Auckland
Regional Council
TE RAUHITANGA TAIAO

Intertidal Life of the Tamaki Estuary and its Entrance, Auckland

July 2005 TP373

Auckland Regional Council
Technical Publication No. 373, 2008
ISSN 1175-205X (Print)
ISSN 1178-6493 (Online)
ISBN 978-1-877483-47-9

Intertidal life of the Tamaki Estuary and its Entrance, Auckland

Bruce W. Hayward[1]
Margaret S. Morley[1,2]

[1]Geomarine Research, 49 Swainston Rd, St Johns, Auckland
[2]c/o Auckland War Memorial Museum, Private Bag 92 018, Auckland

Prepared for
Auckland Regional Council
Envrionmental Research

2005

Approved for ARC publication by:

Grant Barnes
21 July 2008

Recommended Citation:

Hayward, B. W; Morley, M.S (2005). Intertidal life of the Tamaki Estuary and its entrance, Auckland. Prepared for Auckland Regional Council. Auckland Regional Council Technical Publication Number 373. 72p

Contents

1	**Executive Summary**	**1**
2	**Introduction**	**3**
2.1	Study Area	3
2.2	Rock Types Along the Shore	6
2.3	Origin and Shape of the Tamaki Estuary	6
2.4	Previous Work	7
2.4.1	Ecological Surveys	7
2.4.2	Introduced Species	7
2.4.3	Environmental Pollution	8
2.4.4	Geology	9
2.5	Tamaki Estuary Steering Committee	9
3	**Methodology**	**10**
3.1	Survey Methodology	10
3.2	Biodiversity and Specimens	10
4	**Intertidal Habitats and Communities**	**11**
4.1	Salt Marsh and Salt Meadow	11
4.2	Mangrove Forest	11
4.3	Seagrass Meadows	12
4.4	Sublittoral Seaweed Fringe	12
4.5	Estuarine Mud	12
4.6	Shelly Sand Flats	12
4.7	Shell Banks and Spits	13
4.8	Rocky Shores Around the Tamaki Estuary Entrance	13
4.9	Rock Retaining Walls	14
4.10	Microfauna of Seaweeds	15
4.11	Microfauna Beneath Low Tide Rocks	15
4.12	Fauna of Oyster Clumps	15
4.13	Subtidal Washup	15
5	**Geographic Distribution Patterns**	**17**
5.1	Cluster Analysis Methodology	17
5.2	Cluster Analysis Results	19

5.2.1 Outer Estuary Region 21
5.2.2 Middle Estuary Region 21
5.2.3 Inner Estuary Region 21
5.3 Species Diversity Patterns 21
5.4 Geographic Distribution of Species Around the Tamaki Estuary 24

6 Noteworthy Occurrences 33
6.1 Chitons (Fig. 14): 33
6.2 Snails (Fig. 14): 33
6.3 Sea slugs, nudibranchs (Fig. 15): 36
6.4 Bivalves (Fig. 14): 38
6.5 Echinoderms (Fig. 16): 38
6.6 Coral (Fig. 16): 38
6.7 Tubeworms (Fig. 16): 38
6.8 Sea squirt (Fig. 16): 39
6.9 Seaweeds (Fig. 16): 39

7 Human-Related Biotic and Other Changes 41
7.1 Introduced Species 41
7.2 TBT Impacted Species 45
7.3 Seagrass Disappearance and Return 45
7.4 Decline in Mollusc Size 45
7.5 Other "Vanished" Species 46
7.6 Mangrove Forest Expansion 47
7.7 Mud Accumulation 47

8 References 48

9 Appendices 53
9.1 Appendix 1 – Field Surveys 53
9.2 Appendix 2 – Recent Scientific Name Changes 54
9.3 Appendix 3 – Species List 56
9.4 Appendix 4 – Number of Species in Different Taxonmic Groups 71
9.5 Appendix 5 – Intertidal and Subtidal Biota and Habitats of the Tamaki Estuary 72

Peer Reviewed by: Megan Stewart

19 July 2008

1 Executive Summary

This report includes general descriptive accounts and illustrations of the various intertidal communities in Tamaki Estuary, written to accompany a coloured map which shows their distribution (A3 map in Appendix 5). Mapping of the intertidal shore of Tamaki Estuary is based on a combination of its substrate (e.g. basalt, tuff, sandstone, peat, stable cobbles, sand, mud), vegetation (e.g. salt marsh, mangrove forest, sea grass, sublittoral fringe seaweeds), and dominant soft-shore animals (e.g. mud snails, horn shells, cockles, pipi, Asian date mussels).

Five hundred and eight species of plants and animals (390 living, 113 dead or washed up from offshore, mostly shells) are recorded from the intertidal zone of the Tamaki Estuary and its entrance, Auckland (from St Heliers to Eastern Beach). This total includes: 119 species of gastropods, 72 bivalves, 57 seaweeds, 42 polychaete worms, 36 foraminifera, 27 crabs, 24 salt marsh plants, 16 fish, 15 intertidal feeding birds, 12 sponges, 11 echinoderms, 10 sea squirts, 9 chitons, 8 amphipods, 8 sea anemones, 7 barnacles, and 6 shrimps. Total species numbers are under-reported for some groups that have not been studied in detail, such as polychaetes, small crustaceans and bryozoans.

Noteworthy records include 12 colourful species of sea slugs around the entrance of the Tamaki Estuary; live specimens of the southern blue mussel, *Mytilus galloprovincialis*; the largest known colonies around Auckland of the estuarine flea mussel, *Xenostrobus securis*; several live colonies at low tide of the encrusting coral *Culicia rubeola*; and several specimens of the relatively rare chiton, *Pseudotonicia cuneata*.

Multivariate analysis of our survey data (presence/absence; qualitative abundance estimates) on the distribution of organisms around the entire Tamaki Estuary and its entrance, identifies three distinct biotic regions – outer estuary, middle estuary and upper estuary with boundaries identified as Tahuna Torea-Half Moon Bay, and Panmure Bridge. The outer estuary region has 120-160 live species, reducing to 50-100 in the middle estuary and 30-50 in the upper estuary. The highest recorded biodiversity occurs along the coastline from Bucklands Beach to Musick Point, with its relatively high diversity of soft and hard shore habitats available.

While they are difficult to quantify, some impacts of human activities that are recognisable include:

a. The disappearance, or greatly reduced abundance, of arabic volutes, southern olive shells, oyster borers, and octagonal murex, are attributed primarily to the impact of TBT poisoning, before this type of anti-fouling paint was banned.

b. The introduction by shipping of at least 16 exotic species that now live in the Tamaki Estuary, with four new arrivals in the last decade – parchment worm, large Japanese swimming crab, Australian bridled goby, and spiny sea squirt.

c. One of the introduced species having the largest impact is the Pacific oyster, *Crassostrea gigas*, which reached Tamaki Estuary in 1992 and now covers large areas of previously clear sandstone reef and in places forms growing patches of sharp oysters attached to shells or pebbles on the intertidal flats.

d. Another high-impact introduced species in the Tamaki Estuary is the Asian date mussel, *Musculista senhousia*, which arrived in the 1980s and now forms large, transient, low tidal mounds scattered through many parts.

e. Many shelled molluscs now living in the Tamaki Estuary are smaller than what they were in the past and smaller than their counterparts outside the estuary.

f. Sea grass, *Zostera*, disappeared from the Waitemata and Tamaki Estuary in the 1950s and 1960s, but is now making a comeback around the entrance to the estuary.

g. Increased mud from subdivisions has buried formerly sandy, shelly and more rocky shores in the middle reaches of Tamaki Estuary over the last 50 years or so.

h. Increased freshwater runoff from impervious surfaces in suburbia have decreased salinity in the estuary and altered the biotic community and decreased its diversity in upper parts of the estuary.

i. Areas of mangrove forest are expanding around the upper reaches and fringes of the estuary.

2 Introduction

2.1 Study Area

The coastal study area reported on here consists of over 50 km of coastline extending right around the Tamaki Estuary and outside its mouth from St Heliers in the west to Eastern Beach in the east. The area studied and mapped covers the full width of the intertidal zone from extreme low water spring level up to extreme high water (extreme tidal range c. 3.5 m) and the splash zone above.

The upper reach of Tamaki Estuary has four main arms – Otahuhu, Middlemore, Otara, and Pakuranga Creek. The shores of all four are dominated by mangrove forest with mud-lined channels. The middle reaches of the estuary are a mix of tidal mud flats, patchy marginal strips of mangroves, mud-covered low-lying shore platforms, and sandy, high-tidal beaches. In the outer reaches of the estuary, the tidal flats are sandier and shellier, the shore platforms have less mud cover, and tidal shell spits and banks are more prevalent.

Around and outside the Tamaki Estuary mouth the shore is dominantly rocky cliffs and platforms interspersed with sand beaches and occasional stable cobble beaches.

Figure 1
Location of Tamaki Estuary study area at the eastern end of the Waitemata Harbour, Auckland.

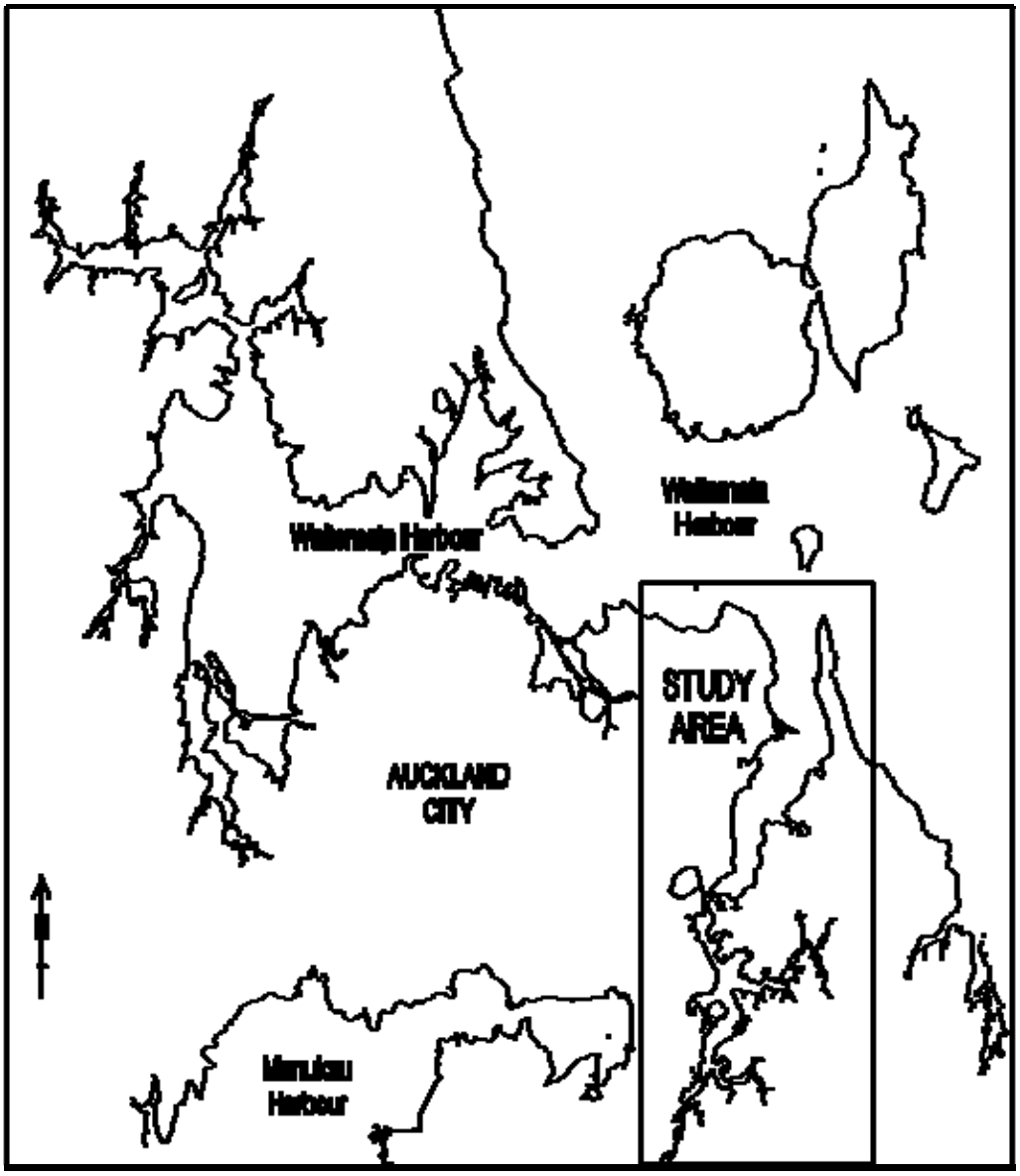
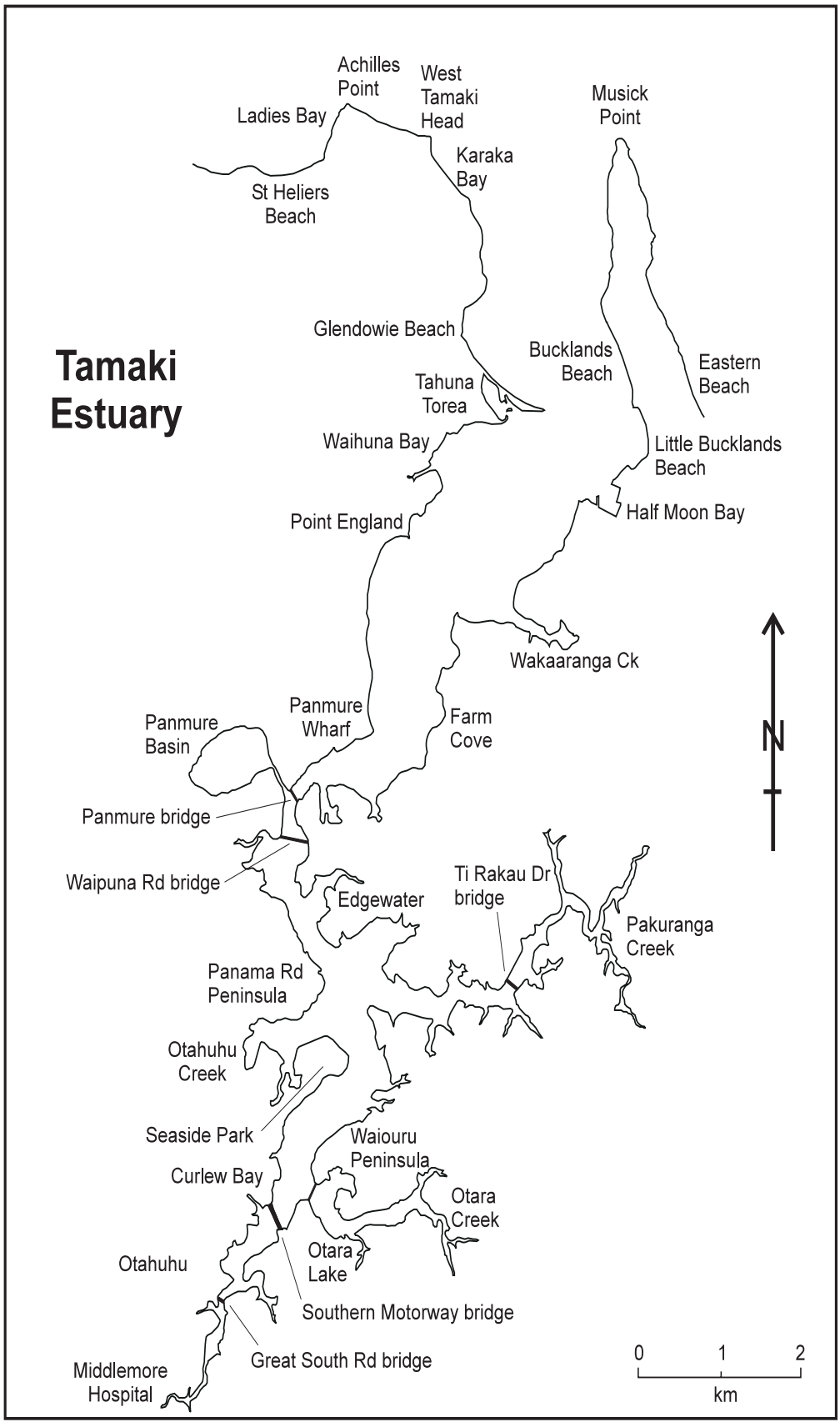


Figure 2

Tamaki Estuary and location of place names used in the text.



2.2 Rock Types Along the Shore

The hardest natural rocky shores in the Tamaki Estuary are made of black basalt lava flow that surrounds the Panama Rd peninsula on the perimeter of McLennan Hills small shield volcano. Waitemata Sandstone shores are largely limited to the outer half and outside of Tamaki Estuary (north of Pt England and Wakaaranga Creek) where they are the dominant rocky shore type. Within the Waitemata Sandstone Formation, beds of massive Parnell Grit are slightly more resistant to erosion and form the reefs off Achilles Pt, West Tamaki Head, on the east side of Musick Pt, and also forming a tidal waterfall in Pakuranga Creek.

The next hardest rock type is the bedded tuff (volcanic ash) from Panmure Basin and Waiouru volcanoes that form tidal reefs and low cliffs around much of the basin, its entrance, and for a short distance either side of the entrance, and also on the north side of the entrance to Otara Creek.

In the middle parts of the Tamaki Estuary, low-lying tidal platforms and sometimes cliffs are composed of light-coloured Pleistocene rhyolitic tuff, or ignimbrite, which in some places is interbedded with black, wood-bearing peat. A small outcrop of cemented Holocene tuffaceous beach rock occurs at the north end of Bucklands Beach.

2.3 Origin and Shape of the Tamaki Estuary

The Tamaki Estuary is a flooded river valley system. Its many branches reflect the branching drainage pattern prior to flooding. The orientation of many of the branches in the middle and upper parts of the estuary (from Pakuranga Creek up) suggest that the drainage pattern was formed by a river system that flowed southwards into the Manukau Harbour. This drainage system was eroded into a sequence of soft peat, rhyolite ash and ignimbrite layers that filled an earlier depression about 1 million years ago (Alloway et al., 2004). This south-flowing river system was presumably dammed by eruption of McLennan Hills, Mt Richmond and Crater Hill between 200,000 and 20,000 years ago. Until about that time, a dividing ridge of Waitemata Sandstone between the east- and west-flowing catchments existed between Glendowie and Half Moon Bay.

The present day Tamaki Estuary was formed about 7000 years ago when rising sea level, after the low of the Last Ice Age, flooded the Tamaki River and its branches. This was not the first time that an estuary existed here, as the river valley was presumably flooded for a few thousand years every 100,000 years going back to at least 1 million years ago. A prominent terrace at 5-8 m above sea level borders the estuary and may have been formed by erosion during the last high sea level stand, 130,000 years ago.

2.4 Previous Work

2.4.1 Ecological Surveys

This study appears to be the first to map and list the majority of intertidal species throughout the Tamaki Estuary.

An ecological report on the Waitemata Harbour (Larcombe, 1973) records the distribution and abundance of the common intertidal fauna and flora, its purpose was to provide information to be considered in drafting future policies. The report divided the Harbour into 27 areas, three (p. 123-176) are the entrance to the Tamaki Estuary; Point England to Panmure bridge; and Panmure Basin. General descriptions of the areas are given, comments are made on the marine birds, fish, and plant species. More common species of marine invertebrates and algae are listed under high water, mid tidal level and low water. Information is given on edible mollusc species, pollution, ecological values and potential protection.

Grange (1982) reported on the soft sediment benthos in stations located immediately downstream of highway 1 motorway bridge, as part of an investigation for a possible Otara power station. This was later followed by a survey of the benthos in 9 stations in the same area by Kingett Mitchell (1996) who recorded 39 benthic taxa and 10 species of fish in the estuary and Otara Lake.

A coastal wetland inventory of Tahuna Torea listed wetland plants, dominant and endangered bird species, with brief comments made on the abundance of crabs and mud snails (Department of Conservation, 1988). Clark (1997) surveyed the cockle populations of Tamaki Estuary.

A study was done on the intertidal life on the east side of the Tamaki Estuary near its mouth from Musick Point to Little Bucklands Beach (Morley 2002). It was noted that the molluscs at Bucklands Beach have suffered severe decreases in diversity and abundance from the 1950's to 2001. It appeared that the main causes were siltation, pollution, especially tributyltin in antifouling paint, the Imperial Chemical Industries fire, loss of habitat and harvesting.

2.4.2 Introduced Species

Tamaki Estuary has been the recipient of a number of marine species introduced to New Zealand by shipping in recent decades. Read and Gordon (1991) first recorded the introduced tube worm *Ficopomatus enigmaticus* growing on rocks near the outfall of warm freshwater from Otara Power Station. Willan (1985) recorded the arrival of the Asian date mussel in New Zealand in the mid-late 1970s and its establishment in Tamaki Estuary by 1982. Creese et al. (1997) summarised the results of DeLuca and Wharton's MSc studies on the biology and ecology of the introduced Asian date mussel *Musculista senhousia*, in Tamaki Estuary. Further work on the Asian date mussel was undertaken by Sim (1999). The Australian bridled goby was first reported from New Zealand in Otara Lake by Kingett Mitchell (1996).

Dromgoole and Foster (1978) did not include the Tamaki Estuary in their studies, but their comments on introduced species, reclamation, sedimentation and pollution in the Waitemata Harbour apply here.

2.4.3 Environmental Pollution

An infamous example of chemical spillage and pollution in Tamaki Estuary occurred during the ICI fire in December 1984. This spillage killed off populations of mud crabs and mud snails in the adjacent embayment where mangroves were defoliated or killed, but most of the ecosystem had recovered to its pre-spillage condition within 9 months (Maxwell, 1985, 1987a, b).

During 1990, a video, "Tamaki - Green or Grey?" was made by visiting film maker Peter Watkins who filmed and recorded facts about the Tamaki Estuary. St Kentigerns College senior students interviewed key people concerned with the proposed industrial development of Waiouru Peninsula situated on the east side of the estuary above Panmure Bridge. Results of this and other topics were presented at a public forum. On a similar theme, the Tamaki River Planning Study (KRTA Ltd. 1990), commissioned by the Waitemata Harbour Maritime Planning Authority documented resources, recreational use, identified conflicts, assessed future pressures and recommended appropriate actions. Zones in the Tamaki Estuary in the National Habitat Inventory for New Zealand are also discussed.

An article on the Tamaki Estuary written by Max Chapple (1993) in Metro magazine, reports that at that time the Auckland Regional Council considered the Tamaki Estuary to be in a worse state than the Manukau Harbour and one of the most polluted waterways in the country. Problems included overflows from sewage substations, industrial discharges, siltation, leachate from rubbish dumps, boats and commercial boat yards, road and farm run-off.

A section of the Tamaki Estuary Coastal Strategy (Auckland City Council, 2000) deals with margins of the estuary relating to water run-off, erosion, coastal structures, public access, management and areas considered to be worthy of protection. A report on the restoration of Panmure Basin (Danielle Carter 2001, unpublished report to the Auckland City Council), identified broad problems around the Basin and suggested remedies.

In an MSc thesis, Tang (1999) documented the surficial and late European levels of heavy metals in Panmure Basin sediment, and reported that the most contaminated part was near the stormwater outfall by the swimming baths. Hayward et al. (2004) documented changes in the foraminiferal faunas in two short sediment cores in Panmure Basin that correlated with European urbanisation of the catchment. Swales et al. (2002) provided high resolution documentation of the impact of urbanisation on sediment influx into Pakuranga Creek.

A number of studies have been undertaken in connection with the Otahuhu Power Station (Grange, 1982; Black et al., 1996; Kingett Mitchell, 1996), and Symmons (2000) undertook an environmental risk assessment of the estuary.

2.4.4 Geology

Geology of the intertidal exposures around Tamaki Estuary was mapped by Kermode (1992). Gregory et al. (1994) mapped the seafloor sediment in the estuary.

