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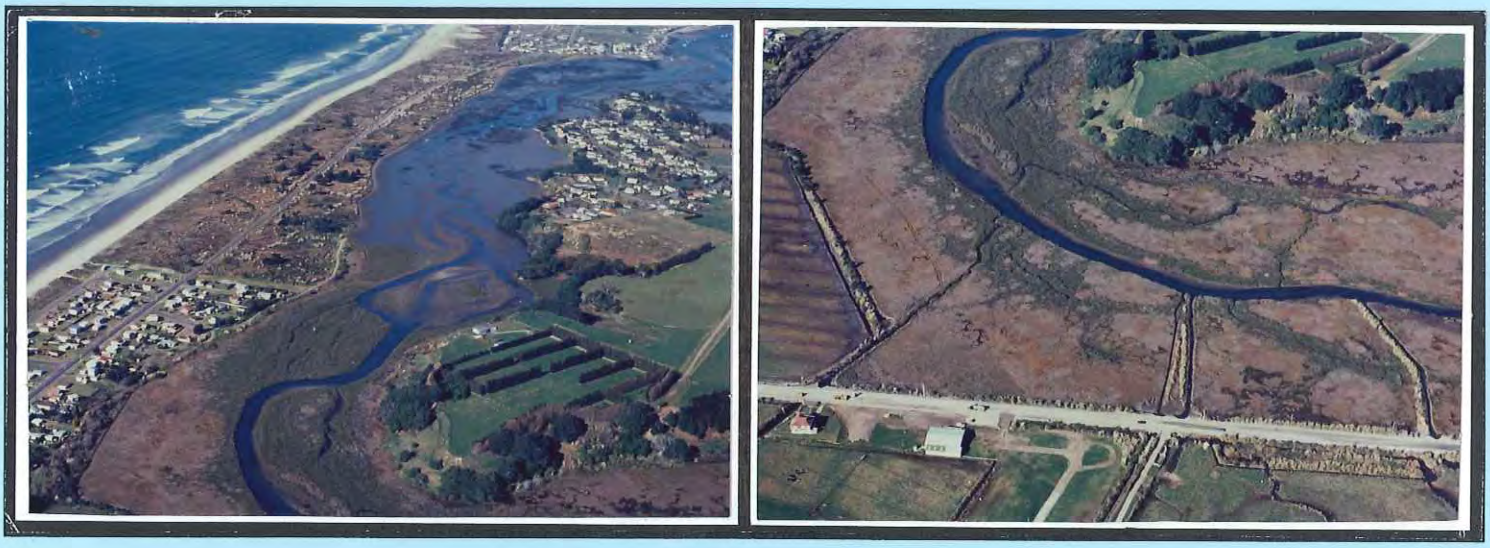
ENVIRONMENT B.O.P

TAURANGA HARBOUR REGIONAL PLAN

ENVIRONMENTAL INVESTIGATIONS

ECOLOGY OF TAURANGA HARBOUR



Pios - Athenree sub-estuary, northern Tauranga Harbour showing loss of marsh habitat

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EXECUTIVE SUMMARY

This report reviews and presents the results of studies into the general ecology of Tauranga Harbour. The harbour ecology is one aspect of an integrated environmental investigation of Tauranga Harbour and catchment undertaken as part of the Tauranga Harbour Regional Plan Project (THRPP). Other modules of the THRPP Environmental Investigations studies include catchment geology and hydrology, inputs of nutrients, harbour sediments, harbour chemistry, sentinel shellfish monitoring of metal and organic contaminants, and investigations into the occurrence of toxic dinoflagellates.

The ecological studies focused on the extensive soft-shore benthic macrofaunal communities and algae of the harbour and the freshwater ecology of the northern harbour catchment streams.

Surveys of algal flora and sea grass throughout Tauranga Harbour showed the dominant species were the sea grasses with an overall cover of 22.5%. At the time of these surveys sea lettuce was next most abundant species. Correlations of species abundance to environmental factors indicted that sea grass was being restricted from many of the harbour's sub-estuaries due to high silt loadings. Sea lettuce also showed significant correlations with increasing concentrations of several important macro-nutrients. Continuing studies have later shown areas of highest increase in sea lettuce biomass to occur in regions of the northern harbour where over-all nutrient concentrations are lower.

