora striata - 25 mm, filter feeder.

Low water spring, clean fine sands, occasional.

Mytilus edulis aoteanus - 70 mm, filter feeder.

Wharf piles and rocky shores, occasional.

Low water neap to low water spring.

Notirus reflexus - 30 mm, filter feeder.

Low water neap to low water spring, boring in sandstone, clean areas, occasional.

Notocorbula zelandica - 10 mm, filter feeder.

Low water spring shell substrates, and sublittoral, occasional.

Notopaphia elegans - 30 mm, filter feeder.

Low water neap to low water spring, boring in sandstone, clean areas, occasional.

Nucula hartvigiana- 6 mm, deposit feeder.
Mid tide level to low water spring, clean sandy areas, abundant.

Offadesma angasi - 55 mm, filter feeder.
Low water spring, clean fine sand, rare.

Ostrea sp. - 35 mm, filter feeder.
Low tide neap to sublittoral, hard shores, abundant.

Paphirus largillierti - 60 mm filter feeder.
Low tide neap to low water spring, clean sand, rare.

Pecten novaezelandiae - 120 mm, filter feeder.
Low water spring to sublittoral, none found alive on present survey.

Perna canaliculus - 130 mm, filter feeder.
Low water neap to sublittoral, rocky shores, occasional.

Pholadidea spathulata - 55mm, filter feeder.
Mid tide level boring in sandstone, clean areas, common.

Pholadidea tridens - 30 mm, filter feeder.
Mid tide level to low water neap, boring in sandstone, clean areas, rare.

Protothacca crassicosta - 25 mm, filter feeder.
Low water neap in coarse shelly substrate, or in crevices in sandstone reefs, rare.

Scintilla stevensoni - 6 mm,
commensal with Lysiosquilla armata.

Solemya parkinsoni - 30 mm, filter feeder.
Low water neap to low water spring, burrowing deeply in soft sand, rare.

Soletellina nitida - 30 mm, filter feeder.
Low water neap to low water spring, firm sand and sandy mud, common.

Trichomusculus barbatus - 15 mm, filter feeder.
Beneath stones below mid tide level, clean situations, occasional.

Zelithophaga truncata - 35 mm, filter feeder.
Mid tide level to low water spring, boring in sandstone, clean areas, common.

Polychaetes

Acrocirrus sp. - 60 mm, selective deposit feeder.
Low water neap and below, beneath boulders on sand, occasional.

Aglaophamus macroura - 120 mm, polychaete carnivore.
Mid tide level to low water spring, sandy and firm muddy shores, abundant.

Asychis theodori - 200 mm, deposit feeder.
Low water neap to low water spring, clean fine sand, common.

Axiothella quadrimaculata - 150 mm, deposit feeder.
Mid tide level to low water spring, clean firm sand, occasional.

Dasychone sp. - 150 mm, filter feeder.
Low water neap to low water spring, clean sand, and shelly substrate, occasional.

Eulalia microphylla - 100 mm, carnivore.
Mid tide level amongst oysters, common.

Filograna sp. - 10-20 mm.
Low water neap to sublittoral, beneath boulders in clean situation, occasional.

Flabelligera affinis - 60 mm.
Mid tide level to low water spring, beneath boulders in clean situation, common.

Galeolaria histrix - 60 mm, filter feeder.
Low water spring, rocky reefs in clean areas, occasional.

Glycera sp. - 150 mm, polychaete carnivore.
Mid tide level to low water spring, sandy and muddy substrates, abundant.

Idyanthrysus quadricornis

Lepidonotus jacksoni - 20 mm, polyzoan carnivore.
Mid tide level to low water neap, beneath boulders in clean situations, common.

Lepidonotus sp. - 20 mm, polyzoan carnivore.
Beneath boulders as above, but in more silted situations.

Lumbriconereis sphaerocephala - 160 mm, deposit feeder.
Mid tide level to low water spring, sandy flats, common.

Marphysa depressa - 180 mm, carnivore.
Half tide level to low water spring, in crevices in sandstone reef areas, occasional.