2.5 Tamaki Estuary Steering Committee

In 1984, a serious fire occurred at the ICI paint factory near Panmure Basin with toxic run off into the estuary having a severe impact on the surrounding marine life. As a result of this catastrophe, in 1988 a Steering Committee (originally known as the Task Force) was set up to improve the water quality and protect the Tamaki Estuary. It aimed to provide a forum for consultation, co-ordination of strategies, plans and work programmes for the organisations taking part. Members include Auckland Regional Council, Auckland and Manukau City Councils, Auckland Harbour Board, Watercare, Ngati Paoa Trust and the Tamaki Estuary Protection Society. Problems tackled are sewage overflows, earthworks control, siltation, coastal erosion, water quality, pollution and recreational safety. Various studies by the Auckland Regional Council include monitoring water temperature, oxygen levels, water clarity, sediment, microbiological indicators, and heavy metals in oysters (1992). The Steering Committee continues to meet regularly. Large sums of money have been spent on upgrading sewage stations, monitoring industrial run-off, sewage disposal from boats, and commercial and public education. Settlement ponds have been established to reduce pollution flowing into the estuary from Omaru Creek in Glen Innes.

3 Methodology

3.1 Survey Methodology

All accessible sections of the intertidal coastline were surveyed on foot by the authors during 23 days of field work between 2002 and 2005 (Appendix 1). The coastline was subdivided into 13 separate sections (Appendix 3), each of which was of sufficiently small size to enable a thorough survey during one low tidal cycle. Each survey was undertaken on the monthly spring tide, when low tide was in the range 0.1-0.4 m (mean low tide is 0.7 m and low tide range is 0-1.4 m). Each survey consisted of 3-4 hours of detailed examination of all the intertidal habitats present, recording all the living taxa found, assessing their relative abundance (see Appendix 3), and also recording the presence of any additional dead taxa observed. Specimens of taxa that needed microscopic or other detailed study for identification were taken back to the laboratory, as were samples of shell sand from beneath low tide boulders, and microscopic shells washed off the underside of boulders or washed off seaweeds, including turfs and holdfasts. The biotic composition of the infauna in soft sediment habitats was periodically surveyed by digging and sieving.

The distribution of macrohabitats, rocky substrates and distinctive macrocommunities and key organisms was plotted on maps in the field and later traced onto a digital map. This map was later transferred onto GIS software by ARC staff and is published at the end of this report.

3.2 Biodiversity and Specimens

Recent scientific name changes of the more common intertidal species are listed in Appendix 2.

A list of 508 species recorded from the intertidal coast of the Tamaki Estuary and its entrance is presented in Appendix 3. The list is almost entirely based on the results of this survey, but some additional historical records of rarer species have been added from publications, from earlier observations of one of us (MSM), and from specimens lodged in the Auckland War Memorial Museum collections (Marine and Botany Departments). Preserved reference specimens of most recorded invertebrate taxa have been placed in the collections of the Marine Department, Auckland War Memorial Museum, and dried reference specimens of many seaweeds have been placed in the herbarium of the Botany Department of the Auckland War Memorial Museum.

This species list is not exhaustive and is clearly weak in some areas, such as polychaete worms, sponges, and intertidal fish. There has been no attempt to collect and systematically identify a number of groups of smaller organisms, such as amphipods, isopods, ostracods, bryozoa, foraminifera or marine microalgae. The present list is most complete in groups such as molluscs, seaweeds and echinoderms. A comprehensive species list is likely to result in a census of nearly 800 species.

4 Intertidal Habitats and Communities

4.1 Salt Marsh and Salt Meadow

Minor areas of salt marsh occur around the fringes of the Tamaki Estuary, between Curlew Bay and Tahuna Torea. Low growing, higher tidal salt meadow is best developed in a small area on the landward north side of Tahuna Torea. This salt meadow is primarily composed of patches of white-flowering sea primrose *Samolus repens* and saltwort *Sarcocornia australis*, and less commonly yellow-flowering Bachelor's button *Cotula coronopifolia*.

The salt marsh, which is best developed at the head of Wakaaranga Creek, is dominated by a mix of the rushes, oioi *Leptocarpus similis*, wiwi *Juncus maritimus* and giant umbrella sedge *Cyperus ustulatus*, and on slightly higher ground they are joined by saltmarsh ribbonwood *Plagianthus divaricatus* and pohuehue *Muehlenbeckia complexa*. Older ribbonwood branches often have a thick covering of fruticose lichens, especially *Ramalina celasteri* and yellow-grey *Teloschistes*. Around the roots of the rushes are found the mudsnail Amphibola crenata, the small banded ear shell *Ophicardelus costellaris*, tiny snail *Potamopyrgus estuarinus*, and sometimes dark mats of the seaweed *Gigartina chapmani*.

4.2 Mangrove Forest

Mangrove forest thickly lines the banks of the upper reaches of the Tamaki Estuary, including Pakuranga, Otara and Otahuhu. In the middle reaches the mangroves become more patchy and decrease in abundance towards the mouth, with the largest patches in the sheltered bays, like Wakaaranga or Omaru, or inside the spits of Tahuna Torea.

Older mangrove plants have a wide variety of lichens growing on their trunks and larger branches. In shade or partial shade the lichens are dominantly foliose. In less dense shade, fruticose lichens such as old man's beard *Usnea* and *Ramalina*, are more common. Growing on the pneumatophores or lower trunks of the mangroves are patches of the soft, dark alga *Catenella nipae*.

The small acorn barnacle *Austrominius modestus* grows on some of the pneumatophores, lower branches and leaves of the mangroves. The small flea mussel *Xenostrobus pulex* and the Pacific oyster grow in clumps on *pneumatophores* and lower trunks. Living in the mud beneath the mangroves are mud crabs *Helice crassa*, numerous mud snails *Amphibola crenata*, horn shells *Zeacumantus lutulentus*, and around mean high water level with freshwater seepage, the small snail *Potamopyrgus estuarinus*. The associated fauna in this habitat in the Tamaki Estuary appears to be less diverse than that recorded from similar mangrove forest around the middle Waitemata Harbour (Hayward et al., 1999).

4.3 Seagrass Meadows

Only one large area of bright green sea grass meadow of *Zostera muelleri* occurs in Tamaki Estuary and this covers most of the area of low tidal sand flats along a 1 km stretch of Karaka Bay. This sward has developed from small scattered patches which first reappeared at Karaka Bay in 1995, after their die off 30-40 years earlier (see section 6.3). Other small patches occur between reefs outside the estuary entrance and off Tahuna Torea. At Karaka Bay the *Zostera* is peppered with bright orange-pink specimens of the fenestrate sponge *Polymastia granulate*.

4.4 Sublittoral Seaweed Fringe

A 1-5 m wide fringe of large brown seaweeds is prominent around the low tide mark where there is a hard rocky or bouldery substrate on either side of the entrance to the Tamaki Estuary and extending a short distance into its outer parts. The innermost occurrence of these seaweeds occurs on the edge of a sandstone reef just south of Halfmoon Bay marina. This zone is composed of three prominent brown seaweeds, in order of decreasing abundance – *Sargassum sinclairii*, *Carpophyllum maschalocarpum*, and *Ecklonia radiata*.

4.5 Estuarine Mud

Beyond the seaward fringe of the mangroves in the upper and parts of the middle reaches of Tamaki Estuary, the tidal areas are dominantly unvegetated soft mud. This supports a low diversity biota dominated by three species of mud crab, *Helice crassa, Hemigrapsus crenulatus,* and *Macropthalmus hirtipes.* Grazing deposit-feeders on the surface are large numbers of mud snails *Amphibola crenata* in the high tidal zone and horn shells *Zeacumantus lutulentus* in the mid tidal zone. Numerous small bivalves *Theora lubrica* and the nut shell *Nucula hartvigiana* live in low tidal and subtidal mud. Around low tide transitory banks of soft mud have in places built up around colonies of the two small mussels *Musculista senhousia* and *Xenostrobus securis*.

4.6 Shelly Sand Flats

Wide intertidal flats in the middle and outer stretches of the Tamaki Estuary, mostly between the entrance and Panmure Bridge, are draped in muddy fine sand, often littered with the shells of dead cockles. This habitat also occurs in a few of the more wave- and current-swept locations above the Panmure Bridge (e.g. Pakuranga Creek entrance). These tidal sand flats have a rich and relatively diverse biota (Fig. 3) dominated by abundant, but small specimens of cockles *Austrovenus stutchburyi*, with common pipi *Paphies australis* where freshwater crosses the sand flats at Tahuna Torea Creek. Usually recognised by their distinctive bird's foot-like feeding traces on the surface are the multitudes of deep-burrowing wedge shells, *Macomona liliana*, in the mid tide regions.

Large numbers of topshells *Diloma subrostrata* are often attached to stones or dead shells on these mid tidal flats. Also commonly present are the predatory and scavenging whelks *Cominella adspersa* and *C. glandiformis*, the bubble shells *Bulla quoyii* and *Haminoea zelandiae*, cheeky burrowing crab *Macrophthalmus hirtipes*, and a wide diversity of burrowing *polychaetes*. Attached to cockle shells or rocks and partly buried in the intertidal sand are many small anemones *Anthopleura aureoradiata*. Sheltering and attached beneath dead cockle shells or small rocks on the tidal sand flats one often finds the green chiton *Chiton glaucus*, and the tiny limpet *Notoacmea helmsi* and *N. elongata*. Attached to the upper surface of shells, pebbles, wood or other debris are numerous Pacific oysters, *Crassostrea gigas*, and in the outer reaches of the estuary, the spiny tube worm *Spirobranchus cariniferus*.

At low and spring low tide levels on the muddy sand flats, the fauna is less abundant but quite diverse. Humps in the sand may be the shallow burrowing olive shell *Amalda australis*, or the circular imprint of the sand dollar *Fellaster zelandiae*. Living infaunally within the low tidal, and subtidal, sediment are numerous specimens of the small bivalves *Nucula hartvigiana* and *Theora lubrica*. Many of the low tide burrows openings belong to the shrimps *Alpheus novaezelandiae*, *Palaemon affinis*, and *Callianassa filholi*. Occasional large horse mussels *Atrina zelandica* have their tops sticking out of the sand at and below low tide level, with the largest population at Karaka Bay.

4.7 Shell Banks and Spits

A number of shell banks occur intertidally in the middle and outer parts of Tamaki Estuary. They are mostly composed of cockle shells that are concentrated into banks by the action of tidal currents and waves. Some occur in the middle of extensive intertidal sand flats, as off Wakaaranga Creek mouth and off Tahuna Torea. Some form spits attached to land and stretching partly across the mouths of small embayments (e.g., mouth of Wakaaranga Ck, Curlew Bay). By far the largest shell spit is the V-shaped complex forming Tahuna Torea, with the 1 km long spit extending almost right across the Tamaki Estuary to Bucklands Beach.

These relatively mobile shell banks and spits seldom support much intertidal life, unless they build up above mean high tide level and become colonised by salt-tolerant plants, such as Sarcocornia.

4.8 Rocky Shores Around the Tamaki Estuary Entrance

Inside and outside the entrance to Tamaki Estuary is bordered by high Waitemata Sandstone cliffs. The base of the cliffs and the rock platforms that extend seawards from them are colonised by a zoned succession of plants and animals from the narrow maritime zone down to low water spring level. Below the maritime zone is the splash zone of bare rock with small, blue-grey periwinkles *Austrolittorina antipodum* sheltering in cracks or other shady places. Around high tide level, there are sometimes a few, large, ribbed barnacles *Epopella plicata*, small patches of the black flea mussel *Xenostrobus pulex* (especially in the shade of large overhanging pohutukawa trees), and a few limpets of the species *Cellana ornata* and *Siphonaria australis*.

Organisms that are common and characteristic of the broad mid-tidal part of the sheltered rocky shores are the acorn barnacles *Austrominius modestus*, the barnacle-eating oyster borer *Haustrum scobina*, red seaweeds *Gelidium caulacantheum* and *Apophlaea sinclairii*, and the grazing herbivorous topshell *Melagraphia aethiops*, the leathery slug *Onchidella nigricans*, and snakeskin chiton *Sypharochiton pelliserpentis*.

In some places there is a patchy zone of the shelly tube worm *Spirobranchus cariniferus* just below mid tide level. The Pacific oyster *Crassostrea gigas* is widespread on the rocky shore at various levels between mid and low tide. Below mean low water neap level, large areas of rock, often in and around tidal pools, are covered in the pink, commonly stunted turf of *Corallina officinalis*, which is often discoloured with silt accumulation. Grazing on rock at this level are numerous cat's eye *Turbo smaragdus*, which also occur in large numbers grazing over the dominant, large brown, low tidal seaweeds *Carpophyllum maschalocarpum* and *Ecklonia radiata*. Below mean low tide level, sponges become moderately common, especially the spherical, brown *Aaptos tentum*, the orange golf ball sponge *Tethya aurantium*, orange *Cliona celata*, scarlet encrusting *Microciona coccinea*, and the yellow finger sponge.

4.9 Rock Retaining Walls

About 50% of the shoreline of Tamaki Estuary between the Highway 1 motorway and the entrance has been modified by the construction of retaining walls, mostly made from basalt blocks. These walls have been erected to stop the natural and human-induced high-tidal erosion of the low cliffs of soft Pleistocene rocks. Large stretches of coastline that have been most impacted are between Whakaaranga and Pakuranga Creeks on the east side, and between Point England and Otahuhu on the west side.

Dependent upon the tidal level at the foot of the wall, these rock walls are home to small periwinkles *Austrolittorina antipodum* above high tide, and at mid tide to large oysters *Crassostrea gigas* and sometimes the leathery, shell-less *Onchidella nigricans*. The black *nerita* snails, *Nerita atramentosa*, retreat into the spaces between the rocks when the tide goes out but come out to graze when covered by water at high tide. The rock retaining walls are also a popular home for rats, which require regular local council control programmes.

One unusual area of man-made retaining wall occurs within the high-tide zone on the west side of West Tamaki Head, where a rectangular area was enclosed by giant basalt and Coromandel granite boulders as the first stage of the aborted Browns Island sewage project in the late 1950s.

In addition to Pacific oysters, the basalt and concrete of the Otara Lake weir is richly colonised by estuarine flea mussels (*Xensotrobus securis*) and on the top of the weir beneath fast flowing water, specimens of the introduced barnacle *Balanus amphitrite*.

Wooden groynes at Tahuna Torea have *Ulva intestinalis* and *U. lactuca* growing together.

4.10 Microfauna of Seaweeds

Seaweeds in the subtidal fringe and low-tidal zones around the entrance to Tamaki Estuary are the habitat of numerous small crustaceans and molluscs. The small crustaceans (e.g. amphipods and isopods) were not identified in this study, but a diverse fauna of microgastropods was documented. Of these the most common are *Eatoniella limbata*, *Eatonina atomaria* and *Tubbreva exigua*. Other frequently encountered species were *Eatoniella lutea*, *E. olivacea, Zalipais lissa*, and the small bivalve *Neolepton antipodum*.

4.11 Microfauna Beneath Low Tide Rocks

In addition to the larger, more obvious organisms that live in the shelter beneath low-tidal rocks, there are also a number of microscopic gastropods that graze on the microalgae on the rocks' undersurface or live in the sand beneath. This fauna is mostly confined to the zone outside the mouth of the estuary and extending up into it as far as Tahuna Torea and Bucklands Beach. The most characteristic and common gastropods in this habitat are *Pisinna zosterophila*, *P. olivacea impressa* and *Anabathron hedleyi*.

4.12 Fauna of Oyster Clumps

Clumps of oysters provide sheltered crevices and nooks for a variety of associated organisms, particularly the small limpet *Notoacmea elongata*, small snail *Risellopsis varia*, leathery *Onchidella nigricans*, juvenile *Sypharochiton pelliserpentis*, isopods, small mussel *Xenostrobus pulex*, acorn barnacle *Austrominius modestus*, the marine spider *Desis marina*, and scale worm *Lepidonotus polychromus*. Dark mats of the seaweed *Gigartina chapmani* attach to the oyster clumps around mid tide level. Near Seaside Park, Otahuhu, oyster clumps supported populations of the Asian mussel *Musculista senhousia* and large *Diloma subrostrata*.

4.13 Subtidal Washup

A wide variety of shells are washed up the beaches and rocks in and around the entrance to the Tamaki Estuary. Many are cockles, pipis and speckled topshells *Melagraphia aethiops* and other species that live on the local intertidal beaches and rocks. Also washed up are many shells of species that live subtidally just offshore in the harbour, and their presence gives us an insight into these subtidal communities. These include the ostrich shells *Pelicaria vermis*, snails *Cominella quoyana*, and *Neoguraleus murdochi*, horse mussel *Atrina zelandica*, basket shell *Corbula zelandica*, biscuit shells *Dosina zelandica*, and *Dosinia subrosea*, *Leptomya retiaria*, box shell *Myadora striata*, oblong venus shell *Ruditapes largillierti*, morning star shell *Tawera spissa*, sunset shells *Gari stangeri* and *G. convexa*, scallop *Pecten novaezelandiae*, ribbed venus shell *Protothaca*

crassicosta, *Pleuromeris zelandica*, and small tusk shell *Antalis nana*. Also present are rare valves of the fragile bivalves *Soletellina nitida* and *S. siliquens*, and heart urchins *Echinocardium cordatum*.

5 Geographic Distribution Patterns

5.1 Cluster Analysis Methodology

Cluster analyses were undertaken to investigate whether the intertidal biota is randomly distributed around the coast of the Tamaki Estuary study area or whether it exhibits distinct geographic patterns. Our field survey methodology (see section 2.6) was designed to enable this kind of analysis. Species presence was recorded in each of 13 separate coastal sections, and each live species was allocated a qualitative assessment of abundance, which was converted to numbers for generation of a similarity matrix (abundant = 5, common = 4, frequent = 3, occasional = 2, rare = 1). Dead specimens were also recorded.

Four cluster analyses were run (Fig. 3):

a. Numerical conversions of abundance data on all live species recorded in our surveys (excluding birds, fish, maritime plants and lichens). Bray Curtis Similarity coefficient used as basis for clustering.

b. Presence/absence records of all biota recorded (live and dead, wash-up and in situ), excluding birds, fish, maritime plants and lichens. Jaccards Similarity coefficient used as basis for clustering.

c. Abundance records of all seaweeds recorded. Bray Curtis Simmilarity coefficient used as basis for clustering.

d. Abundance records of all live molluscs recorded. Bray Curtis Simmilarity coefficient used as basis for clustering.

Figure 3

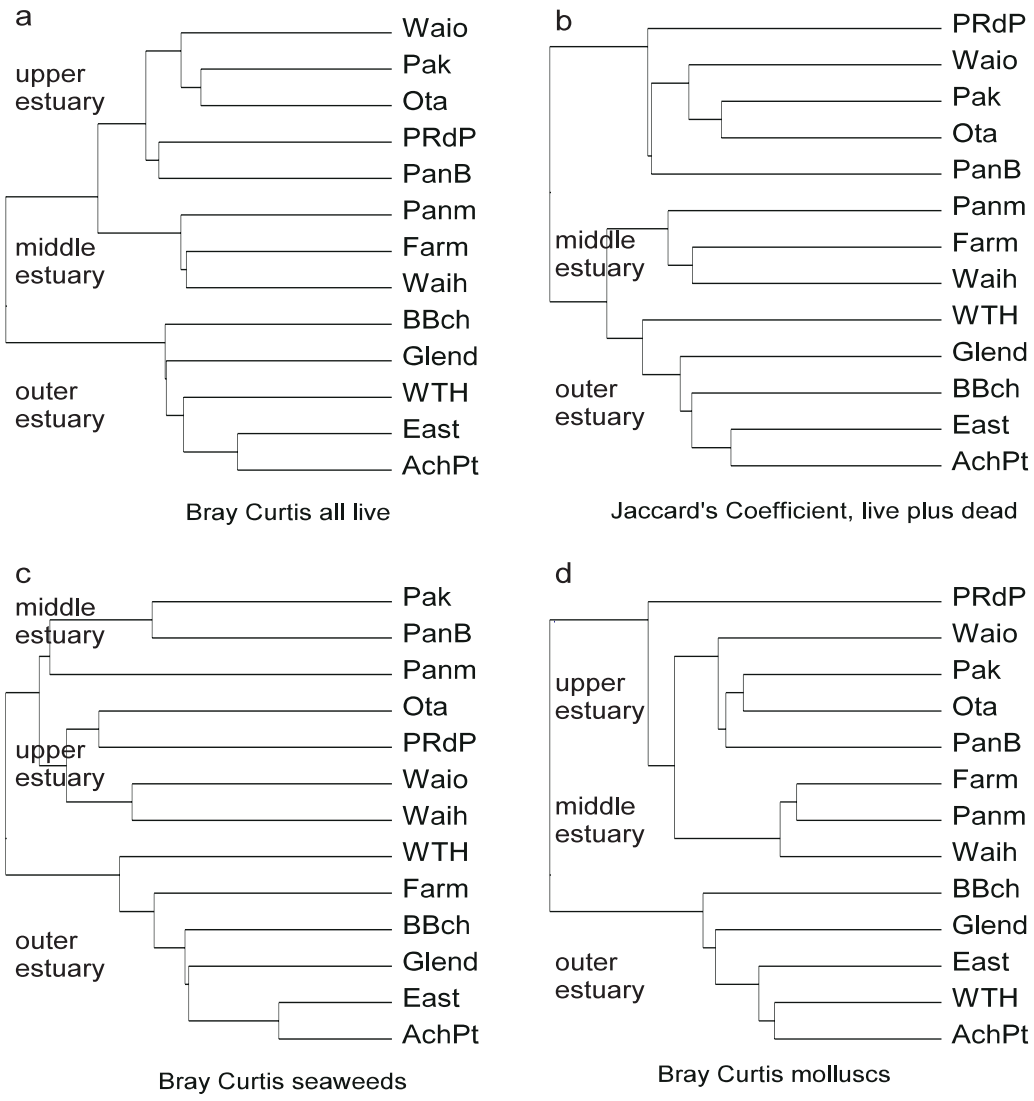
Cluster analysis dendrograms showing groupings of the different coastal localities based on four subsets of our intertidal biota data (Appendix 3):

a. Clusterings based on all records of live biota in this survey, using our qualitative abundance scale and Bray Curtis similarity coefficient;

b. Clusterings based on all records of live and dead biota, presence/absence data and Jaccards similarity coefficient;

c. Clusterings based on all records of seaweed, using our qualitative abundance scale and Bray Curtis similarity coefficient;

d. Clustering based on all records of live molluscs in this survey, using our qualitative abundance scale and Bray Curtis similarity coefficient.



5.2 Cluster Analysis Results

The two cluster analyses based on the abundance data of the live biota and presence/absence records of the live and dead biota produced three identical high level clusters (Fig. 3) – one comprised the five seaward localities (Achilles Pt, West Tamaki Head, Eastern Beach, Bucklands Beach, and Glendowie); another comprised three middle estuary localities (Farm Cove, Waihuna Bay and Panmure); and the third comprised five inner estuary localities (Panmure Basin, Panama Rd Peninsula, Otahuhu, Pakuranga Creek, and Waiouru Peninsula). The dividing lines between these three biogeographic regions are at Tahuna Torea – Half Moon Bay, and at Panmure Bridge (Fig. 4).

The cluster analysis based on the abundance of live molluscs produced almost the same three high level clusters (Fig. 3), except that the Panama Rd Peninsula locality is more of an outlier and does not cluster directly with the other upper estuary localities.

The cluster analysis based on the abundance of seaweeds produced three slightly different high level clusters (Figs. 3, 4) – the seaward cluster additionally includes the Farm Cove section on the east side of the estuary; Waihuna Bay clusters with the upper estuary localities; and a new middle estuary cluster is formed by Panmure, Panmure Basin and Pakuranga Creek.