Investigations of the subtidal soft-bottom macrofauna of Tauranga Harbour revealed a progressive sequence of communities related to current velocity and sediments within the harbour channels. These communities are similar to those associations which have been described from the same types of habitat found else-where in northern New Zealand. The hard-bottom communities found at both entrances to Tauranga Harbour, although not covered in this investigation are very diverse and consideration should be given to providing some provision of protection.

The intertidal areas of Tauranga Harbour are very extensive and are dominated by cockle-wedge shell and seagrass macrofaunal communities. These communities have a similar species diversity and composition to other northern New Zealand harbours. The highest diversity of macrofauna was shown to exist within the sea grass beds. Sea grass beds are very important to most estuarine ecosystems as they are known to increase over-all productivity in part by stabilizing the benthic sediments and increasing micro-habitat diversity.

Marked changes to the harbours sub-estuary and fringing maritime marsh habitats are noted to have taken place over longer time periods by comparing harbour photography between 1943 and 1991. Deforestation of the catchments has lead to increased silt loads to the harbour which has impacted mainly the sheltered sub-estuaries and in some areas will have lead to a reduction in

species diversity. The increase of suspended and deposited silt has also caused the loss of seagrass from many of the sub-estuaries.

Large areas of maritime marsh from above and below mean high water spring tide level have been reclaimed or impacted in some way. These areas not only add character and specialized habitat to the harbour but in many areas would also help to improve overall water quality entering the harbour. The total area of mangroves within Tauranga Harbour has increased (mainly within the sub-estuaries) as a response to increased siltation rates.

The water quality and ecology of small streams in the Northern Tauranga Harbour catchment is affected by agricultural development. The downstream transition from indigenous forest to pasture generally results in an increase in organic enrichment, a decrease in dissolved oxygen concentrations and an increase in stream temperature. The response of invertebrate communities to these changes is a decline in the abundance of sensitive species and an increase in those that are more tolerant. It is suggested that these impacts could be mitigated to some extent by providing riparian protection zones.

Relatively little work has been done on the freshwater fishery values of the Tauranga Harbour catchment. The Wairoa system is the most popular trout fishery. Recent fisheries surveys have found only rainbow trout and longfinned eels in the upper Wairoa River system. The general lack of native fish in this area has been related to obstruction of migration by structures associated with hydro-electric generation.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

This report on the general ecology of Tauranga Harbour is one component of a number of studies looking at water quality and resource management issues of the harbour and its surrounding catchment. The studies were undertaken as the Environmental Investigations component of the Tauranga Harbour Regional Plan Project (THRPP).

The information gained from these studies forms an extensive database from which the major resource management issues facing the harbour and its catchment could be more clearly defined or identified and used to help Environment B.O.P formulate appropriate management policy.

This report focuses mainly on the areas of the harbour's soft-shore benthic macrofaunal and algal communities and on the freshwater ecology of the inflowing catchment streams in the northern portion of Tauranga Harbour.

Other modules of the THRPP Environmental Investigations studies include catchment geology and hydrology, inputs of nutrients, harbour sediments, harbour chemistry, sentinel shellfish monitoring of metal and organic contaminants, and investigations into the occurrence of toxic dinoflagellates. The bibliography of references for both this report and the other reports is contained in one document (Environment B.O.P Environmental Report 94/11).

For the purposes of uniformity with the other modules of the THRPP Environmental Investigations, Tauranga Harbour hydrography was described with the following nomenclature. The term "Northern Basin" refers to the whole of the harbour north of the power cable line extending from Matahui Point to Matakana Island. The "Southern Basin" is all the area south of the power cable excluding the Town Reach and associated bays and estuaries which were collectively referred to as the "Town Basin". Any reference to the harbours sub-estuaries is in accordance with the standard hydrographic chart.

1.2 INTRODUCTION TO HARBOUR ECOLOGY

Tauranga Harbour supports extensive intertidal and shallow subtidal benthic communities. The intertidal zones are dominated by cockle - wedge shell and sea grass communities. Large productive beds of edible shellfish are common throughout extensive areas of the harbour. The harbour ecology has been summarised by Bioresearches (1976) as having exceptionally high ecological value. It is productive, stable, rich in species and habitat, in excellent ecological condition and of importance to the ecology of the greater region.

Historically pressures on the harbour's ecology appear to have been minimal but pressures may be increasing over time with changes to land usage, increasing urbanisation and industrialisation, increased demands for port facilities, marinas etc.