Nicon aestuariense - 120 mm.
Above mid tide level to low water spring, beneath stones in muddy situations, and burrowing in mud flats, common.

Orbinia papillosa - 120 mm, deposit feeder.
Mid tide level to low water spring, clean firm sand, occasional.

Onuphis aucklandensis - 200 mm, carnivore.
Low water neap, clean firm sand, occasional.

Owenia fusiformis - 120 mm, surface deposit feeder.
Low water neap to sublittoral, sandy-mud substrate, common.

Pectinaria australis - 60 mm, deposit feeder.
Low water neap to sublittoral, clean sand and sandy-mud, common.

Perinereis novaehollandiae - 120 mm, deposit feeder?
Mid tide level to low water spring, firm sandy substrate, abundant.

Pomatoceros caeruleus - 60 mm, filter feeder.
Mid tide level to low water neap, rocky shores in clean situations, abundant.

Prionospio aucklandica - 40 mm, surface deposit feeder.
Mid tide level to low water spring, wet, muddy-sand substrates, abundant.

Sabellaria kaiparensis - 100 mm, filter feeder.
Low water neap, on rocks, near sand, Takapuna-Cheltenham, occasional.

Scolelepis sp. - 50 mm, surface deposit feeder.
Mid tide level to low water neap, sandy-mud, abundant.

Spirorbis sp. - 3 mm, filter feeder.

Epiphytic on low tidal algae, on stones and shells, abundant.

Stylarioides parmatus - 60 mm.

Mid tide level to low water spring, boring in sandstone, clean areas, occasional.

Terebella spp. - 70 mm surface deposit feeder.

Beneath stones mid tide level to low water spring. Probably more than one species in the Harbour, occasional.

Timarete sp. - 80 mm, surface deposit feeder.

In soft substrates sometimes beneath stones, near low water neap. Occasional.

Crustacea

Alpheus sp. - 50 mm, surface deposit feeder.
Mid tide to low water spring, soft muds, abundant.

Balanus amphitrite - 12 mm, filter feeder.
Low water neap to sublittoral, on hard objects in areas with reduced salinities, abundant.

Balanus trigonus - 8 mm, filter feeder.
Low water spring and sublittoral, on hard surfaces, clean substrates in currents, common.

Callianassa filholi - 40 mm, surface deposit feeder.
Mid tide to low water spring, firm sand, common.

Cancer novaezelandiae - 100 mm, scavenger.
Low water spring, gravelly areas and near sand, occasional.

Chamaesipho brunnea - 10 mm, filter feeder.
Mid tide level on exposed hard substrates, common.

Chamaesipho columna - 4 mm, filter feeder.
Mid tide to low water neap, hard surfaces, moderate exposure, common.

Cirolana cooki - 15 mm.
Mid tide level to sublittoral, sandy substrate, occasional.

Cyclograpsus lavauxi - 30 mm, detritus feeder.
High water neap and above, beneath boulders, abundant.

Elminius modestus - 5 mm, filter feeder.
Mid tide level to low water spring on all hard surfaces, abundant.

Elminius plicatus - 15 mm, filter feeder.
Mid tide level, exposed hard substrates, common.

Halicarcinus cooki - 25 mm, detritus feeder.
Mid tide level to low water spring, clean sandy substrate, occasional.

Halicarcinus varius - 18 mm,
Mid tide to low water spring, amongst algae and beneath boulders, common.

Helice crassa - 25 mm, surface deposit feeder.
High water spring to low water neap, soft substrates, abundant.

Hemigrapsus crenulatus - 45 mm, detritus feeder and scavenger.
Mid tide level to low water spring, wet, shelly areas on soft shores, common.

Hemigrapsus edwardsi - 140 mm, scavenger.
High water neap, beneath boulders in clean situations, occasional.

Heterozius rotundifrons - 25 mm.
Mid tide level, beneath boulders in clean situations, rare.

Hymenicus pubescens - 10 mm
Low water neap to low water spring, beneath stones, common.

Isocladus armatus - 10 mm
In pools on rocky shores, more exposed areas, common.

Leptograpsus variegatus - 150 mm, carnivore.
Mid tide level, beneath boulders and in crevices, exposed rocky areas, common.