Figure 4

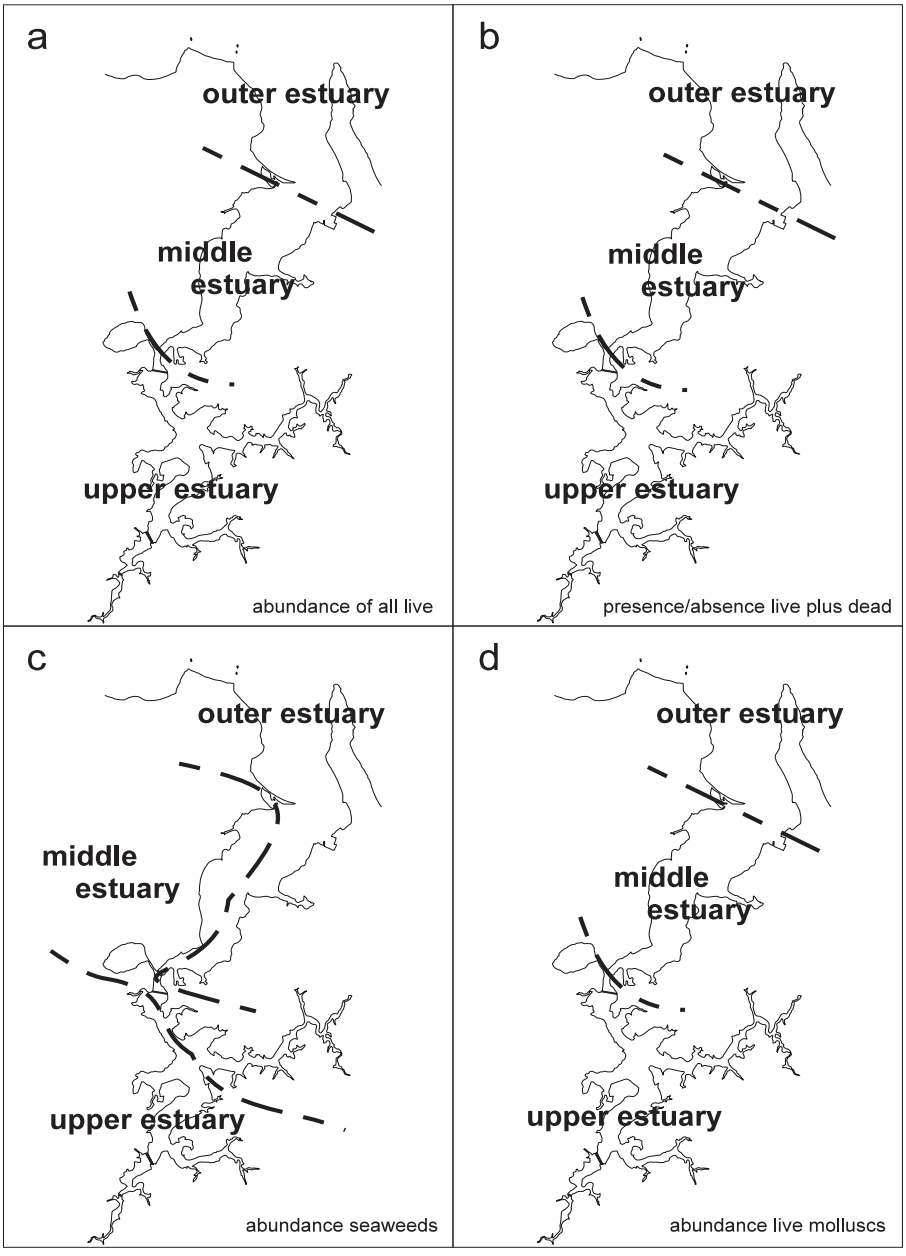
Geographic distribution of the groups identified by cluster analyses (Fig. 3):

a. Clusterings based on all records of live biota in this survey, using our qualitative abundance scale and Bray Curtis similarity coefficient;

b. Clusterings based on all records of live and dead biota, presence/absence data and Jaccards similarity coefficient;

c. Clusterings based on all records of seaweed, using our qualitative abundance scale and Bray Curtis similarity coefficient;

d. Clustering based on all records of live molluscs in this survey, using our qualitative abundance scale and Bray Curtis similarity coefficient.



5.2.1 Outer Estuary Region

The diverse biota of the region around the mouth of Tamaki Estuary living on intertidal rocks and sand is dominated by the topshell *Melagraphia aethiops*, cat's eye *Turbo smaragda*, Pacific oyster *Crassostrea gigas*, half crab *Petrolisthes elongatus*, acorn barnacle *Austrominius modestus*, tube worm *Spirobranchus cariniferus*, and seaweeds *Carpophyllum maschalocarpum*, *Corallina* turf, *Hormosira banksii*, and *Sargassum sinclairii*. Other species that are frequent and characteristic of this region include: chitons *Ischnochiton maorianus*, *Cryptoconchus porosus*, and *Sypharochiton pelliserpentis*, snails *Haustrum scobina*, *Maoricrypta*, and *Sigapatella*, yellow sea slug *Dendrodoris citrina*, bivalves *Perna canaliculus*, *Xenostrobus pulex*, starfish *Coscinasterias muricata* and *Patiriella regularis*, crabs *Cyclograpsus lavauxi*, *Pagurus novaezelandiae*, sponge *Aaptos tentum* and *Tethya aurantium*, sea squirts *Corella eumyota*, orange *Cnemidocarpa biconuata*, and spiny *Styela clavata*, and seaweeds *Codium fragile*, *C. convolutum*, and *Ecklonia radiata*.

5.2.2 Middle Estuary Region

The biota of the middle estuary is dominated by the epifaunal snails *Zeacumantus lutulentus, Amphibola crenata, Cominella glandiformis, Diloma subrostrata, Micrelenchus huttonii,* bubble shells *Haminoea zelandiae*, the tiny limpet *Notoacmea elongata*, the bivalves *Austrovenus stutchburyi, Nucula hartvigiana, Macomona liliana* and the Asian date mussel *Musculista senhousia*, three mudcrabs Helice crassa, *Hemigrapsus crenulatus*, and *Macrophthalmus hirtipes*, snapping shrimp *Alpheus novaezelandiae,* tube worm *Spirobranchus cariniferus*, acorn barnacle *Austrominius modestus*, and anemone *Anthopleura aureoradiata*.

5.2.3 Inner Estuary Region

The biota of this region is dominated by mangroves and their epiphytic acorn barnacles *Austrominius modestus* and small brown algae *Gigartina chapmanii* and *Catenella nipae*, high tidal mud snails *Amphibola crenata*, the leathery slug *Onchidella nigricans*, epifaunal snails *Cominella glandiformis*, *Diloma subrostrata*, and horn shell *Zeacumantus lutulentus*, Pacific oysters *Crassostrea gigas*, cockles *Austrovenus stutchburyi,* and three mudcrabs *Helice crassa*, *Hemigrapsus crenulatus*, and *Macrophthalmus hirtipes*.

5.3 Species Diversity Patterns

One of the major reasons behind the cluster analyses results is the dramatic trend of decreasing species diversity from around the mouth of Tamaki Estuary and passing up to its upper reaches (Fig. 5). The five outer estuary localities all have records of more than 118 live species, >120 live plus dead species, >15 species of seaweed, and >53 species of live molluscs. The Bucklands Beach locality, extending north to the tip of Musick Pt, has the largest number of recorded total live, live plus dead, and live mollusc species.

This is partly influenced by the much higher intensity of survey it has received in recent years by MSM (Morley, 2002), but the greater diversity here is probably real and reflects the greater diversity of habitats present.

The middle estuary group of three localities has intermediate levels of diversity, with 50-100 live species, 65-125 live plus dead species, 5-17 species of seaweed, and 25-50 species of live molluscs (Fig. 5). The five upper estuary localities have just 29-43 live species each, 35-48 live plus dead species, just 2-6 seaweed species, and 15-25 species of live molluscs (Fig. 5).

Figure 5

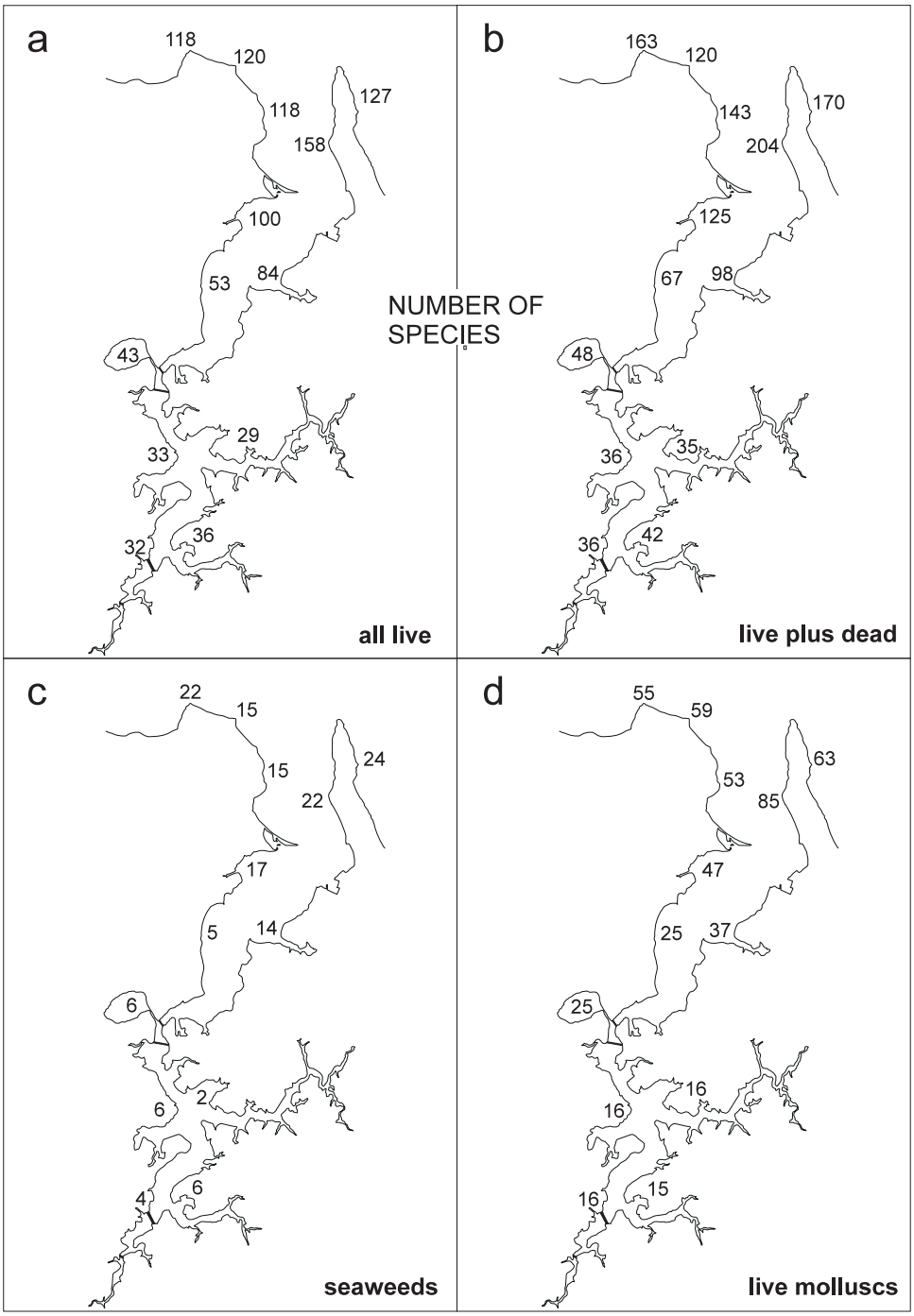
Species diversity in each area (Appendix 3) of Tamaki Estuary for:

a. Number of live species, other than vascular plants, lichens, fish, birds and mammals;

b. Number of all live and dead species, other than vascular plants, lichens, fish, birds and mammals;

c. Number of species of seaweed;

d. Number of species of live molluscs.



5.4 Geographic Distribution of Species Around the Tamaki Estuary

Some species occur around the entire coast of the Tamaki Estuary (e.g. Pacific oysters *Crassostrea gigas*, acorn barnacle *Austrominius modestus*, half-crab *Petrolisthes elongatus*, leathery slug *Onchidella nigricans*), but many have more limited geographic distributions (rather than habitat or substrate), mostly influenced by their distance from the open harbour. As shown by the cluster analyses, the major biotic divisions reflect the distance up the estuary away from the cleaner water, less muddy substrates and more exposed, rocky habitats.

Examples of some of the various distribution patterns are shown by selections of chitons (Fig. 6), gastropods (Fig. 7), bivalves (Fig. 8), echinoderms (Fig. 9), crabs (Fig. 10), barnacles (Fig. 11), anemones, worms, sponges and sea squirts (Fig. 12) and seaweeds (Fig. 13).

Figure 6

Geographic distribution of a selection of chitons in the Tamaki Estuary.

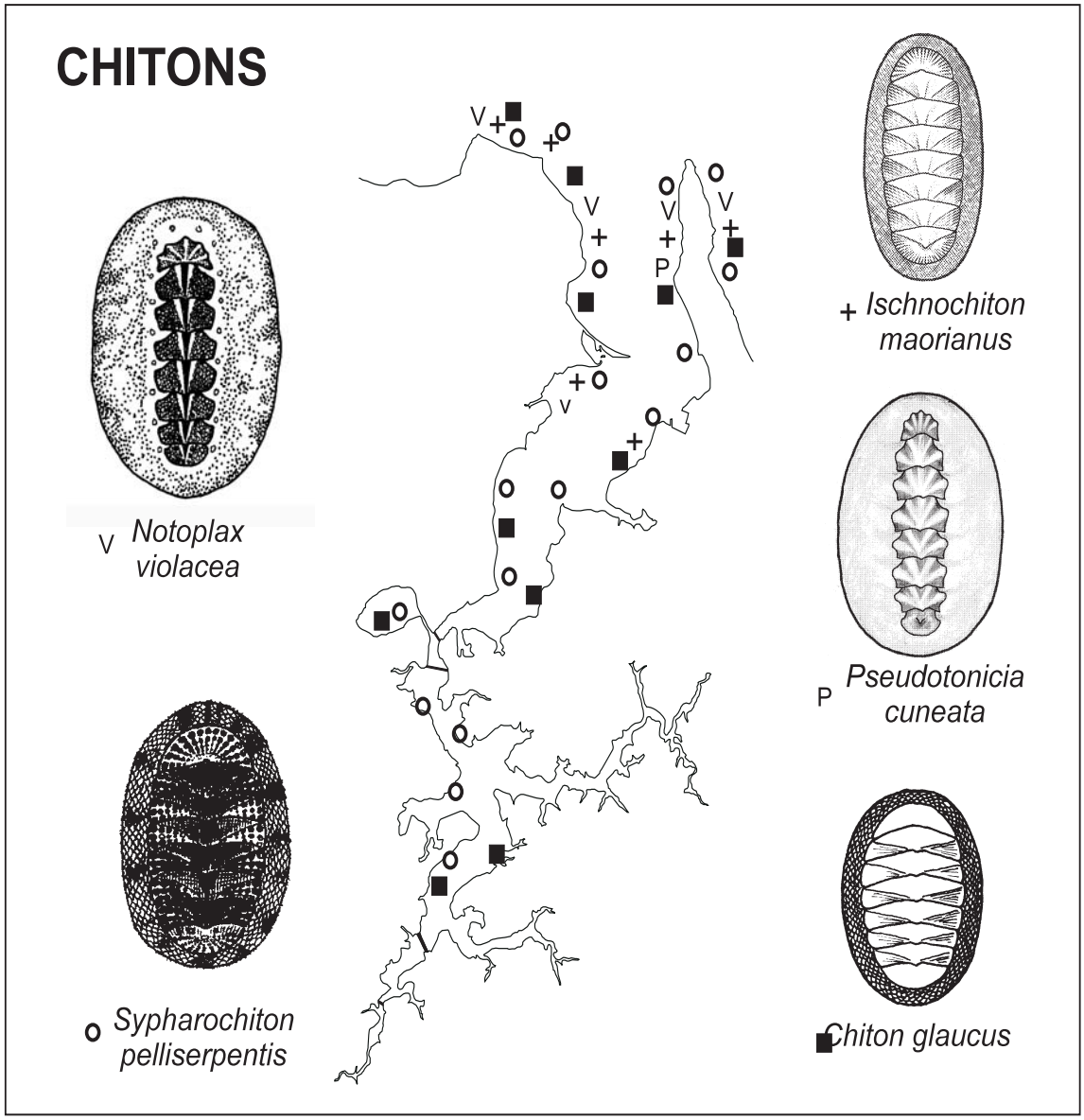


Figure 7

Geographic distribution of a selection of gastropods in the Tamaki Estuary.

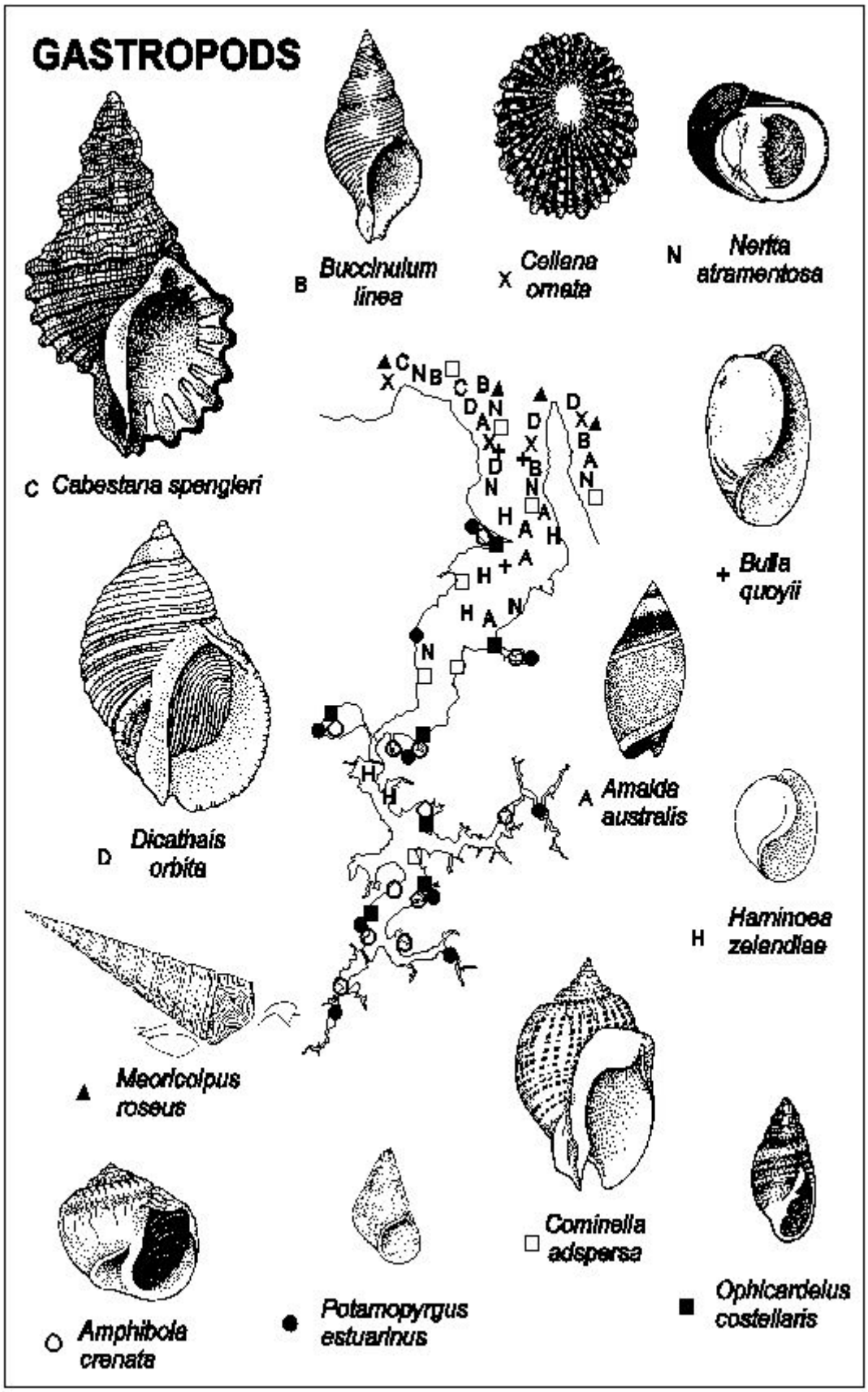


Figure 8

Geographic distribution of a selection of bivalves in the Tamaki Estuary.

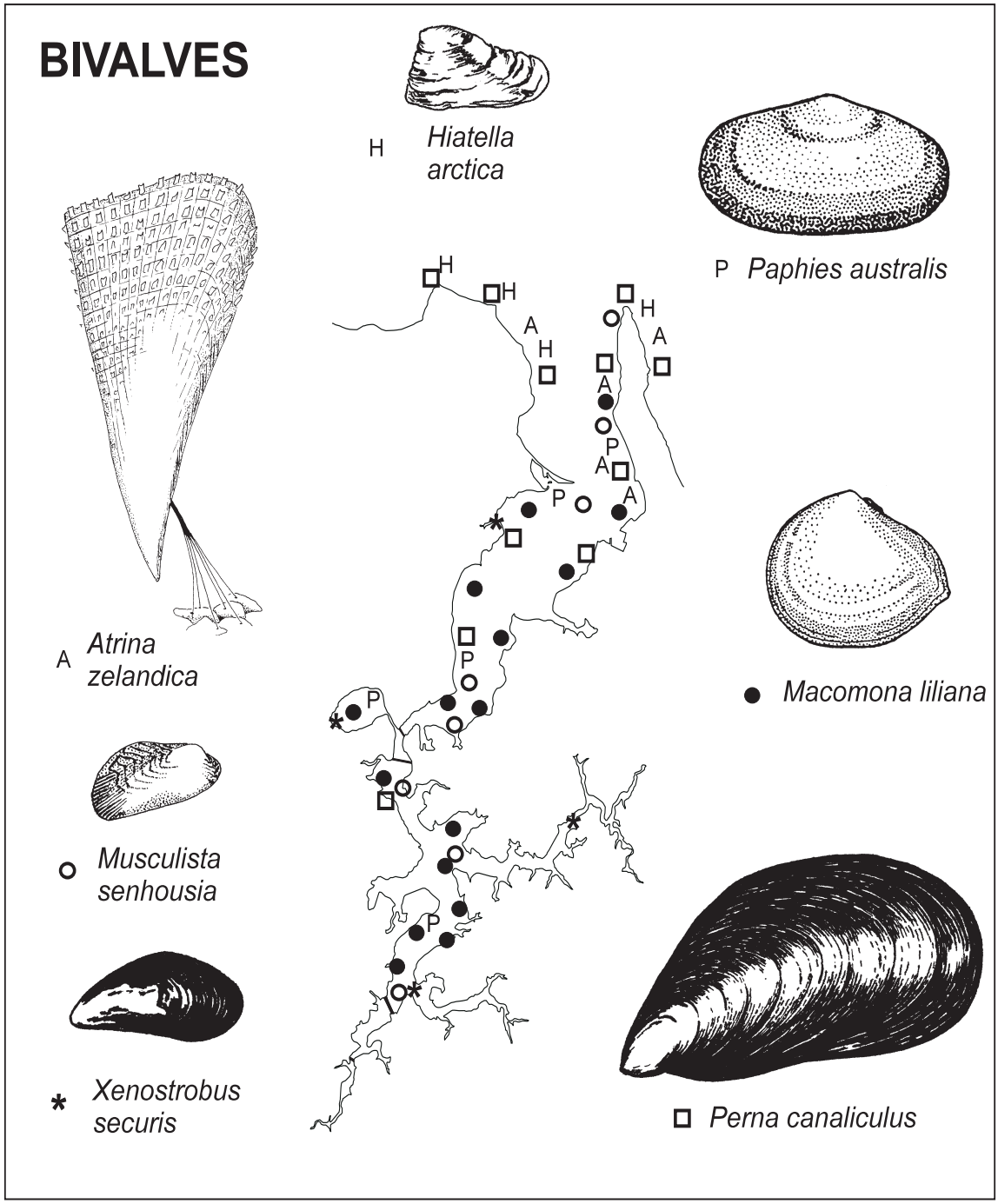


Fig. 8

Figure 9

Geographic distribution of a selection of echinoderms in the Tamaki Estuary.