An assessment of impacts on the ecology and general water quality of Tauranga Harbour has been provided by Bioresearches (1976a). The processes or changes identified as having the greatest potential to impact the harbour included:

a, sedimentation, especially the increase in fine material.

b, Reclamation of maritime marsh and intertidal areas was noted as being extensive.

c, Pollution by organic enrichment with a case example from Rereatukahia Estuary having been identified (now rehabilitated).

d, The potential impacts from metals, organic chemicals, pesticides, rubbish tip leachate, storm water runoff, and nutrient enrichment from industrial, agricultural and municipal sources were all addressed.

Previous studies of the harbour's ecology have tended to be either descriptive and qualitative in nature (Bioresearches 1974b, 1976a, 1977a, 1977b) or quantitative and focused on certain components of benthic communities or confined to small areas of the harbour (Bioresearches 1974a, 1975a, 1975b, 1984a, 1988a, 1988d, Harrison and Grierson 1982, Healy *et al* 1988, Port of Tauranga Limited 1991, Roan 1989, Roper 1990).

Prior to the introduction of Environment B.O.P's Natural Environment Regional Monitoring Network (NERMN) Coastal and Estuarine Ecology programme (Environment B.O.P 1992) there had been no comprehensive or systematic collection of data from which impacts on the intertidal macrofaunal communities on a harbour-wide basis could be assessed, particularly with respect to a regional perspective. There was also a lack of accurate and objective data on most other aspects of the harbour's ecology.

The ecological studies undertaken as part of the Tauranga Harbour Regional Plan Project and presented in this report have concentrated on intertidal and subtidal soft-bottom benthic macrofaunal communities, and intertidal algal distribution and abundance. At the same time Environment B.O.P has undertaken a separate study which has provided a detailed inventory, classification and mapping of maritime marsh, fringing wetlands and coastal vegetation for the entire harbour. Previous records on the harbour vegetation have been made by Beadel (1989a, 1989b).

Rocky shore habitats of Tauranga Harbour have not been included in the study as they cover approximately less than 0.1% of the area or shoreline perimeter. Both the Bowentown and Mount Maunganui entrances have similar and very rich hard substrate communities comprising high densities of sessile filter feeding species. Information on these diverse communities is presented in environmental impact reports by Harrison and Grierson (1982) and Port of Tauranga Limited (1991).

Studies of the resident and migratory bird species that utilise the harbour have been made by Bioresearches (1976a) and Rasch (1989). There is also information available on the shallow subtidal benthos of the open coast (Bioresearches 1977e, 1991a, 1991e, Healy *et al* 1988) in the immediate vicinity of Tauranga Harbour. The extent of the introduced highly invasive and habitat modifying cord grass within Tauranga Harbour is documented by the Department of Internal Affairs (1977, 1984).

1.3 OBJECTIVES OF THE ECOLOGICAL INVESTIGATIONS

The objectives of the ecological investigations undertaken as part of the Tauranga Harbour Regional Plan Project were to:

1) show distributions and abundance of algae and macrofauna;

2) provide baseline data against which future changes could be reliably made;

3) provide data which would enable trends of algal and macrofauna abundances to be associated with other parameters or aspects of the Tauranga Harbour;

4) provide information which will enhance resource management of the harbour.

CHAPTER TWO

MACROALGAL ABUNDANCE AND DISTRIBUTION IN TAURANGA HARBOUR

2.1 STUDY METHODS

The study of the abundance and distribution of macroalgae within Tauranga Harbour was confined to the intertidal zone and no measurements were made in the very restricted areas of rocky habitat. Measurements were taken throughout Tauranga Harbour to attain coverage of all regions. The measurements comprised the recording of percentage cover of all algae and sea grass (*Zostera sp.*) along transects running either from the shore line or in some instances from the low tide mark back up the shore. The location of the 91 algal transects throughout Tauranga Harbour is shown in Figure 2.1.