Lysiosquilla armata - 70 mm, filter feeder.
Mid tide level to low water spring, in clean firm sand, common.

Notomithrax minor - 35 mm.
Low water neap to low water spring, rocky areas, occasional.

Ovalipes punctatus - 120 mm, carnivore.
Sublittoral fringe, exposed sandy shores, occasional.

Palaemon affinis - 35 mm, scavenger.
Pools and sublittoral, abundant.

Petrolisthes elongatus - 40 mm, filter feeder.
Mid tide level, beneath boulders, abundant.

Pilumnopeus serratifrons - 100 mm.
Mid tide level to low water spring, beneath boulders and objects on sandy substrate, occasional.

Pontophilus australis - 25 mm.

Low water neap - remains in the water, shallow pools, etc, clean sand areas, occasional.

Plagusia capense - 180 mm, carnivore.

Sublittoral fringe, and larger pools, exposed hard-shore areas, common.

Sphaeroma quoyana - 12 mm.

High tide neap, burrowing in sandstone, abundant.

Talorchestia quoyana - 15 mm.

High tide level, clean sandy beaches, beneath algae and drift material, common.

Tetraclita purpurascens - 12 mm, filter feeder.

Mid tide level in shaded areas, beneath boulders, occasional.

Echinoderms

Amphiura aster - 250 mm, surface deposit feeder.
Low water neap to low water spring, clean sand - Cheltenham, occasional.

Coscinasterias calamaria - 150 mm, carnivore.
Low water neap to sublittoral, on clean rocky shores and subtidal beds of Amphidesma australe, common.

Evechinus chloroticus - 80 mm, algal feeder.
Low water neap to sublittoral, clean rocky shores, uncommon.

Patiriella regularis - 65 mm, detritus feeder and algal grazer.
Low water neap to subtidal, rock platforms and sometimes on soft substrate, common.

Trochodota dendyi - 120 mm, deposit feeder.
Low water neap, soft substrate, occasional.

Coelenterates

Actinia tenebrosa - 20 mm, filter feeder.
High water neap to mid tide level in shaded situations, on sheltered rocky shores, occasional.

Actinothoe albocincta - 15 mm, filter feeder.
Low water neap to sublittoral, in shaded situations, in strong current areas, common.

Anthopleura aureoradiata - 8 mm, filter feeder.
Mid tide level to sublittoral, hard substrates and shells of living and dead bivalves, on soft shores, abundant.

Diadumene neozelanica - 25 mm, filter feeder.
Low water neap to subtidal, sheltered situations, tolerant of some degree of siltation, occasional.

Isactinia olivacea - 25 mm, filter feeder.
Mid tide level to sublittoral, rocky shores, common.

Paractis ferax - 6 mm.

Low water neap, buried in sandy mud and attached to stones, occasional.

Tubularia larynx - 3 mm, filter feeder.

Sublittoral, attached to buoys and wharf piles, common.

Simple ascidians

Asterocarpa coerulea - 30 mm, filter feeder.

Under stones in clean rocky situations, common.

Asterocarpa cerea - 30 mm, filter feeder.

Under stones in clean rocky situations, common.

Ciona intestinalis - 35 mm, filter feeder.

About low water neap, on rocky shores, on vertical rocky faces.

Corella eumyota - 40 mm, filter feeder.

Low water neap to low water spring, amongst algal tuff, common.

Microcosmus claudicans - 30 mm.

Low water neap to low water spring and in pools, sheltered situations on hard substrate, also beneath stones, occasional.

Microcosmus kura - 30 mm, filter feeder.

Low water neap to sublittoral, on sandstone reefs throughout Harbour, abundant.

Pyura rugata - 30 mm, filter feeder.

Low water neap to low water spring, under ledges, sheltered situations, occasional.

Styella plicata - 40 mm, filter feeder.

Low water neap to low water spring, under ledges, clean areas, with some exposure, occasional.

Hemichordate

Balanoglossus australiensis - 150 mm, surface deposit feeder.

Low water neap to low water spring, clean sand, occasional.

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