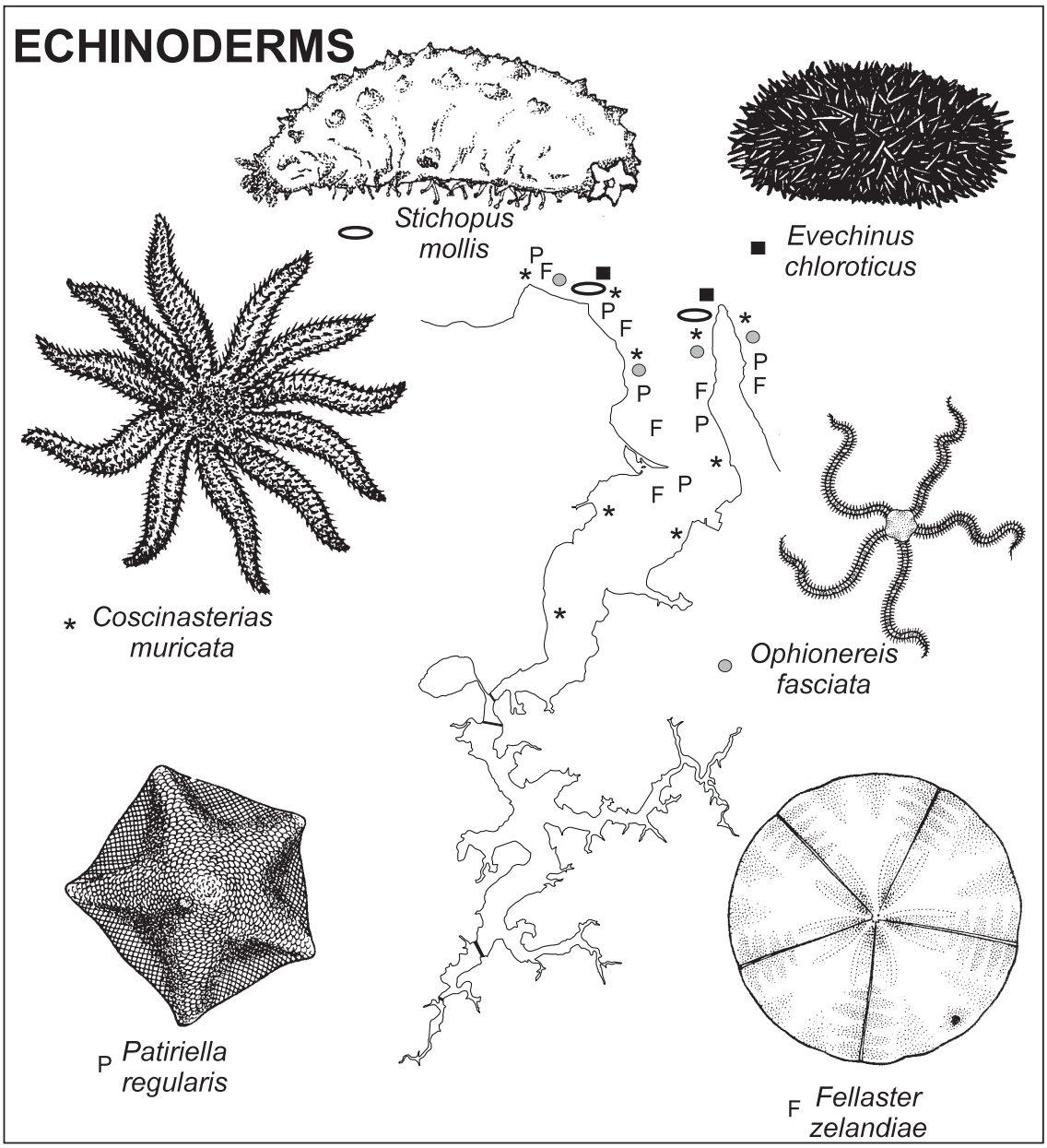


Figure 10

Geographic distribution of a selection of crabs in the Tamaki Estuary.

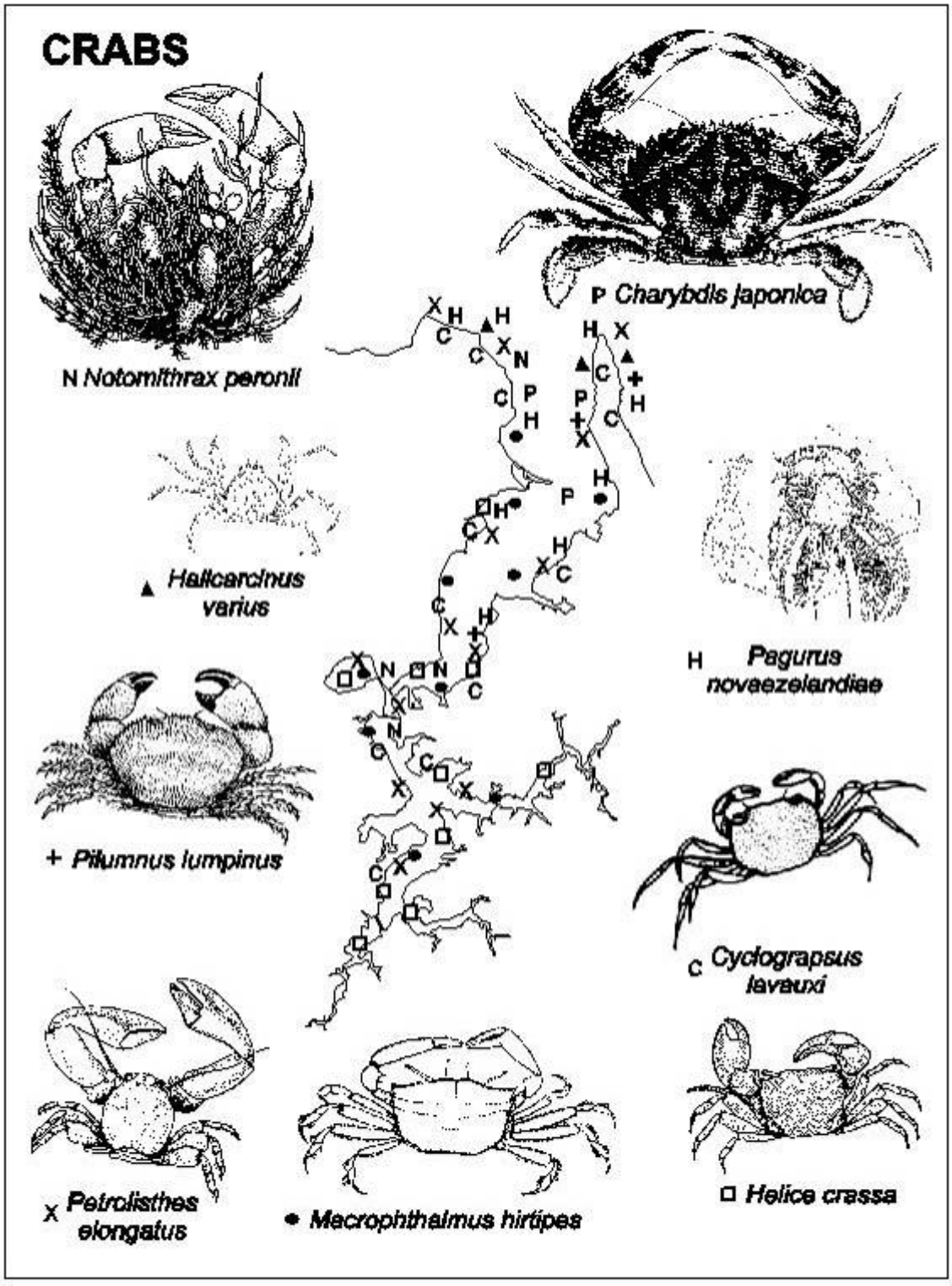


Figure 11

Geographic distribution of a selection of barnacles in the Tamaki Estuary.

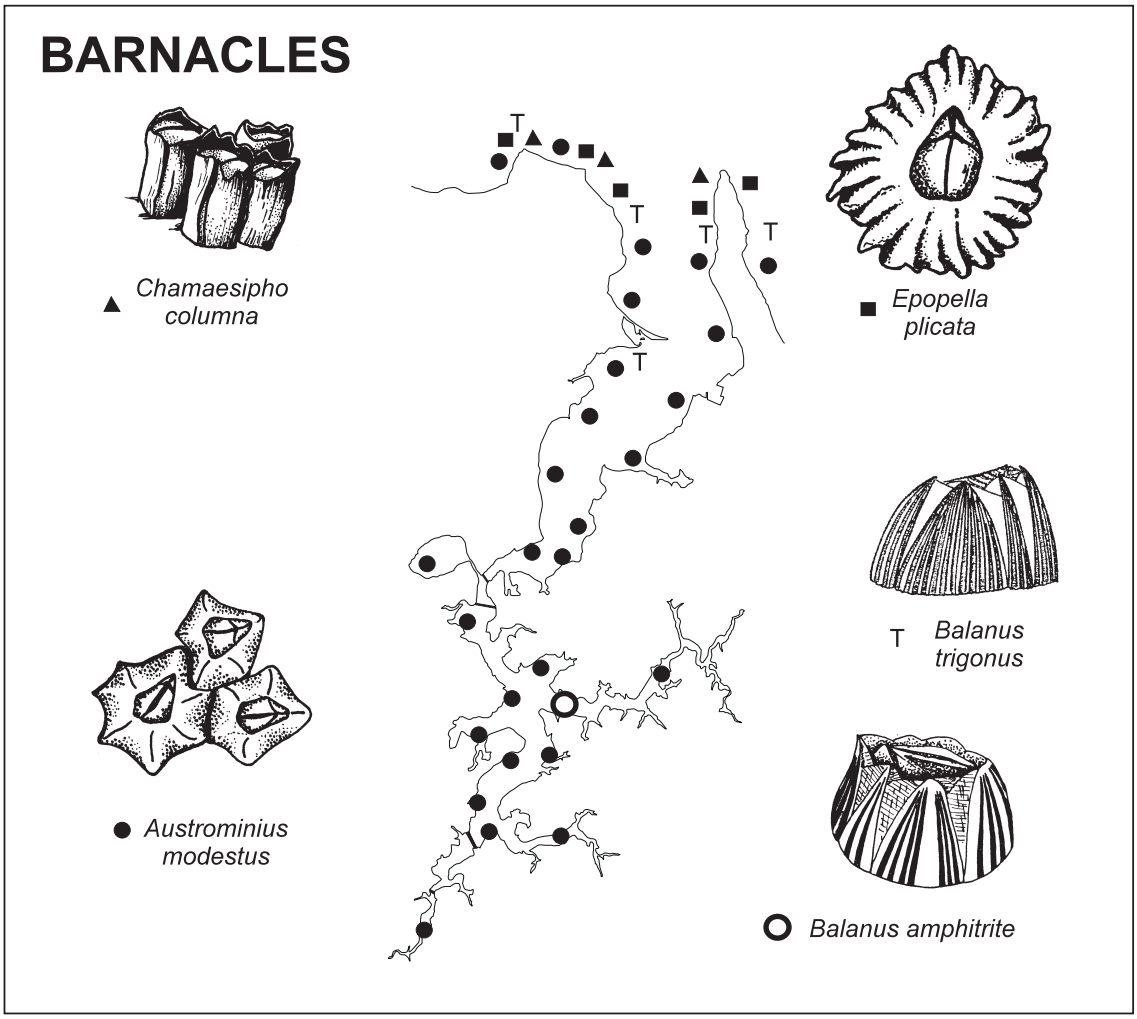


Figure 12

Geographic distribution of a selection of anemones, worms, sponges and sea squirts in the Tamaki Estuary.

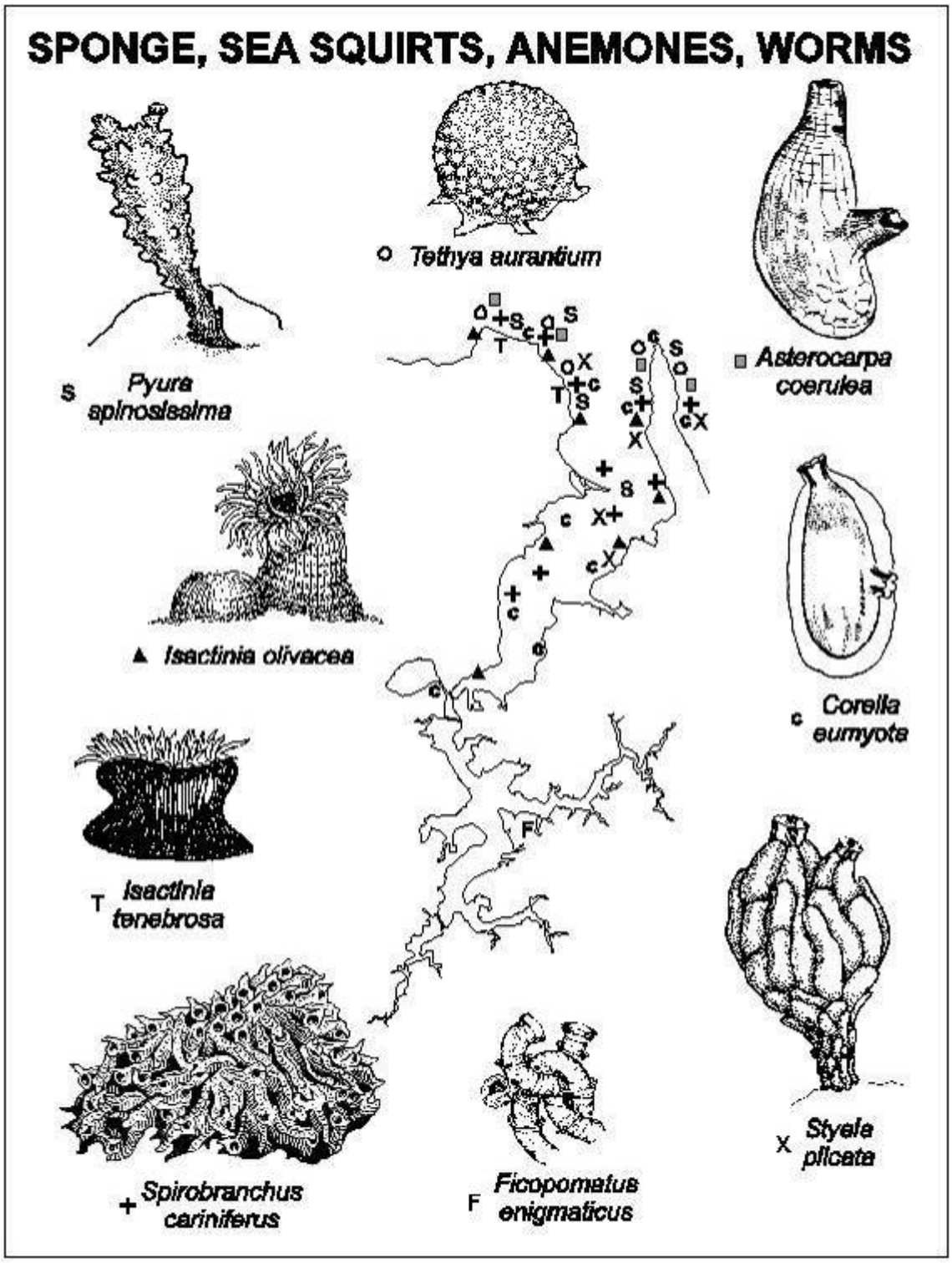
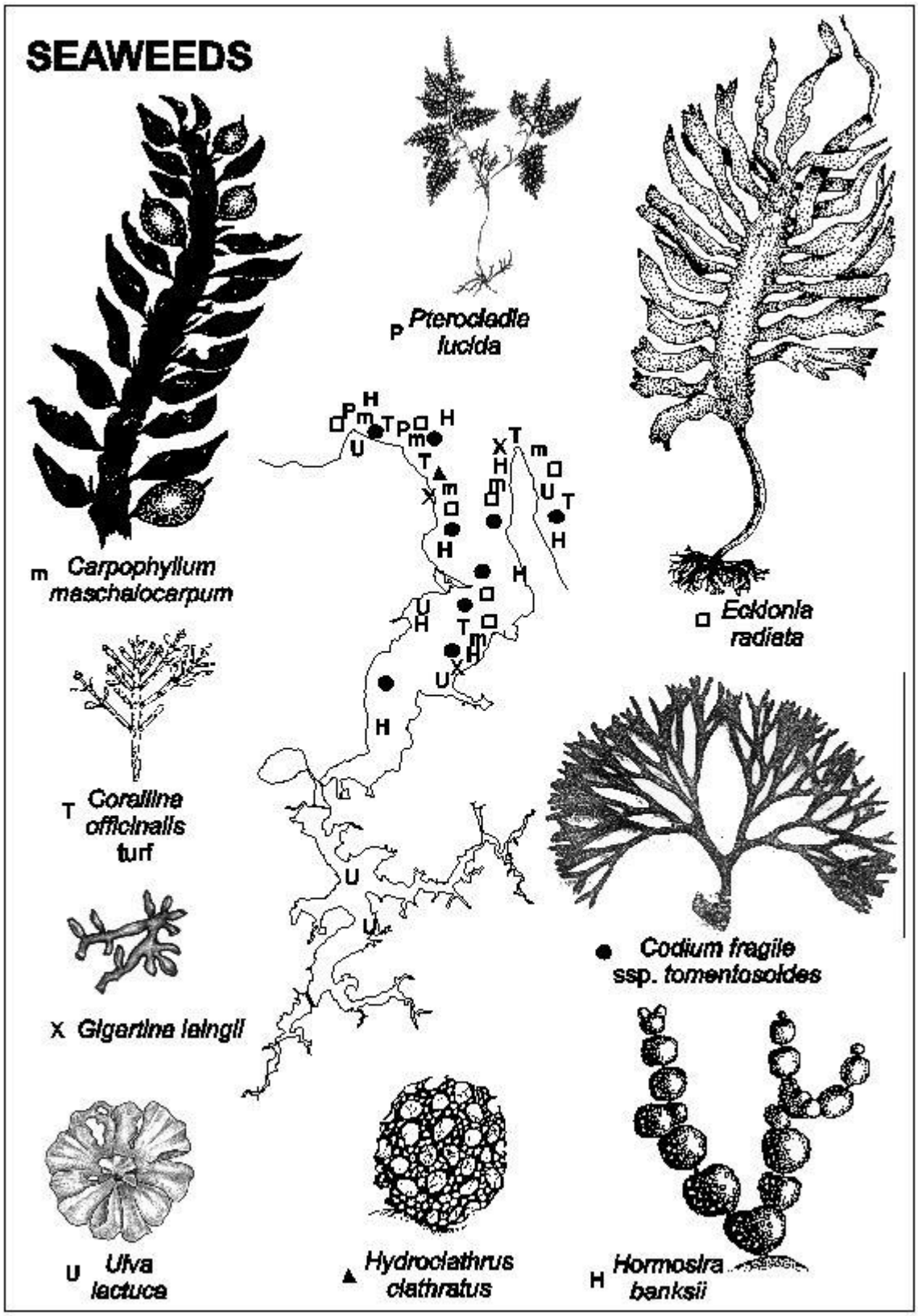


Figure 13

Geographic distribution of a selection of seaweeds in the Tamaki Estuary.



6 Noteworthy Occurrences

This section describes the occurrences of some of the rarer or more interesting species noted during this study.

6.1 Chitons (Fig. 14):

Acanthochitona violacea – This large colourful chiton with a wide girdle occurs sporadically beneath low tidal rocks on either side of the outer part of the estuary and on the coasts outside.

Pseudotonicia cuneata – This chiton has been recorded only rarely at Bucklands Beach (1950s, 2003 and 2004). It used to be considered a rare chiton until it was found to live in soft sediment.

6.2 Snails (Fig. 14):

Alcithoe arabica – The abundance of dead shells of this volute throughout the outer part of the estuary testify to their former abundance. It is known to be susceptible to TBT poisoning and this may partly explain its current rareness, with live specimens only seen burrowing through the surface of low tide sand at both ends of Bucklands Beach. Several specimens have been found eating pipi.

Austrolittorina cincta – This species of large brown periwinkle mostly occurs on more exposed, mostly west coast shores, but was recorded in this study from one place in Waihuna Bay, near Pt England.

Bulla quoyii – Live specimens of this large brown bubble shell were only seen around the Zostera sea grass at Karaka Bay and in filamentous cyanobacteria on the west side of Musick Pt. Its distinctive ovoid spawn was noted north of Pt England in November 2002.

Bursatella leachii – this sea hare was seen in good numbers along the east side of Musick Pt, along the Karaka Bay coast and around the end of Tahuna Torea spit.

Cabestana spengleri – The only records of this large carnivorous snail were rare specimens on the low tide at Achilles Pt reef and two specimens at Karaka Bay.

Cominella glandiformis – a dead sinistral[1] specimen was found at Farm Cove in 1993.

Haminoea zelandiae – Numerous specimens of this fragile bubble shell live on muddy fine sand at low tide in the middle reaches of the estuary, as far up as the mouth of Pakuranga Creek, but especially towards the end of the sand flats that extend into the estuary from Tahuna Torea and Wakaaranga Creek. The speckled grey animal shows through the translucent shell creating camouflage such that they are often first detected by the presence of distinctive, sausage-shaped, white spawn masses in surface pools of water.

[1] A sinistral gastropod shell with the apex upward has it's aperture to the left when facing the observer

Pelicaria vermis – The only place where live specimens of the ostrich foot shell was seen was in soft fine sand at low water spring on the south side of the tip of Tahuna Torea. They were formally present in the 1990s in low numbers at Bucklands Beach.

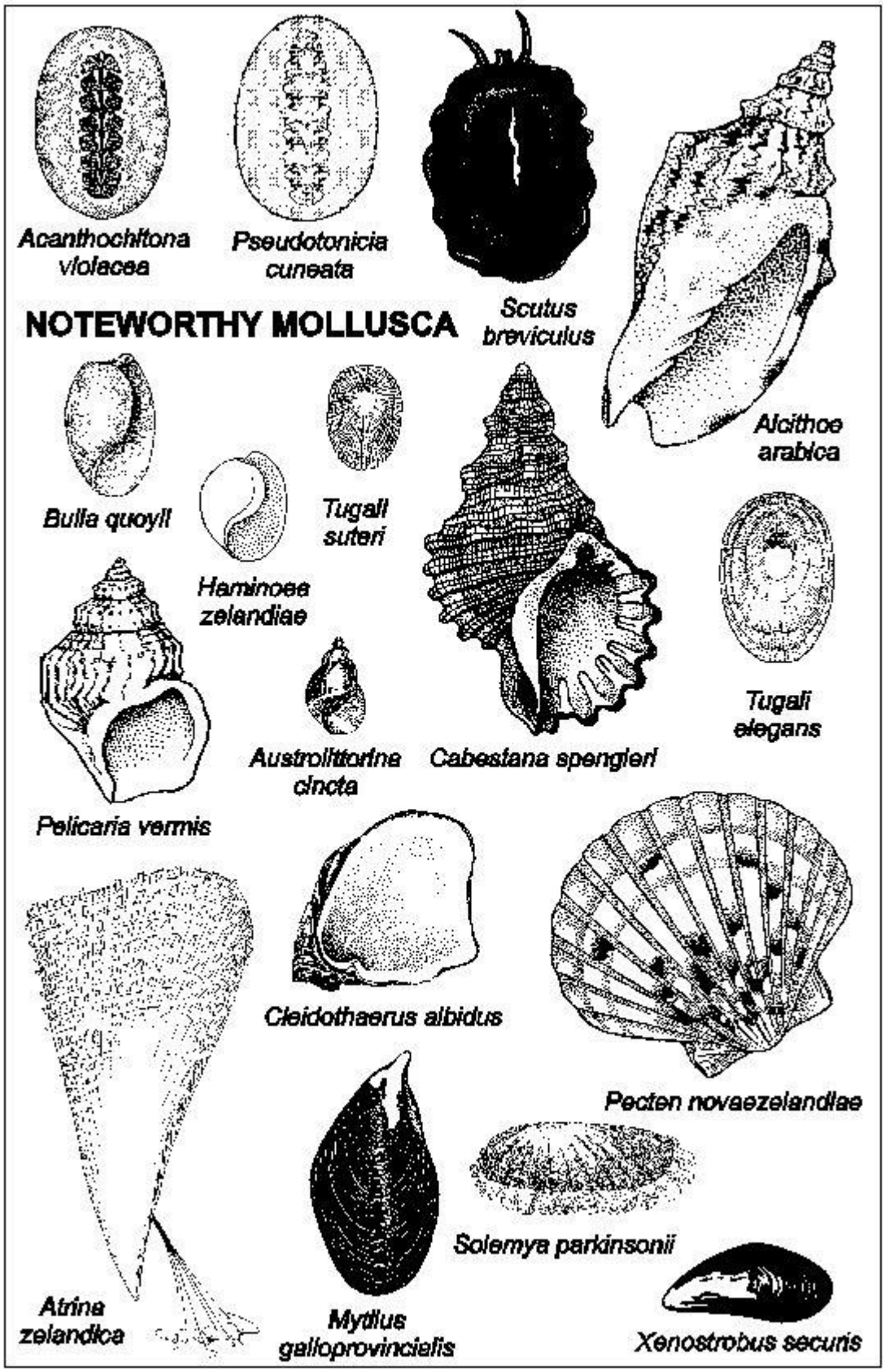
Pleurobranchaea maculata – this large slug-like creature occurred sporadically along the coast on both sides of the estuary mouth, seaward of Tahuna Torea. Large numbers were present at Bucklands Beach in 2002.