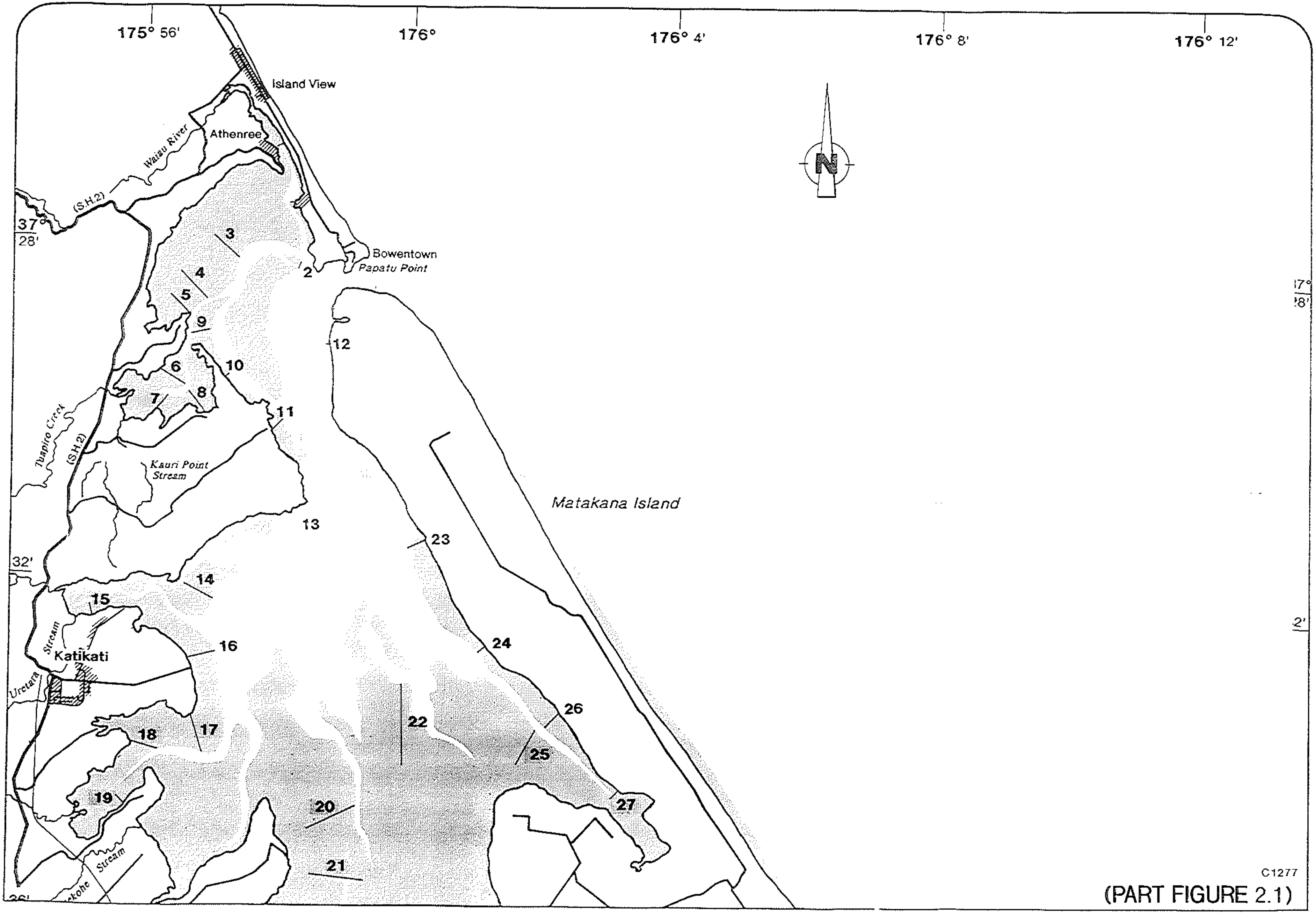
Along each of these transects measurements were made at up to six points up or down the shore to give representative cover of the area being surveyed. Shores with a shorter distance to the low tide margin may have had a smaller number of points along the transect measured. In other areas where the distances from low to high tide marks was sometimes over 2 km, only part of the intertidal area may have been covered. At each point along the transects where measurements of algal cover were made, a block measuring 10 x 10 m was established. Within this 10 x 10 m block, 6 replicate measurements of each species percentage cover were recorded in 0.25 m^2 quadrats. The positioning of the quadrat for the measurements were made using randomly-derived cartesian co-ordinates.

The survey was conducted over the summer months in 1990/91. Raw data collected from this survey is presented in Appendix 1.

2.2 DISTRIBUTION AND ABUNDANCE OF MACROALGAE

The most common species recorded in this survey of Tauranga Harbour was the sea grass with an average percentage cover for all sites of 22.46%. In order of overall abundance were the following algae, *Ulva sp.* (sea lettuce) 3.78%, *Hormosira banksii* 2.38%, *Gracilaria secundata* 0.38%, *Corallina officinalis* 0.64%, *Gelidium caulacantheum* 0.16% and *Ceramium sp.* 0.03%.

Many of the algal species found in the harbour were encountered only rarely and are not further discussed in this report. Some of these rarer species are relatively easy to find if the appropriate area or habitat is searched. In Table 2.1 below is a list of the species that were noted during the survey along with an indication of their relative abundance and the habitat in which they are likely to be found.



(PART FIGURE 2.1)

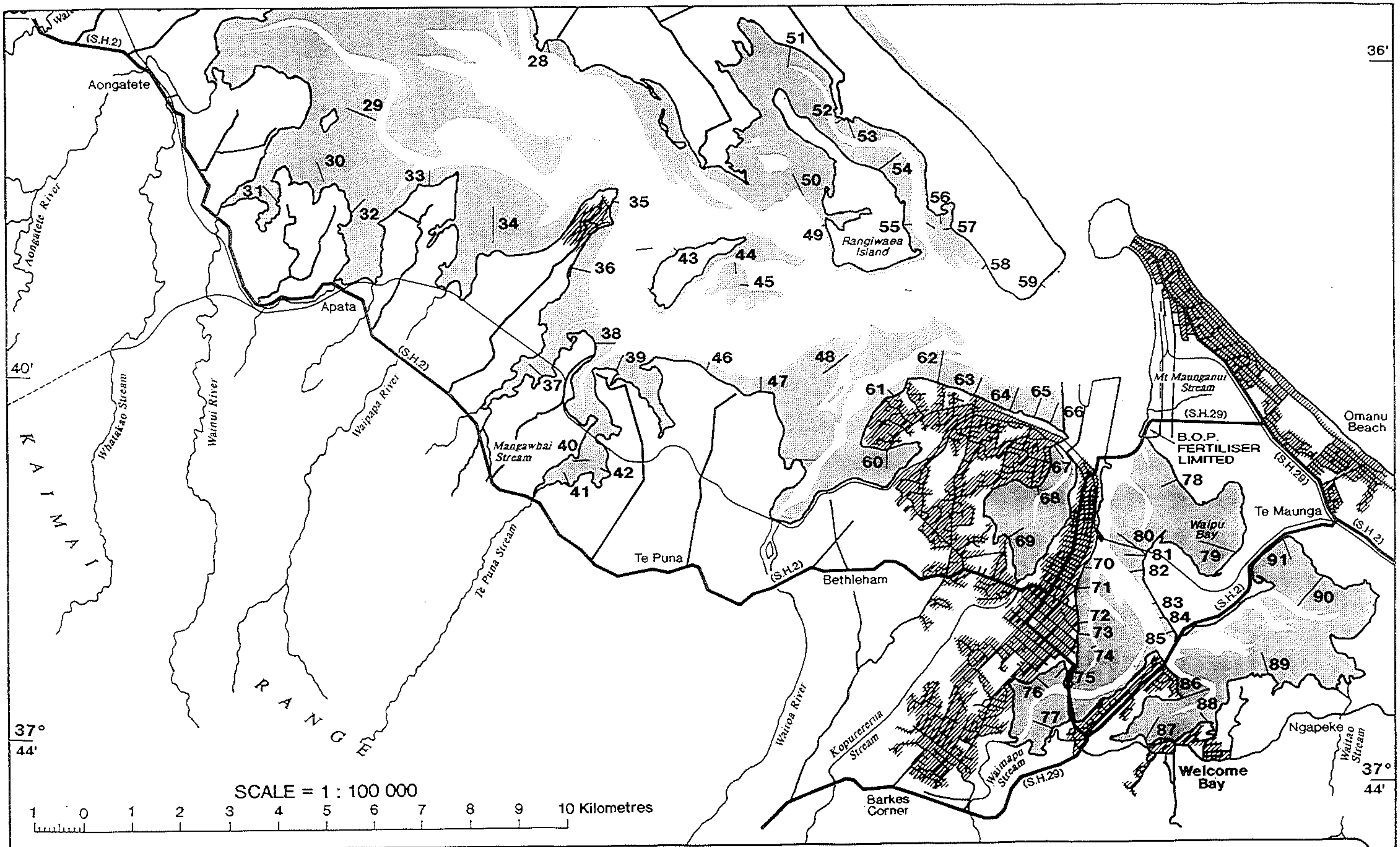


FIGURE 2.1 **LOCATION OF TRANSECTS SURVEYED IN THE SUMMER PERIOD OF 1990/91 FOR PERCENTAGE COVER OF ALGAL SPECIES AS PART OF THE TAURANGA HARBOUR REGIONAL PLAN PROJECT.**