Scutus breviculus – This, large, black, slug-like shield shell mollusc was only seen outside the entrance to Tamaki Estuary under low tide rocks at West Tamaki Head and Achilles Pt.

Tugali elegans and *T. suteri* – These two, somewhat uncommon but distinctive slit limpets were found only rarely in the study area, always sheltering under low tide rocks. The former was found in several places along the West Tamaki Head-Achilles Pt coast and the latter only on the west side of Musick Pt.

Figure 14

Noteworthy molluscs of Tamaki Estuary and its entrance.



6.3 Sea slugs, nudibranchs (Fig. 15):

Twelve species of these distinctive and somewhat rare and always beautiful sea slugs were found during this study, most commonly just outside the Tamaki Estuary entrance but also up the estuary as far as Tahuna Torea and Half Moon Bay. These are:

Acanthodoris mollicella – one specimen from Karaka Bay coast and two specimens under low tide rocks at Eastern Beach., Feb 2005.

Alloiodoris lanuginata – one specimen from West Tamaki Head reef.

Berthella medietas – one specimen from Achilles Pt reef.

Berthella ornata – rare specimens from both sides of Musick Pt, Bucklands Beach yacht club reef and Achilles Pt. Neither of these two *Berthella* species were found in the Waitemata Harbour study (Hayward et al., 1999).

Dendrodoris citrina – the brightest-coloured (yellow-orange) and most common nudibranch, with several hundred seen on the coast just outside and in the entrance to Tamaki Estuary. It extends further up the estuary than any other seaslug, reaching Half Moon Bay and the tip of Tahuna Torea.

Dendrodoris denisoni – one beautiful speckled specimen was seen on sand in a tidal pool on the east side of Musick Pt. (Morley et al., 2001).

Dendrodoris nigra – one specimen found on the west side of Musick Pt.

Elysia maoria – the distinctive spiral spawn of this nudibranch was seen on *Codium convolutum* on the Bucklands Beach yacht club reef in spring 2003 and a live specimen recorded there in the 1990s.

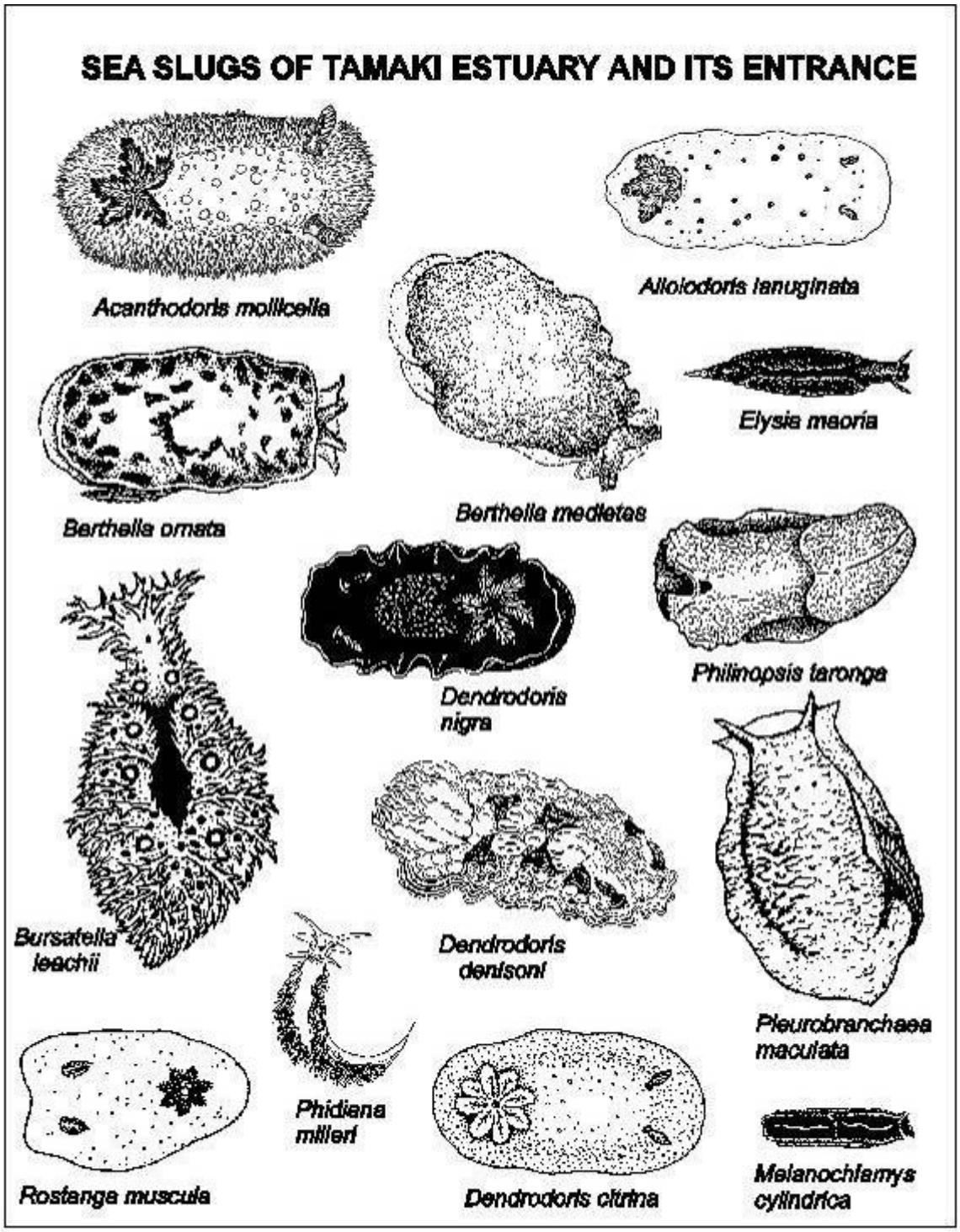
Melanochlamys cylindrica – a small black sea slug found on the west side of Musick Pt, the tip of Tahuna Torea and at Karaka Bay and West Tamaki Head. The Tamaki Heads are the type locality for this slug originally named *Aglaja cylindrica* Cheeseman, 1881. The name has since been updated to *Melanochlamys cylindrica* (Spencer 2002).

Phidiana milleri – two specimens found on *Corallina* edge of channel at Grangers Point, Bucklands Beach in 1995.

Philinopsis taronga – one specimen found near Tahuna Torea preying on *Haminoea zelandiae*.

Rostanga muscula – rare specimens of this small red sea slug were found on both sides of Musick Pt and on the Karaka Bay coast.

Figure 15
Sea slugs of Tamaki Estuary and its entrance.



6.4 Bivalves (Fig. 14):

Atrina zealandica – A few live horse mussels were recorded at low tide level along the Karaka Bay coast, off Tahuna Torea spit and on both sides of Musick Pt down to the north end of Little Bucklands Beach.

Cleidothaerus albidus – Single specimens of this large encrusting bivalve were recorded from low tide reefs at Achilles Pt, West Tamaki Head and Musick Pt.

Mytilus galloprovincialis – The blue mussel is relatively rare around northern New Zealand. A few dead shells were recorded around Musick Pt and one live on West Tamaki Head reef.

Pecten novaezelandiae – Two live specimens were found at low tide at Bucklands Beach in 1991.

Solemya parkinsonii – One live specimen of this fragile-shelled bivalve was recorded from West Tamaki Pt.

Xenostrobus securis – This large estuarine flea mussel forms the densest beds known in Auckland on a reef of Parnell Grit located well up Pakuranga Creek. In many places these mussels attach inside and fill bore holes made by the isopod *Isocladus armatus*. *X. securis* also occurs in the tidal bed of the stream draining Van Dammes Lagoon as it enters Panmure Basin and another near Tahuna Torea.

6.5 Echinoderms (Fig. 16):

Evechinus chloroticus – Kina (the common green sea egg) is extremely rare in the study area with rare occurrences under low tidal rocks on both sides of the mouth of Tamaki Estuary.

Ophionereis fasciatus – This small striped brittle star is slightly more common than sea eggs and has been found on sand beneath low tide rocks from St Heliers to Karaka Bay and on either side of Musick Pt.

Stichopus mollis – This large sea cucumber is extremely rare in the study area with single records from either side of Tamaki Estuary mouth.

Fellaster zelandica – The sea biscuit lives buried shallowly in low tidal sand both outside Tamaki Estuary and inside its mouth as far up as Tahuna Torea and Bucklands Beach.

6.6 Coral (Fig. 16):

Culicia rubeola – This encrusting coral occurs under low-tidal ledges and rocks around the mouth of the estuary and near Omaru Creek inside the estuary.

6.7 Tubeworms (Fig. 16):

Spirobranchus cariniferus – This native spiny tube worm has declined in abundance in the Waitemata Harbour in recent decades (e.g. Hayward et al., 1999), but is still thriving in

places around the mouth of Tamaki Estuary, especially on the west side of Musick Pt where it even overgrows Pacific oysters.

6.8 Sea squirt (Fig. 16):

Styela plicata – This distinctive, white, apparently introduced sea-squirt is moderately common attached to low tide rocks on either side of Musick Pt and inside the entrance of Tamaki Estuary up as far as Tahuna Torea and just beyond at Half Moon Bay.

6.9 Seaweeds (Fig. 16):

Caulerpa geminata – This distinctive grape-like green alga occurs occasionally on low tide reefs from Achilles Pt to Karaka Bay.

Myriogloea intestinalis – The long slimy strands of this brown alga occurs seasonally in spring and summer on rocks just north of Pt England. This species is more commonly found on open coasts (Adams, 1994).

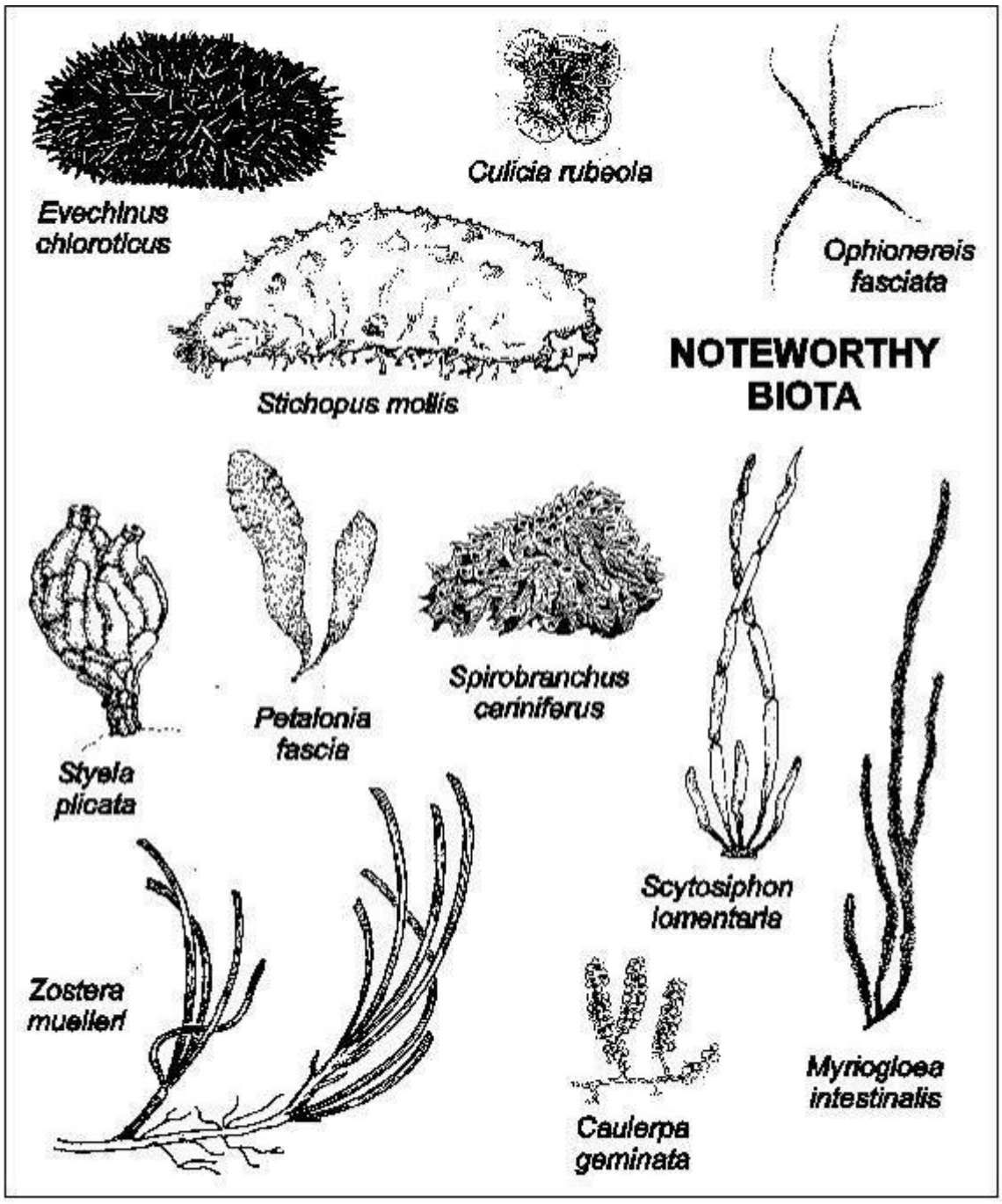
Petalonia fascia – This brown alga has only been recorded in this study on intertidal rocks on the west side of Musick Pt and up the estuary on the coast of Panama Rd peninsula.

Scytosiphon lomentaria – This branching brown alga was only recorded on intertidal rocks on the west side of Musick Pt.

Splachnidium rugosum – A few plants of this brown alga were seen growing in autumn and winter on low tide rocks at the end of Musick and Achilles Points.

Figure 16

Other noteworthy invertebrates and seaweeds of Tamaki Estuary and its entrance.



7 Human-Related Biotic and Other Changes

7.1 Introduced Species

Since Europeans arrived, approximately 70 marine species have been recorded as having been introduced to New Zealand waters and are now living and reproducing in the Waitemata Harbour (Hayward, 1997; Cranfield et al., 1998). A few of these have extended their range into the present study area. These include (Fig. 17):

Crassostrea gigas – Pacific oysters were first observed in Tamaki Estuary settling on *Musculista senhousia* debris at Farm Cove in March 1992. They are now well-established and widespread outside and inside the Tamaki Estuary, becoming less common in the higher reaches, where it still occurs colonising the pneumatophores and lower trunks of mangroves. On its own, this species has brought the largest changes to the intertidal biota of Tamaki Estuary – colonising large areas of previously clear sandstone reef and also in places forming growing patches of sharp oysters attached to shells on the mud flats.

Musculista senhousia – The small Asian date mussel has probably brought about the second largest changes to Tamaki Estuary in European times. Arriving in the Waitemata Harbour in the early 1980s, it was soon noticed to have established intertidal and low tidal colonies in Tamaki Estuary (Willan 1985, 1987, Morley 1988). Studies have shown that after settlement in high concentrations, byssal threads of these mussels trap sediment and can build up a raised mud bank around them. They usually live for 20-22 months and when they die, the mud bank often breaks up and washes away (Creese and Hooker, 1996; Creese et al., 1997). Sometimes the bank is repeatedly settled and it may exist for a number of years. During our study we mapped the present distribution of date mussel beds, with large mud banks on the spring low tidal edge of the channel near Otara Power Station, the junction of Pakuranga Creek, and extending north from Panmure Wharf. Smaller patches were mapped off Tahuna Torea, Bucklands Beach and Farm Cove. In 2003 small numbers of Asian date mussel were also found living among dense patches of *Xenostrobus pulex* on mid tidal sandstone reefs of Musick Pt. When patches of Asian mussels die, they attract large numbers of scavenging starfish *Patiriella*, and *Coscinasterias*, and even ducks.

Limaria orientalis – A few dead shells of the introduced file shell were found in the outer parts of the estuary, but live specimens were only seen at low tide level north of Pt England and in nests in mud at Bucklands Beach in August 2001.

Theora lubrica – This is a small, thin-shelled bivalve that arrived from east Asia in the 1970s (Climo, 1976). It occurs in vast numbers in low tidal and subtidal mud throughout much of the Waitemata Harbour (Hayward et al., 1997; 1999). In the Tamaki Estuary its range is limited to the central and outer parts, with its greatest abundance between Bucklands Beach and Panmure Bridge.

Charybdis japonica – This is a large, rather ferocious, swimming crab that arrived in the Waitemata Harbour in the late 1990s. In this study it has been encountered periodically

sheltering beneath low tidal rocks around the entrance to Tamaki Estuary, on the west side of Musick Pt, and between Tahuna Torea and Karaka Bay.

Balanus amphitrite – A few specimens of this large introduced barnacle live attached to the upper concrete surface of the Otara Lake weir where they are swept by fast-flowing water as it overflows out of the lake for 80 % of the time and by incoming marine waters for the remaining 20 % of the time.

Chaetopterus sp. – This parchment worm was first noticed around the Hauraki Gulf when it started turning up dead washed up in large numbers in 1997 (Acosta and Tricklebank, 2002). It is now established in large numbers subtidally and low tidally in a variety of habitats. It does not seem to like the turbid murky waters of Tamaki Estuary and only occurs in relatively low numbers at low tide outside and just inside the estuary mouth. Live specimens have not been recorded further up the estuary than Tahuna Torea.

Ficopomatus enigmaticus – This brackish water, brittle calcareous tube worm only occurs around the Otara Power Plant cooling water outflow into Otara Lake, where it was first reported in 1980s (Read and Gordon, 1991). This is still its only known occurrence in the Auckland region and only the second known occurrence in New Zealand waters (the other is Whangarei tidal basin).

Watersipora sp. – A number of introduced bryozoa have been recorded living around the Auckland wharves, many are not easily recognisable and the only introduced bryozoa recorded in this study is the distinctive *Watersipora*, which occurs only outside the mouth of the estuary at Achilles Pt.

Styela clavata – This distinctive, spiny, stalked sea squirt arrived in Waitemata Harbour about the time of this study and our records of it in August and September 2002 on low tide rocks at Musick Pt., Bucklands Beach, and Glendowie are the earliest known from New Zealand. It is now flourishing just above and below low tide on rocks and wharves throughout much of the inner Hauraki Gulf. It lives attached to low tidal rocks and occurs in moderately large numbers inside the entrance and outside, on both sides of Musick Pt and up the estuary as far as Tahuna Torea.

Codium fragile ssp. tomentosoides – This introduced green seaweed (Dromgoole, 1975) lives attached to low tidal and subtidal shells, pebbles and rocks, both outside the estuary and in its entrance and middle reaches about as far up as Panmure Bridge. Its greatest density is attached to shells in the strong currents on both sides of the tip of Tahuna Torea shell spit.

Colpomenia durvillaei – This introduced seaweed was rare on intertidal platforms from Bucklands Beach around Musick Pt to Eastern Beach.

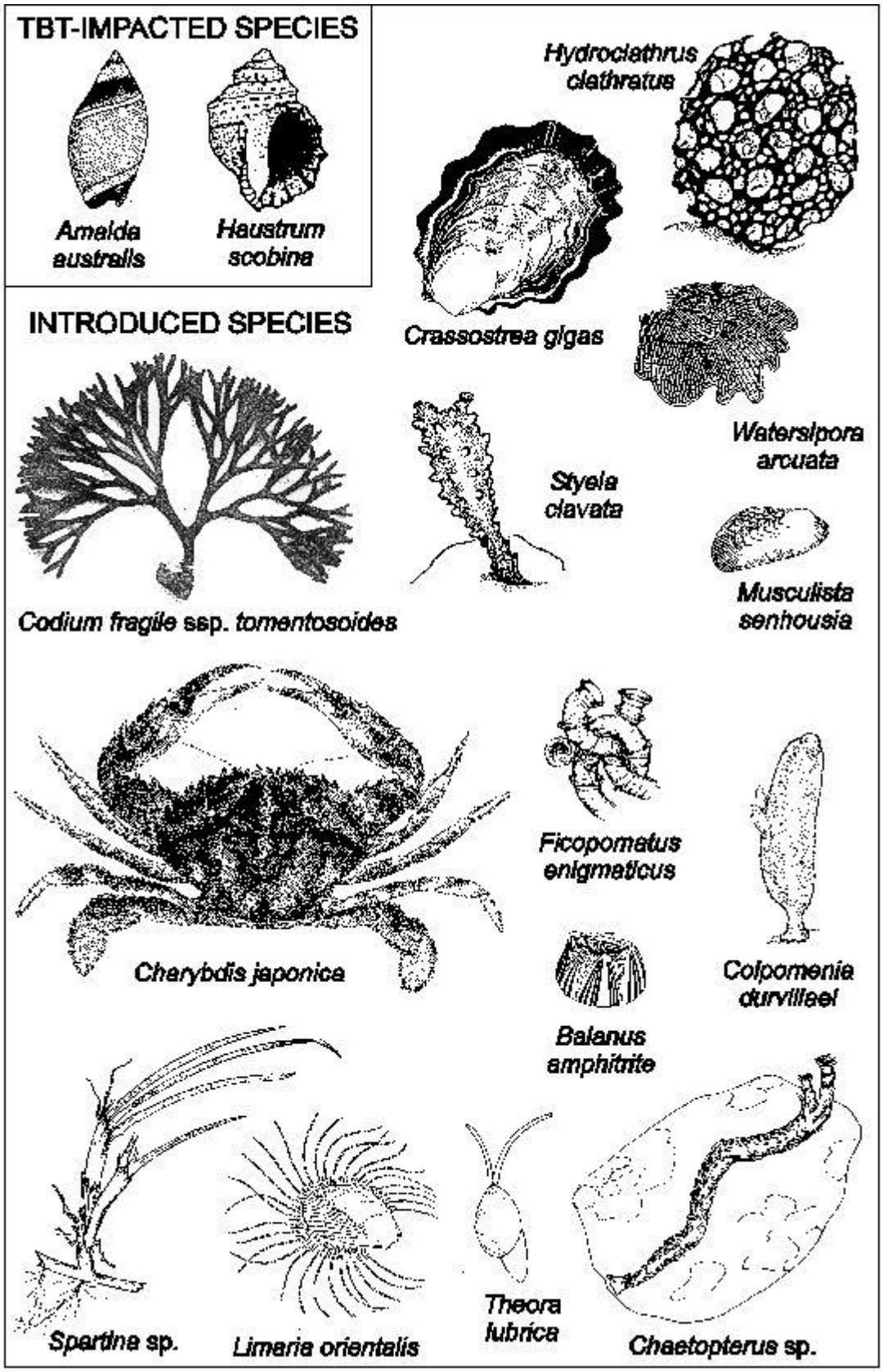
Hydroclathrus clathratus – This seaweed, first reported from the Waitemata Harbour in the 1970s by Dromgoole and Foster (1983) was recorded in this study from low tidal reefs near Karaka Bay and Bucklands Beach, 2001.

Spartina spp. – Three species of chord grass have been introduced deliberately to New Zealand to reclaim mudflats, but now they are recognised as an undesirable weed. The three species can only be distinguished on the basis of adult plants. Two small patches of juvenile Spartina were recorded during this study, near high tide level between Curlew Bay and Seaside Park.