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Table 2.1 Tauranga Harbour - Seaweed species list

Sea Grasses		
Zostera nana	sea grass	very abundant
Zostera tasmanica	sea grass	very abundant
Macroalgae		
Chlorophyceae (green algae)		
Codium fragile		common
Enteromorpha intestinalis		abundant - localised
Enteromorpha ramulosa		common
Enteromorpha compressa		common
Ulva lactuca	sea lettuce	very abundant
Ulva rigida	sea lettuce	very abundant
Ulva lactevirens	sea lettuce	very abundant
Letterstedtia petiolata		rare
Phaeophyceae (brown algae)		
Hormosira banksii	neptunes necklace	very abundant
Rhodophyceae (red algae)		
Catenella nipae		very abundant on mangroves etc
Ceramium uncinatum		very abundant in drift accumulations
Champia novaezelandiae		rare
Chondria macrocarpa		rare
Corallina officinalis	pink coralline turf	very abundant
Delesseria sp.		common
Gelidium caulacantheum		very abundant
Gigartina circumcincta		rare - in drift
Gracilaria secundata		very abundant
Gracilaria sp.		common
Grateloupia pinnata		rare - in drift
Hymenena sp.		common
Hypnea sp.		common
Polysiphonia sp.		common
Pteracladia lucida		rare
Rhodymenia leptophylla		common
Spyridia sp.		common

The list does not cover the seaweed species found on the rocky shores at both the northern Bowentown and southern Tauranga entrances to Tauranga Harbour. These habitats were not included in this survey. The southern Tauranga entrance has been the focus of a previous study initiated by the Port of Tauranga Limited (1991). The species communities at both entrances are similar.

The most common algal species throughout the harbour are presented in Table 2.2 with averages for some of the major hydrographic regions or basins of Tauranga Harbour. The table shows that the abundance of *Zostera sp.* in the three major basins of the harbour is similar to the overall abundance. Only in the enclosed Waikareao Estuary were the recorded percentage cover figures markedly lower. The table also shows higher mean percentage cover of *Ulva sp.* in the southern-most Town Basin and in the Waikareao Estuary.

The main Northern and Southern Basins also showed higher percentage cover of *Hormosira banksii, Gracilaria secundata, Corallina officinalis* and *Ceramium sp.* in comparison to the Town Basin.

Table 2.2 The mean percentage cover of common algal species (all measurements) for each of four main areas of Tauranga Harbour

	Area			
	1	2	3	4
	Northern Basin	Southern Basin	Waikareao Est.	Town Basin
Zostera sp.	25.25	21.91	0.00	23.17
Ulva sp.	0.57	2.04	15.13	8.84
Hormosira banksii	1.52	4.66	0.00	0.03
Gracilaria secundata	0.44	0.50	0.04	0.18
Gelidium caulacantheum	0.14	0.21	0.00	0.13
Corallina officinalis	0.06	1.51	0.00	0.01
Ceramium sp.	0.05	0.03	0.00	0.00

The full set of descriptive statistics for Table 2.2 is presented in Appendix 2. Figure 2.2 presents the information contained in Table 2.2 graphically.

The differences in mean algal cover of the most common species between the four areas defined in Table 2.2 were tested for significance using both parametric and non-parametric analyses (Appendix 2). The data did not meet the required assumptions of normality when structured in area groupings so only results for non-parametric stats are presented here.

Results of Kruskal-Wallis one-way analysis of variance (KWANOVA) on the percentage cover of *Ulva sp.* between the four areas showed a significant difference with P = 0.011. The same test applied to the percentage cover of *Zostera sp.* between the three main harbour basins (omitting Waikareao Estuary data) shows no significant variation.

Gracilaria secundata was also tested for significance in variation of percentage cover between areas. Results for the KWANOVA were significant for comparison of both all four areas and for just the three main harbour basins (P = 0.002 and 0.003).

Using the commonly occurring algal species, a Principal Components Analysis (PCA) was used on the mean percentage cover of each species at each of the transects sampled. This allowed an investigation of the relationships between transects based on species covariances. The results from this analysis are presented graphically in Figure 8.3 with the full set of results contained in Appendix 3.

The first component explained 74.7% of the total variance and the percentage cover of *Zostera sp.* accounted for 99.7% of this component. This translates to all the algal transects with high sea grass cover being plotted to the right of Figure 2.3, and those with little or no sea grass being plotted to the left. The second component explains 12.6% of the total variance and the percentage cover of *Hormosira banksii* and *Ulva sp.* together account for 99.9% of this

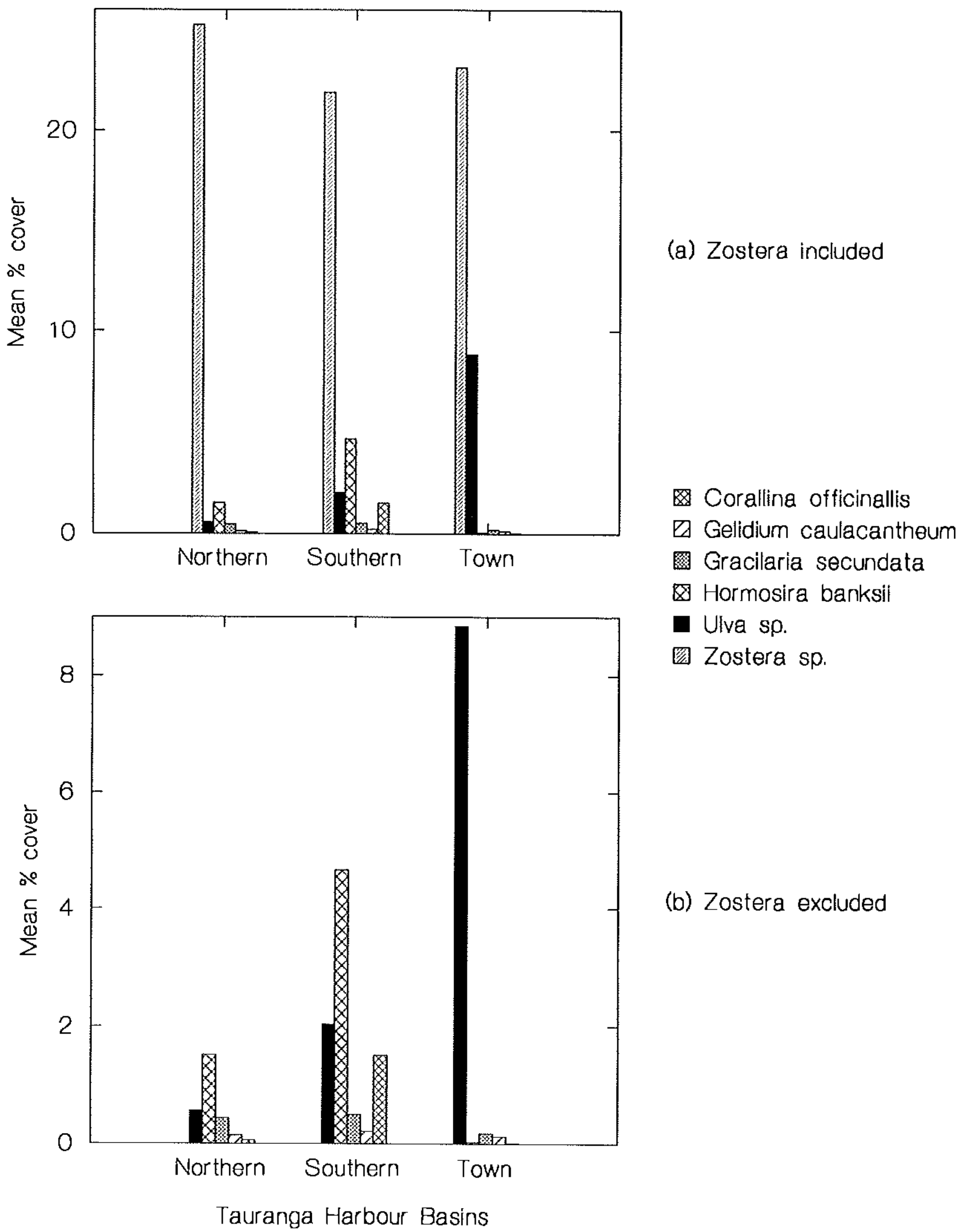

Figure 2.2 Mean percentage cover of the common algal species and Zostera for each of the three main basins of Tauranga Harbour. Means of percentage cover derived from algal transect data recorded as part of the Tauranga Harbour Regional Plan Project over the summer period in 1990/91.