Arenigobius bifrenatus – specimens of the Australian bridled goby were captured during studies in and around Otara Lake in the mid 1990s (Kingett Mitchell, 1996) and were the first records of this introduced species in the wild in New Zealand. Twelve species of these distinctive and somewhat rare and always beautiful sea slugs were found during this study, most commonly just outside the Tamaki Estuary entrance but also up the estuary as far as Tahuna

Figure 17

Introduced marine species now living in Tamaki Estuary and examples of molluscs devastated by TBT poisoning.



7.2 TBT Impacted Species

Poisoning by the anti-fouling paint tributyl tin (TBT) has been shown to produce imposex in many New Zealand neogastropods (Stewart et al., 1992) resulting in an inability to reproduce and the eventual death of the populations around major harbours. In the Tamaki Estuary TBT has probably impacted upon at least three species (Fig. 17):

Alcithoe arabica – Numerous large dead shells of this volute can be found in the outer part of Tamaki Estuary (beyond Farm Cove) and TBT and/or other causes may have all but killed them off. In recent years several live specimens have been monitored near Bucklands Beach (Morley, 2002).

Amalda australis – This olive shell was another gastropod hit hard by TBT, but we note returning numbers in low tidal sand habitats outside the estuary entrance and on the north side of Tahuna Torea spit.

Haustrum scobina – The oyster borer was possibly the most impacted by TBT around Auckland Harbour, where they used to live intertidally in vast numbers. In this study we note that their numbers are beginning to return outside the estuary and just inside the mouth. Still, however, no live specimens (although some dead) were observed upstream from Glendowie or Bucklands Beach.

7.3 Seagrass Disappearance and Return

There are historical reports of widespread *Zostera* in the Tamaki Estuary prior to its dramatic disappearance there and elsewhere in the Waitemata (Armiger, 1964). While this can largely be attributed to the Labyrinthula slime it is conceivable that pathogenic susceptibility is enhanced by unfavourable growth conditions such as increased sediment load (Department of Conservation 1988, unpublished notes). Small patches of *Zostera* returning at Karaka Bay and north of Tahuna Torea were mapped in August 1996 (Morley unpublished) and had grown much larger by the time of the present survey.

7.4 Decline in Mollusc Size

An unpublished study by MSM in 1987 compared the average size of the small ostrich foot *Pelicaria vermis*, cockle *Austrovenus stutchburyi* and pipi *Paphies australis* in the Tamaki Estuary with specimens from unpolluted beaches e.g. Oneroa, Waiheke Island. The average size of all three species in the Estuary was about one third smaller. The smaller size of these species is inferred to reflect the effects of severe stress, most probably due to pollution and increased siltation. Living populations of these species in the Tamaki Estuary together with several other taxa, such as *Mactra* and *Macomona*, are noticeably much smaller than old shells in middens and the estuary. In a more wide-ranging statistical study Stewart (2004) showed that cockles in Tamaki Estuary had a much smaller mean size than any of the other sites studied on the outskirts of Auckland.

7.5 Other "Vanished" Species

The apparent decline in the abundance of cockles and pipi, and also the disappearance of a few rarer rocky shore species (below), parallels similar reported declines in abundance and diversity elsewhere around Auckland, particularly in the inner Waitemata Harbour (Hayward et al., 1999), at Howick Beach (Morley et al., 2001) and along the north Manukau Harbour coast (Hayward and Morley, 2004). The cause of these changes cannot all be attributed to human harvesting. Anti-fouling paint (TBT) poisoning is responsible for some declines in the Tamaki Estuary and Waitemata Harbour (e.g., Stewart et al., 1992), but not of bivalves for example. Clearly there has been an increase in silt accumulation along the more sheltered Waitemata and Tamaki Estuary shores, that may have had some impact in reducing diversity, but this is unlikely to be the total reason. Other less well-defined factors may include combinations of increased freshwater runoff (e.g., Hayward et al., 2004), chemical pollutants of various kinds (e.g., Maxwell, 1985), increased nutrients and diseases, resulting from the proximity of New Zealand's largest city. Widespread decreased abundance of breeding populations to reseed the coastlines may also be a factor, especially in the case of cockles.

Calliostoma pellucidum – This elegant, low tidal to subtidal gastropod was recorded living in the 1980s at Bucklands Beach, and one specimen was found dead at the same locality in 2002 (Morley, 2002).

Marinula filholi – This high tidal gastropod was recorded in the 1980s from Bucklands Beach (Morley, 2002), but was not found again during our 2000s survey.

Muricopsis octogonus – Rare, old, broken shells of this ornamented gastropod were found on either side of Musick Pt during this survey, but no living specimens were found. A similar situation was found in the main part of the Waitemata Harbour in the 1990s (Hayward et al., 1999). Their disappearance in many New Zealand harbours has been attributed to TBT poisoning and/or shell collecting.

Neoguraleus sinclairi – One dead specimen was found on the western coast of Musick Pt in the 1980s and again in 2001 (Morley, 2002).

Sinezona brevis - One specimen was found in Corallina turf at Bucklands Beach in the 1980s (Morley, 2002), but none were found during this 2000s survey.

Zeacolpus pagoda - One dead specimen was found on the western coast of Musick Pt in the 1980s (Morley, 2002), but none were found during this 2000s survey, nor any live specimens in the Waitemata Harbour in the 1990s (Hayward et al., 1997, 1999). It appears to have disappeared from the inner Hauraki Gulf in the last 50 or so years (Powell, 1937; Hayward et al., 1997).

Arthritica crassiformis – A shell of this small bivalve was collected from West Tamaki Head prior to 1960 (AK99887), but none were found in this survey.

Benthocardiella hamatadens – This small bivalve was found at Bucklands Beach in the 1985 (Morley, 2002), but none were found live or dead in this 2000s survey.

Cyclomactra ovata – In-situ beds of these large dead estuarine trough shells are exposed in a number of places around Tamaki Estuary (e.g. Tahuna Torea, north end of Bucklands

Beach, Farm Cove). Although no similar-sized large *Mactra* were found living during this survey, they may be present as they are very deep burrowers.

Pinnotheres atrinocola – This small commensal crab was recorded living inside horse mussels in 1985 at Bucklands Beach (Morley, 2002), but none were seen nor actively looked for during this 2000s survey.

7.6 Mangrove Forest Expansion

Examination of a sequence of historic air photos of Tamaki Estuary show that mangrove forest is expanding its extent around the edges and upper reaches of the Tamaki Estuary.

7.7 Mud Accumulation

Today the upper and middle reaches of Tamaki Estuary are characterised by large intertidal areas of soft gloopy mud that discourages people from using these areas. Mud accumulation is natural in the quietest regions of estuaries and coring shows that even in pre-human times mud was the dominant sediment of the upper parts of the Tamaki Estuary. Mud has spread further down the estuary since the 1950s with increased subdivision in the catchment (e.g., Swales et al., 2002) and now covers a greater proportion of the estuary floor than it did in pre-human, Polynesian and early European times. Coring and probing in Panmure Basin for example, shows that for at least 800 years prior to 1950, its floor was covered with a thick deposit of cockle shells (e.g., Hayward et al., 2004). Since then 0.2-0.4 m depth of mud has accumulated over the floor of the whole basin. Study of sediment cores also shows that shelled molluscs used to live in much greater abundance in the middle reaches of the estuary and that their populations have been decimated since the 1950s by decreased salinity (from increased freshwater runoff, Hayward et al., 2004) and maybe also by the increased mud.

8 References

Acosta, H., and Tricklebank, K., 2002. Changes in marine benthos in relation to the parchment worm *Chaetopterus* sp. in north-eastern New Zealand. New Zealand Marine Science Society Review 43: 69.

Adams, N.M., 1994. Seaweeds of New Zealand. An illustrated guide. Canterbury University Press, 360 p.

Alloway, B., Westgate, J., Pillans, B., Pearce, N., Newnham, R., Byrami, M., and Aarburg, S., 2004. Stratigraphy, age and correlation of middle Pleistocene silicic tephras in the Auckland region, New Zealand: a profilic distal record of Taupo Volcanic Zone volcanism. New Zealand Journal of Geology & Geophysics 47: 447-480.

Armiger, L.C., 1964. An Occurrence of Labyinthula in New Zealand *Zostera*. New Zealand Journal of Botany 2: 3-9.

Auckland City Council, 2000. Tamaki Estuary Coastal Strategy.

Black, K.P., Rutherford, J.C., Oldman, J.W., Carter, G.S., and Bell, R.G., 1996. Numerical modelling in the upper Tamaki Estuary for the environmental assessment of the Otahuhu Power Station heated – cooling – water discharge. NIWA Consultancy Report KIM70201/1, 69 p.

Carter, D., 2001. Restoration of Panmure Basin. Auckland City Council unpublished report.

Chapple, M., 1993. Dead in the Water. Metro Magazine No. 141: 80-91.

Clark, L.J., 1997. A study of cockle (*Austrovenus stutchburyi*) populations in Tamaki Estuary. Unpublished MSc thesis, University of Auckland, New Zealand.

Climo, F.M., 1976. The occurrence of *Theora (Endopleura) lubrica* Gould, 1861 (Mollusca: Bivalvia: Semelidae) in New Zealand. Auckland Museum Conchology Section Bulletin 1: 11-16.

Cranfield, H.J., Gordon, D.P., Willan, R.C., Marshall, B.A., Battershill, C.N., Francis, M.P., Nelson, W.A., Glasby, C.J., and Read, G.B., 1998. Adventive marine species in New Zealand. NIWA Technical Report 34, 48 p.

Creese, R.G., and Hooker, S.H., 1996. The ecology and environmental impact of the introduced Asian date mussel *Musculista senhousia*. Unpublished report of Auckland Uniservices Ltd to Dept of Conservation, 51 p.

Creese, R.G., Hooker, S.H., De Luca, S., and Wharton, Y., 1997. Ecology and environmental impact of *Musculista senhousia* (Mollusca: Bivalvia: Mytilidae) in Tamaki Estuary, Auckland, New Zealand. New Zealand Journal of Marine and Freshwater Research 31: 225-236.

Department of Conservation, 1988. Coastal Wetland Inventory, Tamaki Estuary.

Dromgoole, F.I., 1975: Occurrence of *Codium fragile* subspecies *tomentosoides* in New Zealand waters. New Zealand Journal of Marine and Freshwater Research 9: 257-264.

Dromgoole, F.I., and Foster, B.A., 1983. Changes to the marine biota of the Auckland Harbour. Tane 29: 79-96.

Grange, K.R., 1982. Macrobenthic communities at possible combined-cycle power station sites in Manukau and Waitemata Harbours, Auckland. New Zealand Oceanographic Institute oceanographic summary No. 19, 20 p.

Gregory, M.R., Blacksmore, N.A., Glasby, G.P., and Burrows, M.W., 1994. Manukau and Waitemata Harbours sediments. New Zealand. Oceanographic Institute chart.

Hayward, B.W., 1997. Introduced marine organisms in New Zealand and their impact in the Waitemata Harbour, Auckland. Tane 36: 197-223.

Hayward, B.W., Grenfell, H.R., Nicholson, K., Parker, R., Wilmhurst, J., Horrocks, M., Swales, A., and Sabaa, A.T., 2004. Foraminiferal record of human impact on intertidal estuarine environments in New Zealand's largest city. Marine Micropaleontology 53: 37-66.

Hayward, B.W., and Morley, M.S., 2004. Intertidal life around the coast of the Waitakere Ranges, Auckland, Auckland Regional Council Working Report No. 111, 102 p.

Hayward, B.W., Morley, M.S., Stephenson, A.B., Blom, W.M., Grenfell, H.R., Prasad, R., Rogan, D., Thompson, F., Cheetham, J., and Webb, M., 1999. Intertidal and subtidal biota and habitats of the central Waitemata Harbour. Auckland Regional Council, Technical Publication No. 127, 40 p and map.

Hayward, B.W., Stephenson, A.B., Morley, M.S., Riley, J., and Grenfell, H.R., 1997. Faunal changes in Waitemata Harbour sediments, 1930s-1990s. Journal of the Royal Society of New Zealand 27: 1-20.

Kermode, L.O., 1992. Geology of the Auckland urban area. 1: 50 000. Institute of Geological and Nuclear Sciences geological map 2.

Kingett Mitchell and Associates, 1996. Assessment of biological resources of the upper Tamaki Estuary and Otara Lake. Kingett Mitchell and Associates, 14 p plus appendices.

KRTA Ltd., 1990. KRTA Report. Waitemata Harbour Maritime Planning Authority, 160 p.

Larcombe, M.F., 1973. Waitemata Harbour Study, Ecology. Auckland Harbour Board and Auckland Regional Authority, 160 p.

Maxwell, G.S., 1985. The chemical flush into Auckland's Tamaki Estuary following a major fire, on 21/12/84 at ICI Mt. Wellington site. An ecological assessment. Unpublished Report to ICI (NZ) Ltd., Government Depts and local authorities, 63 p.

Maxwell, G.S., 1987a. The ecological recovery of the Tamaki Estuary: A report on the post ICI Fire Ecological Monitoring Programme, April 1985 to November 1986. Unpublished Report to ICI (NZ) Ltd., Government Depts and local authorities, 52 p.

Maxwell, G.S., 1987b. A survey of some key biological parameters of ecological health in the Panmure Basin and inlet during August and September 1987. Unpublished Report for the Tamaki Estuary Protection Society's symposium "Tamaki-in-crisis", 18 p.

Morley, M.S., 1988. Report on the continuing study of *Musculista senhousia* (Benson, 1842). Poirieria 5(15): 4-8.

Morley, M.S., 2002. Marine biota of Little Bucklands Beach to Musick Point, Tamaki Estuary, Auckland. Poirieria 28:

Morley, M.S., Hayward, B.W., and White, A., 2001. Changes to the intertidal biota 1950's-2000 at Howick Beach, Auckland. Poirieria 27: 4-19.

Morton, J.E., and Miller, M.C., 1968. The New Zealand Sea Shore. Collins, 638 pp.

Powell, A.W.B., 1937. Animal communities of the sea-bottom in Auckland and Manukau Harbours. Transactions of the Royal Society of New Zealand 66: 354-401.

Read, G.B., and Gordon, D.P., 1991. Adventive occurrence of the fouling serpulid *Ficopomatus enigmaticus* (Polychaeta) in New Zealand. New Zealand Journal of Marine and Freshwater Research 25: 269-273.

Sim, C.J.L., 1999. The population ecology of the Asian date mussel, *Musculista senhousia*. Unpublished MSc thesis, University of Auckland, New Zealand.

Spencer, H.G., Willan, R.C., Marshall, B.A., and Murray, T.J., 2002. Checklist of the recent mollusca described from the New Zealand Exclusive Economic Zone.

http://torea.otago.ac.nz/pubs/spencer/Molluscs/index.html

Stewart, C., de Mora, S.J., Jones, M.R.L., and Miller, M.C., 1992. Imposex in New Zealand neogastropods. Marine Pollution Bulletin 24: 204-209.

Stewart, M.J., 2004. Impact of urban development on little neck clam populations. Abstract, NZ Marine Sciences Society Conference, Dunedin.

Swales, A., Williamson, R.B., Van Dam, L.F., Stroud, M.J., and McGlone, M.S., 2002. Reconstruction of urban stormwater contamination of an estuary using catchment history and sediment profile dating. Estuaries 25: 43-56.

Symmons, W.J., 2000. Ecological risk assessment of the Tamaki Estuary, Auckland. Unpublished MSc thesis, University of Auckland, New Zealand.

Tang, J., 1999. Environmental geology study on Panmure basin, Auckland, New Zealand. Unpublished MSc thesis, University of Auckland, New Zealand.

Willan, R.C., 1985. Successful establishment of the Asian mussel *Musculista senhousia* (Benson in Cantor, 1842) in New Zealand. Records of Auckland Institute and Museum 22: 85-96.

Willan, R.C., 1987. The mussel *Musculista senhousia* in Australasia; another aggressive alien highlights the need for quarantine at ports. The Bulletin of Marine Science 41: 475-489.

Acknowledgements

For assistance in the field we thank Hugh Grenfell, Clare Hayward, Kathryn Hayward, Glenys Hayward, Shungo Kawagata, Fraser Morgan, Leslie Newman and Richard Willan. Thanks to Ros Nicholson and Colin Percy for loaning historical documents; Con Morley for information on sea mammal sightings; and Chris Horne for the record of Upogebia hirtifrons. For assistance with identifications we thank Wilma Blom (worms), Doug Rogan, Ewen Cameron (seaweeds), John Early (spider), Jenny Riley and Brett Stephenson (crustaceans). Todd Landers is thanked for assistance in obtaining Auckland Museum records. For funding assistance we acknowledge sponsorship by the Auckland Regional Council.

9 Appendices

9.1 Appendix 1 – Field Surveys

Panmure Basin, July 2002

Pakuranga Creek, June 2002

Half Moon Bay-Whakaaranga, July 2002

Karaka Bay-Glendowie Beach, Aug 2002

Tahuna Torea, Oct 2002

Tahuna Torea-Pt England, Jan 2003

Pt England-Panmure Wharf, Jan 2003

Bucklands Beach, April 2003

Bucklands-Musick Pt, April 2003

Farm Cove coast, June 2003

Farm Cove coast, July 2003

Panmure Bridge and south, July 2003

Edgewater to Tirakau Drive Bridge, Aug 2003

Waipuna Bridge to Otahuhu, Aug 2003

Panmure Wharf-Panmure Bridge and opposite, Sept 2003

Bucklands Beach, with Richard Willan, Oct 2003

Otahuhu to Middlemore, by boat with Kathryn Hayward and Fraser Morgan, Dec 2003

Seaside Park to Curlew Bay, Jan 2004

West Tamaki Head to Ladies Bay, July 2004

Eastern Beach anticline to Musick Pt, Aug 2004

West Tamaki Head, Margaret Morley and Leslie Newman, Sept 2004

Otara Lake, with Hugh Grenfell and Clare Hayward, Dec 2004

Pakuranga Creek-Waiouru coast, Feb 2005

9.2 Appendix 2 – Recent Scientific Name Changes

Recent scientific name changes for common intertidal animals and plants in this report.

Old name	New name
Mollusca:	
Aglaja cylindrica	*Melanochlamys cylindrica*
Amaurochiton glaucus	*Chiton glaucus*
Anchomasa similis	*Barnea similis*
Chelidonura aureopunctata	*Philinopsis taronga*
Chlamys zelandiae	*Talochlamys zelandiae*
Crassostrea glomerata	*Saccostrea cucullata*
Crepidula	*Maoricrypta*
Dendrodoris gemmacea	*Dendrodoris denisoni*
Dentalium nanum	*Antalis nana*
Divaricella huttoniana	*Divalucina cumingii*
Estea	*Pisinna*
Gadinalea nivea	*Gadinia conica*
Guildingia obtecta	*Plaxiphora obtecta*
Lepsiella scobina	*Haustrum scobina*
Lithophaga truncata	*Zelithophaga truncata*
Littorina	*Austrolittorina*
Marginella	*Mesoginella*
Marginella pygmaea	*Mesoginella koma* (in part)
Maurea	*Calliostoma*
Mayena australasia	*Ranella australasia*
Micrelenchus tenebrosus	*Micrelenchus huttonii* (in part)
Murexsul	*Muricopsis*
Neothais scalaris	*Dicathais orbita*
Nodilittorina	*Austrolittorina*
Notirus	*Irus*
Notoacmea daedala	*Notoacmea elongata*
Notopaphia elegans	*Irus elegans*
Notoplax cuneata	*Pseudotonicia cuneata*
Ostrea lutaria	*Ostrea chilensis*
Paphirus largillierti	*Ruditapes largillierti*
Periploma angasi	*Offadesma angasi*
Pleurobranchaea novaezelandiae	*Pleurobranchaea maculata*
Rostanga rubicunda	*Rostanga muscula*
Rufodardanula	*Tubbreva*
Siphonaria zelandica	*Siphonaria australis*
Struthiolaria vermis	*Pelicaria vermis*
Sypharochiton sinclairi	*Sypharochiton pelliserpentis*
Tellina edgari	*Tellinota edgari*
Terenochiton inquinatus	*Leptochiton inquinatus*
Thais orbita	*Dicathais orbita*
Tiostrea	*Ostrea*
Turbonilla	*Chemnitzia*
Xymena pusillus	*Xymenella pusilla*
Zearcopagia	*Pseudoarcopagia*
Zegalerus tenuis	*Sigapatella tenuis*
Echinodermata:	
Arachnoides zelandiae	*Fellaster zelandiae*

Coscinasterias calamaria	*Coscinasterias muricata*
Ocnus calcarea	*Australocnus calcarea*

Crustacea:

Balanus decorus	*Notomegabalanus decorus*
Balanus tintinnabulum	*Megabalanus tintinnabulum linzei*
Balanus vestitus	*Notobalanus vestitus*
Elminius modestus	*Austrominius modestus*
Elminius plicatus	*Epopella plicata*
Mitella spinosa	*Calantica spinosa*
Ovalipes punctatus	*Ovalipes catharus*
Pagurus novae-zelandiae	*Pagurus novizelandiae*
Plagusia capensis	*Plagusia chabrus*
Tetraclita purpurascens	*Tetraclitella depressa*

Polychaeta:

Hydroides norvegicus	*Hydroides elegans*
Idanthyrsus	*Paraidanthyrsus*
Pomatoceros caeruleus	*Spirobranchus cariniferus*
Sabellaria kaiparaensis	*Neosabellaria kaiparaensis*

Bryozoa:

Watersipora cucullata	*Watersipora arcuata*

Porifera:

Aaptos aaptos	*Aaptos tentum*
Tethya ingalli	*Tethya australis*

Cnidaria:

Corynactis haddoni	*Corynactis australis*
Isactinia tenebrosa	*Actinia tenebrosa*

Ascidians:

Cnemidocarpa bicornuata	*Cnemidocarpa bicornuta*

Fish:

Acanthoclinus quadridactylus	*Acanthoclinus fuscus*

Algae:

Apophloea	*Apophlaea*
Codium adhaerens	*Codium convolutum*
Enteromorpha	*Ulva*
Mesogloea	*Myriogloea*
Pterocladia capillacea	*Pterocladiella capillacea*
Vidalia colensoi	*Osmundaria colensoi*

Vascular plants:

Avicennia marina var. *resinifera*	*Avicennia marina*
Salicornia australis	*Sarcocornia quinqueflora*

9.3 Appendix 3 – Species List

List of animal and plant species identified from the intertidal zone from the Tamaki Estuary and around its mouth and their distribution.

Qualitative assessment of abundance:

a = abundant (c.>10,000 live specimens), c = common (c.50-10,000 live specimens), f = frequent (c.6-50 live specimens), o = occasional (3-5 live specimens), r = rare (1-2 live specimens), d = dead wash-up record only,

x = additional records to those recorded in this survey by the authors, from earlier voucher specimen in Auckland Museum (AK) or Margaret Morley collections, or published historic records in Larcombe (1973; L), Kingett Mitchell (1996; KM) and Morley (2002). '99 = year of historic record 80s = decade of historic record

Mollusc names have been updated to follow Spencer et al. (2002).

Key to abbreviations of coastal localities:

AchPt	St Heliers to West Tamaki Head (includes Achilles Pt)
WTH	West Tamaki Head
Glend	Karaka Bay to Tahuna Torea
Waih	Tahuna Torea to Point England (includes Waihuna Bay)
Panm	Point England to Panmure Bridge
PanB	Panmure Basin
PRdP	Panmure Basin to Otahuhu Creek (includes Panama Rd Peninsula)
Ota	Otahuhu Creek up to Middlemore
Waio	Otara Lake, Waiouru Peninsula and Pakuranga Creek
Pak	Pakuranga Creek to Panmure Bridge
Farm	Panmure Bridge to Half Moon Bay (includes Farm Cove)
BBch	Bucklands Beach to Musick Point
East	Musick Point to Eastern Beach

Localities:	AchPt	WTH	East	Glend	BBch	Waih	Panm	Farm	PanB	Pak	PRdP	Waio	Ota
FORAMINIFERA													
Ammobaculites exigua	.	.	.	.	.	.	.	.	x	.	.	x	x
Ammonia aoteana	.	.	.	.	.	.	.	.	x	.	.	x	x
Ammonia pustulosa	.	.	.	.	.	.	.	.	x	.	.	x	.
Ammonia sp.	.	.	.	.	.	.	.	.	x	.	.	.	.
Ammotium fragile	.	.	.	.	.	.	.	.	x	.	.	x	x
Astrononion novozealandicum	.	.	.	.	.	.	.	.	x	.	.	.	.
Bolivina compacta	.	.	.	.	.	.	.	.	x	.	.	.	.
Bolivina neocompacta	.	.	.	.	.	.	.	.	x	.	.	.	x
Bolivina striatula	.	.	.	.	.	.	.	.	x	.	.	.	.
Bolivina subexcavata	.	.	.	.	.	.	.	.	x	.	.	.	.
Bulimina elongata	.	.	.	.	.	.	.	.	x	.	.	.	.
Buliminella elegantissima	.	.	.	.	.	.	.	.	x	.	.	.	x
Cassidulina carinata	.	.	.	.	.	.	.	.	.	.	.	x	.
Cornuspira involvens	.	.	.	.	.	.	.	.	x	.	.	.	.
Discorbinella bertheloti	.	.	.	.	.	.	.	.	.	.	.	x	.
Eilohedra vitrea	.	.	.	.	.	.	.	.	.	.	.	.	x
Elphidium advenum	.	.	.	.	.	.	.	.	x	.	.	.	x
Elphidium charlottense	.	.	.	.	.	.	.	.	x	.	.	.	x
Elphidium excavatum f. *clavatum*	.	.	.	.	.	.	.	.	x	.	.	.	.
Elphidium excavatum f. *excavatum*	.	.	.	.	.	.	.	.	x	.	.	x	x
Elphidium gunteri	.	.	.	.	.	.	.	.	x	.	.	x	x
Fissurina lucida	.	.	.	.	.	.	.	.	x	.	.	x	.
Haplophragmoides wilberti	.	.	.	.	.	.	.	.	x	.	.	x	x
Haynesina depressula	.	.	.	.	.	.	.	.	x	.	.	.	x
Jadammina macrescens	.	.	.	.	.	.	.	.	x	.	.	.	x
Miliammina fusca	.	.	.	.	.	.	.	.	x	.	.	x	x
Miliolinella subrotundata	.	.	.	.	.	.	.	.	x	.	.	.	.
Paratrochammina bartrami	.	.	.	.	.	.	.	.	x	.	.	x	.
Portotrochammina sorosa	.	.	.	.	.	.	.	.	x	.	.	.	x
Quinqueloculina seminula	.	.	.	.	.	.	.	.	x	.	.	.	x
Quinqueloculina tenegos	.	.	.	.	.	.	.	.	.	.	.	.	x
Scheroshorella moniliforme	.	.	.	.	.	.	.	.	x	.	.	x	x
Spiroloxsotoma glabra	.	.	.	.	.	.	.	.	x	.	.	.	x
Textularia earlandi	.	.	.	.	.	.	.	.	x	.	.	x	x
Trochammina inflata	.	.	.	.	.	.	.	.	x	.	.	x	x

Virgulopsis turris	.	.	.	.	.	.	.	.	.	.	.	x	.
MOLLUSCA: POLYPLACOPHORA (chitons)													
Acanthochitona zelandica	r	.	o	.	o	.	.	o	.	.	.	.	.
Chiton glaucus	f	f	f	r	o	o	o	o	r	.	.	r	r
Cryptoconchus porosus	f	f	o	r	o	.	.	r	.	.	.	.	.
Ischnochiton maorianus	f	f	f	o	f	r	.	r	.	.	.	.	.
Leptochiton inquinatus	f	f	f	r	r	r	.	r	.	.	.	.	.
Notoplax mariae	r	.	.	.	.	.	.	r '88	.	.	.	.	.
Notoplax violacea	r	.	o	r	o	r	.	.	.	.	.	.	.
Pseudotonicia cuneata	.	.	.	.	r	.	.	.	.	.	.	.	.
Sypharochiton pelliserpentis	o	f	c	o	c	o	o	o	o	o	o	.	r
MOLLUSCA: GASTROPODA (snails)													
Alcithoe arabica	d	.	d	.	r	d	.	d	.	.	.	.	.
Amalda australis	d	r	f	d	f	o	.	r	.	.	.	.	.
Amphibola crenata	.	.	.	.	d	f	o	c	a	r	d	a	a
Amphithalamus semen	.	.	o	.	.	.	.	.	.	.	.	.	.
Anabathron hedleyi	o	r	r	.	o	.	.	.	.	.	.	.	.
Antisolarium egenum	.	.	.	.	x	.	.	.	.	.	.	.	.
Austrolittorina antipodum	r	o	o	o	f	o	f	o	.	.	o	.	r
Austrolittorina cincta	.	.	.	.	.	r	.	.	.	.	.	.	.
Austromitra rubiginosa	.	.	d	.	x	.	.	.	.	.	.	.	.
Buccinulum linea	o	r	o	.	f	.	.	.	.	.	.	.	.
Buccinulum vittatum	o	o	o	.	r	d	.	.	.	.	.	.	.
Bulla quoyii	d	.	d	r	f	o	.	.	.	.	.	.	.
Cabestana spengleri	r	r	.	.	.	.	.	.	.	.	.	.	.
Caecum digitulum	r	.	.	r	r	.	.	.	.	.	.	.	.
Calliostoma pellucidum	.	.	.	.	d'02	.	.	.	.	.	.	.	.
Cellana ornata	r	.	o	r	o	.	.	.	.	.	.	.	.
Cellana radians	.	.	r	.	r	d	.	.	.	.	.	.	.
Chemnitzia bucknilli	.	.	.	r	r	.	.	.	.	.	.	.	.
Chemnitzia sp.	o	.	d	.	o	o	d	d	.	.	.	.	.
Cirsonella aff. *laxa*	r	.	.	.	.	.	.	.	.	.	.	.	.
Cirsotrema zelebori	.	.	.	AK	.	.	.	.	.	.	.	.	.
Cominella adspersa	d	o	o	o	f	o	o	r	.	.	.	r	.
Cominella glandiformis	o	.	o	o	f	a	a	f	o	o	r	o	o
Cominella maculosa	r	r	.	.	o	.	.	.	.	.	.	.	.
Cominella quoyana quoyana	d	.	o	d	d	.	.	.	.	.	.	.	.
Cominella virgata	o	o	o	.	f	d	.	.	.	.	.	.	.
Crassitoniella carinata	d	.	.	.	.	.	.	.	.	.	.	.	.
Dicathais orbita	d	o	r	r	r	.	.	.	.	.	.	.	.

Diloma subrostrata	d	.	.	.	f	a	a	f	o	f	o	c	o
Diloma zelandica	.	.	.	.	.	.	.	r'93	.	.	.	.	.
Eatoniella albocolumella	.	o	.	r	.	.	.	.	.	.	.	.	.
Eatoniella globosa	.	.	.	.	r	.	.	.	.	.	.	.	.
Eatoniella limbata	f	o	c	c	o	r	.	.	.	.	.	.	.
Eatoniella lutea	r	o	o	o	o	.	.	.	.	.	.	.	.
Eatoniella mortoni	.	.	o	.	.	.	.	.	.	.	.	.	.
Eatoniella notalabia	.	.	.	r	.	.	.	.	.	.	.	.	.
Eatoniella olivacea	c	o	.	.	o	.	.	.	.	.	.	.	.
Eatonina atomaria	c	o	f	r	f	r	.	f	.	.	.	.	.
Eatonina micans	.	.	.	r	f	.	.	.	.	.	.	.	.
Eatonina subflavescens	.	.	.	r	o	.	.	.	.	.	.	.	.
Epitonium tenellum	d	.	.	.	d	.	.	.	.	.	.	.	.
Eulimella levilirata	.	.	.	.	r	.	.	.	.	.	.	.	.
Glyptophysa variabilis	.	.	.	.	d	.	.	d	.	.	.	.	.
Haminoea zelandiae	.	.	.	o	r	f	.	c	.	o	r	.	.
Haustrum scobina	o	r	c	f	f	.	.	.	d	.	.	.	.
Lamellaria ophione	.	.	r	.	.	.	.	.	.	.	.	.	.
Leuconopsis obsoleta	o	.	o	o	.	.	.	.	.	.	.	.	.
Linopyrga rugata rugata	d	.	r	.	r	.	.	.	.	.	.	.	.
Lodderia iota	.	.	.	AK	.	.	.	.	.	.	.	.	.
Maoricolpus roseus roseus	o	o	f	d	f	d	d	d	.	.	.	.	.
Maoricrypta costata	f	o	f	f	o	.	.	.	.	.	.	.	.
Maoricrypta monoxyla	o	o	f	o	o	.	.	.	.	.	.	.	.
Maoricrypta sodalis	.	.	d	.	.	.	.	.	.	.	.	.	.
Marinula filholi	.	.	.	.	80s	.	.	.	.	.	.	.	.
Melagraphia aethiops	a	a	a	a	c	f	o	f	o	o	o	.	.
Merelina taupoensis	d	.	.	.	.	.	.	.	.	.	.	.	.
Mesoginella koma	.	.	d	.	50s	.	.	.	.	.	.	.	.
Micrelenchus huttonii	d	.	.	d	80s	f	o	c	.	.	.	.	.
Muricopsis octogonus	.	.	d	.	d	.	.	.	.	.	.	.	.
Neoguraleus interruptus	.	.	.	.	d	.	.	.	.	.	.	.	.
Neoguraleus murdochi	d	.	d	.	d	d	.	.	.	.	.	.	.
Neoguraleus sinclairi	.	.	.	.	d	.	.	.	.	.	.	.	.
Nerita atramentosa	o	o	r	f	r	.	r	r	.	.	.	.	.
Notoacmea elongata	d	.	d	.	f	c	o	c	r	.	o	d	.
Notoacmea helmsi	.	.	.	d	o	f	o	o	r	.	.	.	.
Notoacmea subtilis	.	.	.	.	d	.	.	.	.	.	.	.	.
Omalogyra fusca	.	.	.	.	r	.	.	.	.	.	.	.	.
Onchidella nigricans	f	f	o	o	f	o	c	o	c	f	c	.	o

Ophicardelus costellaris	.	.	.	.	.	o	.	o	o	o	.	o	f
Orbitestella parva	.	.	.	.	.	.	.	o	.	.	.	.	.
Pelicaria vermis	.	.	.	d	d	r	.	d	.	.	.	.	.
Penion sulcatus	.	.	d	.	r	d	.	d	.	.	.	.	.
Philine auriformis	.	.	.	.	.	.	.	r'78	.	.	.	.	.
Pisinna olivacea impressa	c	.	r	.	o	.	.	.	.	.	.	.	.
Pisinna zosterophila	r	r	o	d	f	.	d	.	.	.	.	.	.
Potamopyrgus estuarinus	.	.	.	.	.	o	.	o	r	o	.	a	o
Potamopyrgus pupoides	.	.	.	.	.	c	.	.	.	.	.	c	.
Pusillina hamiltoni	r	.	.	.	.	.	.	.	.	.	.	.	.
?Rastodens puerilis	.	.	d	.	.	.	.	.	.	.	.	.	.
Risellopsis varia	o	o	o	f	d	.	.	.	.	.	.	.	.
Rissoella elongatospira	.	.	.	.	o	.	.	.	.	.	.	.	.
Rissoina chathamensis	d	.	d	.	r	.	.	.	.	.	.	.	.
Scutus breviculus	r	r	.	.	.	.	.	.	.	.	.	.	.
Sigapatella novaezelandiae	o	o	f	f	o	d	.	o	o	.	.	.	.
Sigapatella tenuis	.	o	.	.	o	.	.	.	.	.	.	.	.
Sinezona brevis	.	.	.	.	80s	.	.	.	.	.	.	.	.
Siphonaria australis	r	r	o	.	o	r	.	.	.	.	.	.	.
Struthiolaria papulosa	.	.	.	d	.	.	.	.	.	.	.	.	.
Trochus tiaratus	d	o	d	.	d	.	.	.	.	.	.	.	.
Trochus viridis	.	o	r	o	o	.	.	.	.	.	.	.	.
Tubbreva exigua	c	.	c	f	.	.	.	.	.	.	.	.	.
Tugali elegans	r	r	.	.	.	.	.	.	.	.	.	.	.
Tugali suteri suteri	.	.	.	.	o	.	.	.	.	.	.	.	.
Turbo smaragdus	a	a	c	o	c	o	f	f	r	.	r	.	.
Xymene plebeius	.	.	d	.	o	f	d	o	.	.	.	.	.
Xymenella pusilla	.	.	d	d	.	.	.	.	.	.	.	.	.
Zaclys murdochi	.	.	.	AK	.	.	.	.	.	.	.	.	.
Zalipais lissa	.	o	r	.	d	.	.	.	.	.	.	.	.
Zeacolpus pagoda pagoda	.	.	.	.	d	.	.	.	.	.	.	.	.
Zeacumantus lutulentus	.	.	.	.	f	a	a	a	a	c	o	a	o
Zeacumantus subcarinatus	d	o	o	c	c	c	c	c	c	.	o	.	.
Zebittium exile	.	.	d	.	.	.	.	.	.	.	.	.	.
Zemitrella choava	.	.	d	d	r	d	.	.	.	.	.	.	.
Zemitrella pseudomarginata	.	.	o	.	.	.	.	.	.	.	.	.	.
Zerotula ammonitoides	.	.	.	.	r	.	.	.	.	.	.	.	.
MOLLUSCA: Nudibranchia/Aplysiidae (sea slugs)													
Acanthodoris mollicella	.	.	r	r	.	.	.	.	.	.	.	.	.
Alloiodoris lanuginata	.	r	.	.	.	.	.	.	.	.	.	.	.

Berthella medietas	r	.	.	.	.	.	.	.	.	.	.	.	.
Berthella ornata	r	.	r	.	r	.	.	.	.	.	.	.	.
Bursatella leachii	.	.	.	o	f	o	.	.	.	.	.	.	.
Dendrodoris citrina	f	f	o	f	f	r	.	o	.	.	.	.	.
Dendrodoris denisoni	.	.	r	.	.	.	.	.	.	.	.	.	.
Dendrodoris nigra	.	.	.	.	r	.	.	.	.	.	.	.	.
Elysia maoria	.	.	.	.	r	.	.	.	.	.	.	.	.
Melanochlamys cylindrica	.	o	.	r	o	.	.	r'85	.	.	.	.	.
Phidiana milleri	.	.	.	.	r'95	.	.	.	.	.	.	.	.
Philinopsis taronga	.	.	.	.	.	r	.	r'86	.	.	.	.	.
Pleurobranchaea maculata	.	o	.	.	f	o	.	.	.	.	.	.	.
Rostanga muscula	.	r	r	r	r	.	.	.	.	.	.	.	.
MOLLUSCA: BIVALVIA													
Anomia trigonopsis	.	r	.	d	d	.	.	d	.	.	.	.	.
Arthritica bifurca	d	r	d	.	d	d	.	d	r	.	.	KM	d
Arthritica crassiformis	.	AK	.	.	.	.	.	.	.	.	.	.	.
Atrina zelandica	d	.	r	o	o	r	.	d	.	.	.	.	.
Austrovenus stutchburyi	d	.	d	f	f	a	c	a	o	o	o	a	f
Bankia australis	d	.	d	o	.	.	.	r	.	d	r	.	.
Barnea similis	d	f	f	d	d	d	.	d	.	.	.	.	.
Benthocardiella hamatadens	.	.	.	.	80s	.	.	.	.	.	.	.	.
Cleidothaerus albidus	r	r	.	.	r	.	.	.	.	.	.	.	.
Corbula zelandica	.	.	.	.	d	.	.	.	.	.	.	.	.
Crassostrea gigas	a	a	c	c	c	o	f	a	c	o	c	a	c
Cyclomactra ovata	d	.	d	d	d	d	d	d	d	.	.	.	.
Cyclomactra tristis	.	.	.	.	.	.	.	d	.	d	.	d	d
Diplodonta striatula	.	.	.	r	50s	.	.	.	.	.	.	.	.
Divalucina cumingi	.	.	AK	.	.	.	.	.	.	.	.	.	.
Dosina zelandica	d	r	d	r	o	.	.	.	.	.	.	.	.
Dosinia greyi	.	.	d	.	.	.	.	.	.	.	.	.	.
Dosinia lambata	.	.	d	d	.	.	.	.	.	.	.	.	.
Dosinia subrosea	d	.	d	d	d	.	.	.	.	.	.	.	.
Felaniella zelandica	.	AK	AK	.	d	d	d	.	.	.	.	.	.
Gari convexa	.	.	.	.	d	.	.	.	.	.	.	.	.
Gari lineolata	.	.	.	d	d	.	.	.	.	.	.	.	.
Gari stangeri	d	.	AK	.	d	.	.	.	.	.	.	.	.
Hiatella arctica	r	o	o	r	.	.	.	.	.	.	.	.	.
Irus elegans	.	.	.	.	d	.	.	.	.	.	.	.	.
Irus reflexus	.	.	r	.	.	.	.	.	.	.	.	.	.
Lasaea hinemoa	d	.	o	.	.	.	.	.	.	.	.	.	.

Leptomya retiaria retiaria	.	.	d	.	d	d	.	.	.	.	.	.	.
Limaria orientalis	d	.	d	d	o	r	.	.	.	.	.	.	.
Lissarca sp.	d	.	.	.	.	.	.	.	.	.	.	.	.
Macomona liliana	d	.	d	c	o	a	c	c	r	d	d	d	r
Melliteryx parva	d	.	.	.	d	.	.	.	.	.	.	.	.
Modiolarca impacta	d	r	r	.	d	.	.	r	.	.	.	.	.
Musculista senhousia	d	.	.	d	c	f	a	c	.	f	.	c	c
Myadora striata	.	.	.	r	d	.	.	.	.	.	.	.	.
Myllita stowei	d	.	.	.	.	.	.	.	.	.	.	.	.
Mytilus galloprovincialis	.	r	d	.	d	.	.	.	.	.	.	.	.
Neolepton antipodum	o	o	o	o	r	.	.	.	.	.	.	.	.
Nucula gallinacea	d	.	.	.	.	.	.	.	.	.	.	.	.
Nucula hartvigiana	o	r	o	o	f	a	a	a	o	o	d	c	d
Nucula nitidula	r	.	d	.	d	.	.	.	.	.	.	.	.
Offadesma angasi	.	.	.	.	d	.	.	.	.	.	.	.	.
Oxyperas elongata	.	.	.	.	d	.	.	.	.	.	.	.	.
Ostrea aupouria	o	f	o	c	f	r	.	.	o	.	.	.	.
Ostrea chilensis	.	.	.	.	d	d	.	.	.	.	.	.	.
Panopea zelandica	.	.	d	.	.	.	.	.	.	.	.	.	.
Paphies australis	d	.	d	d	o	c	o	d	o	d	.	d	r
Paphies subtriangulata	.	.	.	.	.	.	d	.	d	.	.	.	.
Pecten novaezelandiae	r	.	d	d	d	d	d	d	d	d	.	.	.
Perna canaliculus	f	c	o	o	f	r	r	r	d	.	r	d	.
Peronaea gaimardi	.	.	.	.	d	.	.	.	.	.	.	.	.
Pholadidea suteri	.	.	r	.	.	.	.	.	.	.	.	.	.
Pholadidea tridens	.	.	d	.	d	.	.	.	.	.	.	.	.
Pleuromeris zelandica	d	.	.	.	.	d	d	.	.	.	.	.	.
Protothaca crassicosta	.	.	d	.	.	.	.	.	.	.	.	.	.
Pseudoarcopagia disculus	.	.	d	.	.	.	.	.	.	.	.	.	.
Ruditapes largillierti	d	.	d	d	d	.	.	.	.	.	.	.	.
Saccostrea cucullata	d	.	.	.	.	.	.	.	.	.	.	.	.
Scintillona zelandica	.	.	r	.	.	.	.	.	.	.	.	.	.
Solemya parkinsonii	.	r	.	.	d	d	.	.	.	.	.	.	.
Soletellina nitida	.	.	.	.	d	d	.	.	.	.	.	.	.
Soletellina siliquens	d	.	.	d	d	d	.	.	.	.	.	.	.
Talochlamys zelandiae	.	.	o	d	.	.	.	.	.	.	.	.	.
Tawera spissa	.	.	d	.	d	.	.	.	.	.	.	.	.
Tellinota edgari	.	.	.	.	.	.	.	.	r	.	.	.	.
Theora lubrica	.	.	d	o	c	d	o	f	o	o	.	o	d
Tucetona laticostata	.	.	.	.	d	.	.	.	.	.	.	.	.

Venericardia purpurata	.	.	.	.	d	.	.	.	.	.	.	.	.
Xenostrobus pulex	o	o	f	o	c	r	o	o	.	r	r	.	r
Xenostrobus securis	.	.	.	.	.	r	.	.	o	c	.	c	.
Zelithophaga truncata	.	r	d	.	d	.	.	.	.	.	.	.	.
Zenatia acinaces	.	.	.	.	d	.	.	.	.	.	.	.	.
MOLLUSCA: SCAPHOPODA													
Antalis nana	d	.	.	.	.	.	.	.	.	.	.	.	.
MOLLUSCA: CEPHALOPODA													
squid eggs	.	.	.	.	r	.	.	.	.	.	.	.	.
BRACHIOPODA (lamp shells)													
Calloria inconspicua	.	.	AK	.	.	.	.	.	.	.	.	.	.
ECHINODERMATA: ASTEROIDA (starfish)													
Allostichaster polyplax	r	o	.	r	o	o	.	.	.	.	.	.	.
Coscinasterias muricata	f	o	o	c	o	o	o	o	.	.	.	.	.
Patiriella regularis	o	f	o	c	f	o	.	.	r	.	.	.	.
ECHINODERMATA: OPHIUROIDA (brittle stars)													
Amphiopolis squamata	.	.	.	.	.	.	.	r	.	.	.	.	.
Amphiura sp.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ophionereis fasciata	r	.	r	r	r	.	.	.	.	.	.	.	.
ECHINODERMATA: ECHINOIDA (sea eggs)													
Echinocardium cordatum	d	.	d	.	.	d	.	.	.	.	.	.	.
Evechinus chloroticus	d	r	d	.	r	d	d	d	.	.	.	.	.
Fellaster zelandica	f	.	f	c	f	f	d	.	.	.	.	.	.
ECHINODERMATA: HOLOTHURIA (sea cucumbers)													
Stichopus mollis	.	r	.	.	r	.	.	.	.	.	.	.	.
Trochodota dendyi	.	.	.	.	.	.	.	L	.	.	.	.	.
CRUSTACEA: REPTANTIA (crabs)													
Charybdis japonica	.	.	.	r	o	r	.	.	.	.	.	.	.
Cyclograpsus lavauxi	f	c	c	f	c	r	o	f	.	o	r	.	r
Elamena producta	.	.	.	r	.	f	f	o	.	.	.	.	.
Halicarcinus cooki	.	.	.	.	.	.	.	L	.	.	.	.	.
Halicarcinus pubescens	.	r	.	.	.	.	.	.	.	.	.	.	.
Halicarcinus varius	.	r	r	.	f	.	.	.	.	.	.	.	.
Halicarcinus whitei	.	.	.	.	.	.	.	.	.	.	.	KM	.
Halicarcinus sp.	.	.	.	.	.	.	o	.	.	.	.	.	.
Helice crassa	.	.	.	.	.	c	c	c	c	a	c	a	a
Hemigrapsus crenulatus	.	.	.	.	o	c	c	o	a	f	c	f	c
Hemigrapsus edwardsi	.	.	r	.	o	o	.	.	.	.	.	.	f
Heterozius rotundifrons	.	r	r	.	.	o	f	.	.	.	.	KM	.
Leptograpsus variegatus	.	.	.	.	.	.	.	r	.	.	.	.	.

Macrophthalmus hirtipes	.	.	.	o	o	a	f	c	a	c	c	o	.
Neohymenicus pubescens	.	.	.	o	.	.	.	.	.	.	.	.	.
Notomithrax minor	d	r	r	d	o	.	.	.	.	.	.	.	.
Notomithrax peronii	.	.	.	r	.	r	.	r	r	.	.	.	.
Ovalipes cantharus	.	.	.	d	.	.	d	.	.	.	.	.	.
Ozius truncatus	.	.	.	r	r	.	.	.	.	.	.	.	r
Paguristes pilosus	.	.	.	.	.	.	.	AK	.	.	.	.	.
Pagurus novizelandiae	r	o	o	r	o	o	.	o	.	.	.	.	.
Petrolisthes elongatus	a	c	c	f	f	f	o	f	r	r	r	o	r
Pilumnopeus serratifrons	o	o	.	o	.	.	.	o	o	r	.	o	.
Pilumnus lumpinus	.	.	r	.	o	.	.	o	.	.	.	.	.
Pilumnus novaezelandiae	.	.	.	o	.	.	.	.	.	.	.	.	.
Pinnotheres atrinocola	.	.	.	.	80s	.	.	.	.	.	.	.	.
Plagusia chabrus	.	r	d	d	.	.	.	.	.	.	.	.	.
CRUSTACEA: DECAPODA (shrimps)													
Alpheus novaezelandiae	o	r	.	r	.	o	o	c	.	o	L	f	o
Alpheus richardsoni	.	.	.	.	.	.	.	.	.	.	.	.	.
Calianassa filholi	.	.	.	.	r	L	.	.	.	.	.	.	.
Hippolyte bifidirostris	.	.	o	.	.	.	.	.	.	.	.	.	.
Lysiosquilla spinosa	.	.	.	.	.	L	.	L	.	.	.	.	.
Upogebia hiritifrons	.	.	r	.	.	.	.	.	.	.	.	.	.
CRUSTACEA: CIRRIPEDIA (barnacles)													
Austrominius modestus	a	a	c	a	c	f	f	c	c	f	c	c	f
Balanus amphitrite	.	.	.	.	.	.	.	.	.	.	.	r	.
Balanus trigonus	r	.	o	r	o	r	.	d	.	d	.	d	.
Chamaesipho columna	o	o	.	.	f	.	.	.	.	.	.	.	.
Epopella plicata	r	r	r	r	o	.	.	.	.	.	.	.	.
Notobalanus vestitus	.	r	.	r	.	.	.	.	.	.	.	.	.
Notomegabalanus decorus	.	.	.	.	f	.	.	.	.	.	.	.	.
CRUSTACEA: AMPHIPODA													
Aora maculata	.	.	.	AK	.	.	.	.	.	.	.	.	.
Ceradocus chiltoni	.	o	.	.	.	.	.	.	.	.	.	.	.
Paradexamine houtete	.	.	.	AK	.	.	.	.	.	.	.	.	.
Paradexamine pacifica	.	.	.	AK	.	.	.	.	.	.	.	.	.
Paraphoxus australis	.	.	.	.	.	.	.	.	.	.	.	KM	.
Photocephalidae sp.	.	.	.	.	.	.	.	.	.	.	.	KM	.
Polycheria obtusa	.	.	.	AK	.	.	.	.	.	.	.	.	.
Talorchestia sp.	f	.	.	.	.	.	L	.	.	.	.	.	.
CRUSTACEA: ISOPODA													
Isocladus armatus	.	.	.	.	f	.	.	.	.	.	.	f	.

Ligia sp.	.	.	.	L	.	.	L	.	.	.	.	.	.
Sphaeroma quoyana	.	.	.	.	.	.	L	o	.	.	.	AK	.
CRUSTACEA: OSTRACODA													
Archasterope cf. *dentata*	.	.	.	x	.	.	.	.	.	.	.	.	.
Euphilomedes sp.	.	.	.	x	.	.	.	.	.	.	.	.	.
?*Neosidea* sp.	.	.	.	x	.	.	.	.	.	.	.	.	.
Propontocypris subreniformis	.	.	.	x	.	.	.	.	.	.	.	.	.
Scleroconcha aff. *arcuata*	.	.	.	x	.	.	.	.	.	.	.	.	.
ARACHNIDA (spiders)													
Desis marina	.	.	r	.	.	.	.	.	.	.	.	.	.
POLYCHAETA (worms)													
Aedicira sp.	.	.	.	.	.	.	.	.	.	.	.	KM	.
Aglaophamus macroura	.	.	.	.	.	L	.	.	.	.	.	.	.
Armandia maculata	.	.	.	.	.	.	.	.	.	.	.	KM	.
Capitella capitata	.	.	.	.	.	.	.	.	.	.	.	KM	.
Chaetopterus	o	.	d	o	o	r	d	.	.	.	.	.	.
Cossura sp.	.	.	.	.	.	.	.	.	.	.	.	KM	.
Eulalia microphylla	.	AK	.	.	.	.	.	.	.	.	.	.	.
Eunoe sp.	.	.	.	.	.	.	o	.	.	.	.	.	.
Ficopomatus enigmaticus	.	.	.	.	.	.	.	.	.	.	.	o	.
Flabelligera affinis	o	.	o	r	o	.	.	r	.	.	.	.	.
Flabelligera bicolor	.	.	.	.	o	.	.	.	.	.	.	.	.
Glycera americana	.	AK	.	.	.	.	.	.	.	.	.	KM	.
Heteromastus filiformis	.	.	.	.	.	.	.	.	.	.	.	KM	.
Hydroides elegans	.	r	.	.	.	.	.	.	.	.	.	.	.
Idanthyrsus pennatus	.	r	.	.	.	.	.	.	.	.	.	.	.
Lepidasthenia sp.	.	.	.	.	.	.	.	.	.	.	.	KM	.
Lepidonotus polychromus	.	r	.	.	.	o	o	.	.	.	.	KM	.
Lumbrinereis coccinea	.	AK	.	.	.	.	.	.	.	.	.	KM	.
Maldanidae	.	.	.	.	.	.	.	.	.	.	.	KM	.
Nereis cricognatha	.	.	.	.	.	.	.	.	.	.	.	KM	.
Nereis jacksoni	.	.	.	.	.	.	.	.	.	.	.	o	.
Nicon aestuarinus	.	.	.	.	.	.	.	.	.	.	.	KM	.
Notomastus zealandicus	.	.	.	.	.	.	.	.	.	.	.	KM	.
Orbinia papillosa	.	.	.	.	.	.	.	.	.	.	.	KM	.
Owenia fusiformis	.	.	.	.	.	L	.	L	.	.	.	.	.
Pectinaria australis	d	.	.	d	.	d	d	d	.	.	.	.	.
Perenereis amblyodonta	.	AK	.	.	.	.	.	.	.	.	.	.	.
Perenereis camiguinoides	.	AK	.	.	.	.	.	.	.	.	.	.	.
Perenereis nuntia	.	AK	.	.	.	.	.	.	.	.	.	KM	.

Polydora polybranchia	.	.	.	.	.	.	.	.	.	.	.	KM	.
Sabellastarte sp.	.	.	.	.	.	.	.	.	.	.	.	KM	.
Scolecolepides sp.	.	.	.	.	.	.	.	.	.	.	.	KM	.
Scolecolepis sp.	.	.	.	.	.	.	.	.	.	.	.	KM	.
Spirobranchus cariniferus	c	f	c	r	c	c	r	c	.	.	.	.	.
Salmacina australis	o	.	o	o	o	d	.	o	.	.	.	.	.
Spionid tubes	o	.	f	.	.	.	.	a	.	.	.	.	.
Spirorbis sp.	o	f	f	o	f	d	.	.	.	.	.	.	.
Syllidae	.	.	.	.	.	.	.	.	.	.	.	KM	.
Terebella haplochaeta	.	.	.	r	.	.	.	.	.	.	.	.	.
Terebellidae	.	.	r	.	.	r	.	.	.	.	.	.	.
Thelepus plagiostoma	.	AK	.	.	.	.	o	.	.	.	.	.	.
Timarete anchylochaeta	.	.	.	.	.	.	.	.	.	.	.	KM	.
NEMERTEA	.	AK	.	r	.	.	.	.	.	.	o	KM	.
PLATYHELMINTHES (flat worms)	r	r	o	r	.	o	.	r	.	.	.	KM	r
OLIGOCHAETA	.	.	.	.	.	.	.	.	.	.	.	KM	.
PHORONIDA													
Phoronis ovalis	.	.	.	.	.	.	.	L	.	.	.	.	.
SIPUNCULIDA													
Dendrostomum huttoni	.	AK	.	.	.	.	.	.	.	.	.	.	.
CNIDARIA (anemones)													
Actinothoe albocincta	.	.	.	.	r	o	r	.	.	.	.	KM	r
Anthopleura	.	.	.	f	r	a	c	o	.	.	.	o	r
Culicia rubeola	.	o	r	.	r	.	.	.	.	.	.	.	.
Diadumene neozelanica	.	r	r	.	r	.	r	.	.	r	.	.	.
Isactinia olivacea	r	r	.	o	f	o	f	o	.	.	.	KM	.
Isactinia tenebrosa	r	.	.	r	.	.	.	.	.	.	.	.	.
Oulactis muscosa	.	r	.	o	.	.	.	.	.	.	.	.	.
Paractis ferox	r	r	.	.	.	.	.	.	.	.	.	.	.
PORIFERA (sponges)													
Aaptos tentum	f	f	f	f	o	.	.	o	.	.	.	.	.
Ancorina alata	.	r	r	r	.	.	.	.	.	.	.	.	.
Cliona celata	.	r	.	r	.	.	.	.	.	.	.	.	.
Haliclona sp.	.	r	.	.	.	.	.	.	.	.	.	.	.
Hymeniacidon perleve	o	o	.	o	r	.	.	o	r	.	o	.	.
Ircinia fasciculata	.	r	.	.	.	.	.	.	.	.	.	.	.
Microciona coccinea	o	.	.	o	o	.	.	r	.	.	.	.	.
Ophliataspongia seriata	.	o	.	.	.	.	.	.	.	.	.	.	.
Polymastia granulosa	.	.	.	f	.	r	.	.	.	.	.	.	.
Tethya aurantium	o	r	o	o	o	.	.	.	.	.	.	.	.

Tethya australis	.	.	.	.	r	.	.	.	.	.	.	.	.
purple finger sponge	r	.	.	.	o	.	.	.	.	.	.	.	.
BRYOZOA													
Beania magellanica	o	.	o	o	o	.	r	r	.	.	r	.	.
Watersipora arcuata	**o**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**
***ASCIDIA* (sea squirts)**	.	.	.	.	.	.	.	.	.	.	.	.	.
Aplidium phortax	.	.	.	.	.	.	.	r	.	.	.	.	.
Asterocarpa coerulea	o	o	o	.	o	.	.	.	.	.	.	.	.
Botryllus schlosseri	r	.	r	.	.	o	.	.	.	.	.	.	.
Corella eumyota	f	o	f	f	o	r	o	o	r	.	.	.	.
Cnemidocarpa bicornuata	c	c	o	o	o	.	.	.	.	.	.	.	.
Hypsistozoa fasmeriana	.	.	.	o	.	.	.	.	.	.	.	.	.
Microcosmus claudicans	.	o	.	.	.	.	.	.	.	.	.	.	.
Pyura rugosa	o	.	o	o	o	r	o	f	r	r	o	KM	.
Styela clavata	f	f	f	o	o	r	.	.	.	.	.	.	.
Styela plicata	.	.	f	o	o	o	.	o	.	.	.	.	.
HEMICHORDATA													
Balanoglossus australiensis	.	.	.	.	.	L	.	.	.	.	.	.	.
TELEOSTA (fish)													
Acanthoclinus fusus (olive rockfish)	o	o	r	o	f	.	.	r	.	.	.	.	.
Aldrichetta forsteri (yellow-eyed mullet)	.	.	.	.	.	.	.	.	.	.	.	KM	.
Arenigobius bifrenatus (Australian bridled goby)	.	.	.	.	.	.	.	.	.	.	.	AK	.
Forsterygion lapillum (common triplefin)	.	.	.	.	f	.	.	.	.	.	.	.	.
Forsterygion nigripenne (cockabully)	.	.	.	.	L	.	.	.	.	.	.	.	.
Forsterygion varium (variable triplefin)	o	.	.	.	.	.	.	.	.	.	.	.	.
Galaxias maculatus (inanga)	.	.	.	.	.	.	.	.	.	.	.	KM	.
Girella tricuspidata (parore)	.	.	.	.	.	.	.	.	.	.	.	AK	.
Gobiomorphus cotidianus (common bully)	.	.	.	.	.	.	.	.	.	.	.	KM	.
Gobiomorphus gobioides (giant bully)	.	.	.	.	.	.	.	.	.	.	.	KM	.
Gonorynchus gonorynchus (sandfish)	.	.	.	.	AK	.	.	.	.	.	.	.	.
Lissocampus filum (pipefish)	.	.	.	AK	.	.	.	.	.	.	.	.	.
Mugil cephalus (grey mullet)	.	.	.	.	.	.	.	.	.	.	.	KM	.
Notolabrus celidotus (spotty)	.	.	.	.	.	.	.	.	.	.	.	KM	.
Retropinna retropinna (smelt)	.	.	.	.	.	.	.	.	.	.	.	KM	.
Rhombosolea leporina (yellow belly flounder)	.	.	.	.	.	.	.	.	.	.	.	KM	.
AVES: (birds, feeding intertidally)													
Anarhynchus frontalis (wrybill)	.	.	.	.	.	.	.	o	.	.	.	.	.
Anas platyrhynchos (mallard duck)	.	.	.	.	.	.	.	.	.	c	.	.	o
Ardea novaehollandiae (white-faced heron)	.	.	.	.	.	.	.	o	.	.	.	.	r
Columba livia (rock pigeon)	.	.	.	.	.	r	.	.	.	.	.	.	.

Egretta sacra (reef heron)	.	.	.	L	r	.	o	r	.	.	o	.	r
Haematopus ostralegus (SI pied oystercatcher)	o	.	o	L	o	f	o	o	.	.	.	.	r
Halcyon sancta (kingfisher)	.	.	r	L	r	r	.	r	o	.	o	.	r
Himantopus leucocephalus (pied stilt)	.	.	.	L	.	.	o	o	o	.	.	.	.
Hydroprogne caspia (caspian tern)	.	.	.	.	.	.	.	o	r	.	.	.	.
Limosa lapponica (godwit)	.	.	.	.	.	f	o	o	.	.	.	.	.
Larus dominicanus (black-backed gull)	r	.	.	r	o	.	o	o	o	.	o	.	o
Larus novaehollandiae (red-billed gull)	.	.	.	.	c	.	.	c	c	.	o	.	o
Phalacrocorax varius (pied shag)	.	.	o	L	r	.	.	o	o	.	o	.	.
Porphyrio melanotus (pukeko)	.	.	.	.	.	r	.	o	.	.	o	.	.
Sturnus vulgaris (starling)	.	.	.	.	.	.	.	.	o	.	.	.	r
REPTILE													
Turtle indet	.	.	.	.	‘03-04	.	.	.	.	.	.	.	.
MAMMALIA													
Arctocephalus forsteri (NZ fur seal)	.	.	.	.	.	.	.	.	.	.	.	.	.
Delphinus delphis (common dolphin)	.	.	.	.	.	.	.	.	.	.	.	.	.
Orcinus orca (orca)	.	.	.	.	.	.	.	.	.	.	.	.	.
whale indet.	.	.	.	.	.	.	.	.	.	.	.	.	.
PLANTAE (vascular plants)													
Atriplex prostrata	.	.	.	.	.	.	.	o	o	.	.	.	r
Austrostipa stipoides (needle tussock)	.	.	.	.	.	.	.	f	.	.	.	.	.
Avicennia marina (mangrove)	.	.	.	.	.	c	r	c	o	a	c	a	a
Cassinia leptophylla	.	.	.	.	.	.	.	r	.	.	.	r	.
Chrysanthemoides monilifera	.	.	.	.	.	c	.	.	.	.	.	.	.
Cortaderia splendens	.	.	.	.	.	r	.	o	.	.	.	f	.
Cotula cornopifolia	.	.	.	.	.	o	.	.	r	.	.	r	.
Cyperus ustulatus	.	.	.	.	.	r	o	o	f	.	.	.	o
Disphyma australe	.	.	.	.	.	o	.	o	.	.	.	.	.
Isolepis nodosa	.	.	.	.	.	.	.	.	.	.	.	r	.
Juncus maritimus var australiensis	.	.	.	.	.	r	.	f	f	.	.	o	o
Leptocarpus similis	.	.	.	.	.	f	.	o	.	r	.	o	.
Lobelia anceps	.	.	.	.	.	.	.	.	.	.	.	.	r
Muehlenbeckia complexa	.	.	.	.	.	.	.	o	.	.	.	.	.
Plagianthus divaricatus	.	.	.	.	.	o	.	o	.	.	.	o	r
Samolus repens	.	.	.	.	.	f	.	f	f	f	.	f	r
Sarcocornia quinqueflora	.	.	.	.	.	o	o	c	o	f	o	o	f
Selliera radicans	.	.	.	.	.	.	.	f	o	.	.	o	r
Senecio lautus	.	.	.	.	.	.	.	r	.	.	.	.	.
Spartina sp.	.	.	.	.	.	.	.	.	.	.	.	.	o
Spinifex sericeus	.	.	.	.	.	o	.	.	.	.	.	.	.

Zostera muelleri	r	o	r	a	.	o	.	.	.	.	.	.	.
LICHENS													
Parmotrema perlata	.	.	.	.	.	o	.	.	.	.	.	.	r
Ramalina celasteri	.	.	.	.	.	f	f	f	.	.	.	o	o
Teloschistes sp.	.	.	.	.	.	f	.	r	.	.	.	r	o
Usnea sp.	.	.	.	.	.	o	.	.	.	.	.	r	.
Xanthoria parietina	.	.	.	.	.	.	o	.	.	.	o	.	o
ALGAE													
Apophlaea sinclairii	.	.	.	.	o	.	.	.	.	.	.	.	.
Arthrocardia corymbosa	o	.	o	.	.	.	.	.	.	.	.	.	.
?Bachelotia antillarum	.	.	.	.	.	o	.	.	.	.	.	.	.
Boodlea mutabile	r	.	o	.	o	.	.	.	.	.	.	.	f
Caloglossa leprieurii	.	.	.	.	.	.	.	.	c	.	.	.	.
Carpophyllum mascholocarpum	f	c	o	r	f	.	.	o	.	.	.	.	.
Carpophyllum plumosum	.	.	.	.	o	.	.	.	.	.	.	.	.
Catenella nipae	.	.	.	.	.	f	.	.	.	.	o	c	f
Caulerpa geminata	r	.	.	r	.	.	.	.	.	.	.	.	.
Chaetomorpha ?aerea	.	o	.	.	.	.	.	.	.	.	.	.	.
Chaetomorpha capillaris	.	.	.	.	.	o	.	f	.	.	r	.	.
Chaetomorpha coliformis	.	.	.	.	.	.	.	.	r	.	.	.	.
Chaetomorpha ?linum	.	.	.	.	.	.	.	o	.	.	.	.	.
Cladophoropsis herpestica	.	r	.	.	.	.	.	.	.	.	.	.	.
Codium convolutum	o	o	r	r	o	.	.	o	.	.	.	.	.
Codium fragile ssp. *tomentosoides*	o	f	o	r	o	c	r	f	.	.	.	.	.
Colpomenia peregrina	f	.	c	f	o	o	.	o	.	.	.	.	.
Colpomenia durvillaei	.	.	o	.	.	.	.	.	.	.	.	.	.
Colpomenia sp.	.	r	.	.	.	.	.	.	.	.	.	.	.
Corallina officinalis turf	c	c	c	f	f	.	.	c	.	.	.	.	.
Corallina paint	f	c	o	.	.	.	.	.	.	.	.	.	.
Cystophora retroflexa	.	.	c	.	.	.	.	.	.	.	.	.	.
Derbesia novae-zelandiae	.	.	o	.	.	.	.	.	.	.	.	.	.
Dictyota dichotoma	.	.	.	.	.	.	o	.	.	.	.	.	.
Dictyota ocellata	.	.	o	.	o	r	.	.	.	.	.	.	.
Ecklonia radiata	f	f	o	f	o	r	.	r	.	.	.	.	.
Gelidium caulacantheum	.	f	o	.	o	.	.	.	.	.	.	.	.
Gigartina chapmanii	o	.	o	c	.	f	o	.	o	o	r	o	o
Gigartina laingii	.	.	.	o	f	.	.	c	.	.	.	.	.
Gracilaria chilensis	.	.	.	.	.	o	.	.	.	.	.	.	.
Grateloupia urvilleana	.	.	.	.	r	.	.	.	.	.	.	.	.
Haliptilon roseum	o	.	o	.	.	.	.	.	.	.	.	.	.

Hormosira banksii	c	f	a	f	a	c	f	a	.	.	.	.	.
Hydroclathrus clathratus	.	.	.	r	d	.	.	.	.	.	.	.	.
Laurencia distichophylla	.	o	.	.	.	.	.	.	.	.	.	.	.
Laurencia thyrsifera	r	.	o	.	.	.	.	.	.	.	.	.	.
Myriogloea intestinalis	.	.	.	.	.	o	.	.	.	.	.	.	.
Petalonia fascia	.	.	.	.	r	.	.	.	.	.	r	.	.
Plocamium microcladioides	.	.	.	.	r	.	.	.	.	.	.	.	.
?Polysiphonia sp.	.	.	.	.	.	.	.	r	.	.	.	.	.
Pterocladiella capillacea	r	.	.	.	.	.	.	.	.	.	.	.	.
Pterocladia lucida	r	r	.	.	.	.	.	.	.	.	.	.	.
Rhizoclonium implexum	.	.	.	f	f	f	.	.	o	.	.	.	.
Rhizoclonium riparium	.	.	.	.	.	.	.	.	o	.	.	.	.
Sargassum scabridum	.	c	.	.	.	.	.	.	.	.	.	.	.
Sargassum sinclairii	c	.	c	c	o	.	.	f	.	.	.	.	.
Scytosiphon lomentaria	.	.	o	.	.	r	.	.	.	.	.	.	.
Scytothamnus australis	.	o	.	.	o	r	r	o	.	.	r	.	.
Splachnidium rugosum	o	.	f	.	o	.	.	.	.	.	.	.	.
Ulva bulbosa	.	.	.	.	.	.	.	.	.	.	.	.	o
Ulva compressa	r	.	.	.	.	.	.	.	.	.	.	.	.
Ulva intestinalis	o	.	f	.	f	f	.	.	o	o	.	f	.
Ulva lactuca	r	.	r	.	.	f	.	o	.	.	r	o	.
Ulva ralfsii?	.	.	.	.	f	.	.	.	.	.	.	o	.
Ulva ramulosa	o	.	o	o	.	o	.	.	.	.	.	.	.
Ulva sp. (narrow)	.	.	.	o	.	.	.	.	.	.	.	.	.
Ulva sp. (leafy)	.	.	.	.	.	.	.	.	.	.	.	r	.
BACTERIA													
Cyanobacteria	f	.	f	a	a	a	.	.	.	.	.	f	.

9.4 Appendix 4 – Number of Species in Different Taxonmic Groups

Foraminifera	36
Molluscs (total)	202
Polyplacophora (chitons)	9
Gastropoda (snails, sea slugs)	119
Bivalvia	72
Scaphopoda (tusk shells)	1
Cephalopoda (squid)	1
Brachiopoda (lampshells)	1
Echinodermata (total)	11
Asteroidea (starfish)	3
Ophiuroidea (brittle stars)	3
Echinoidea (sea eggs)	3
Holothurian (sea cucumbers)	2
Crustacea (total)	51
Reptantia (crabs)	27
Decapoda (shrimps)	6
Cirripedia (barnacles)	7
Amphipoda (sand hoppers)	8
Isopoda (sea slaters)	3
Ostracoda (sea fleas)	5
Arachnida (spiders)	1
Polychaeta (worms)	42
Nemertea	1
Platyhelminthes	1
Oligochaeta	1
Phoronida	1
Sipunculida	1
Cnidaria (anemones)	8
Porifera (sponges)	12
Bryozoa	2
Ascidea (sea squirts)	10
Hemichordata	1
Reptilia (turtle)	1
Mammalia	4
Teleosts (fish)	16
Aves (birds)	15
Vascular plants	24
Lichens	5
Algae (seaweeds)	57
TOTAL	503

9.5 Appendix 5 – Intertidal and Subtidal Biota and Habitats of the Tamaki Estuary