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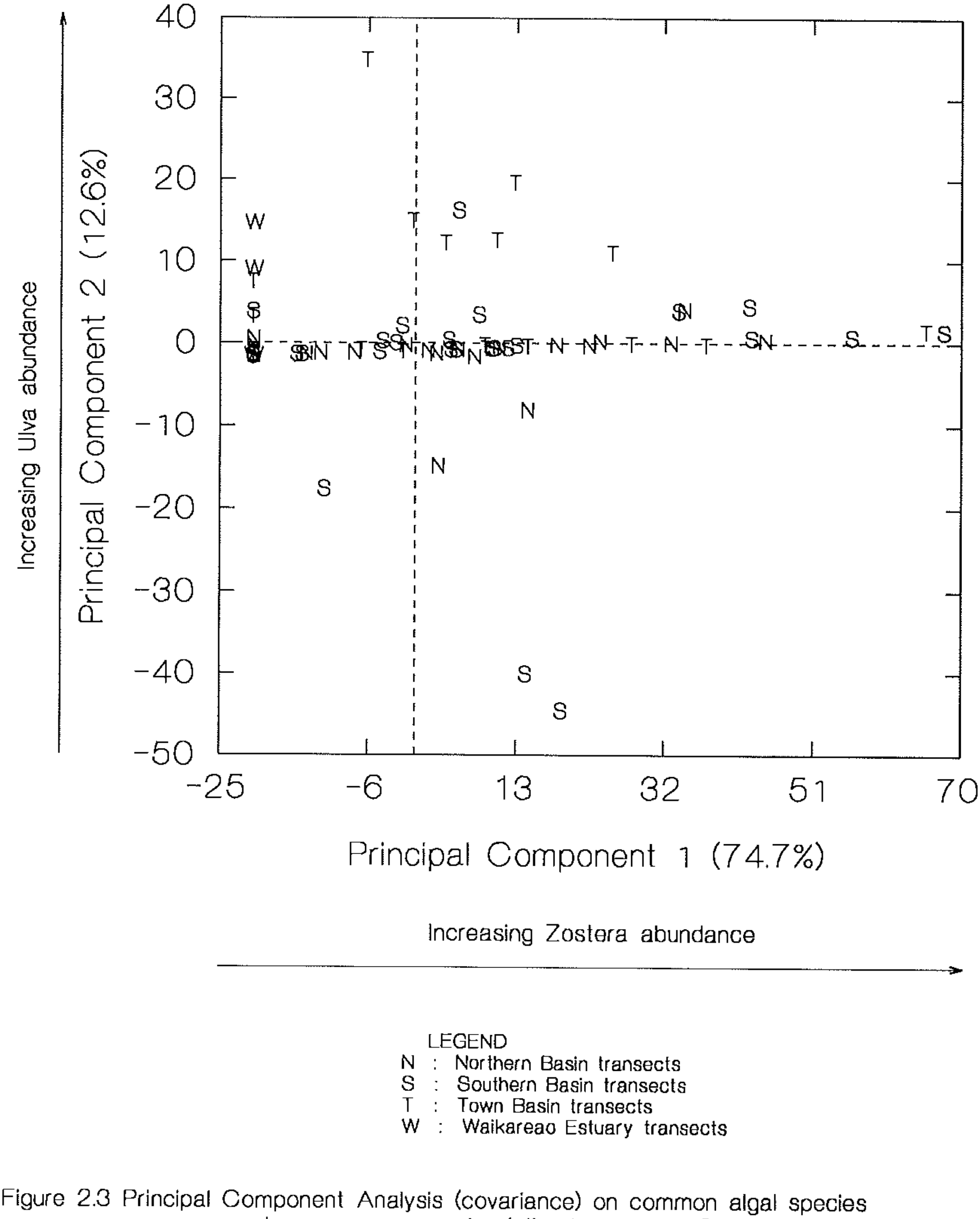

Figure 2.3 Principal Component Analysis (covariance) on common algal species mean percentage cover on each of the transects. Commparison of algal transects sampled throughout Tauranga Harbour over the summer 1990/91 as part of the Tauranga Harbour Regional Plan Project.

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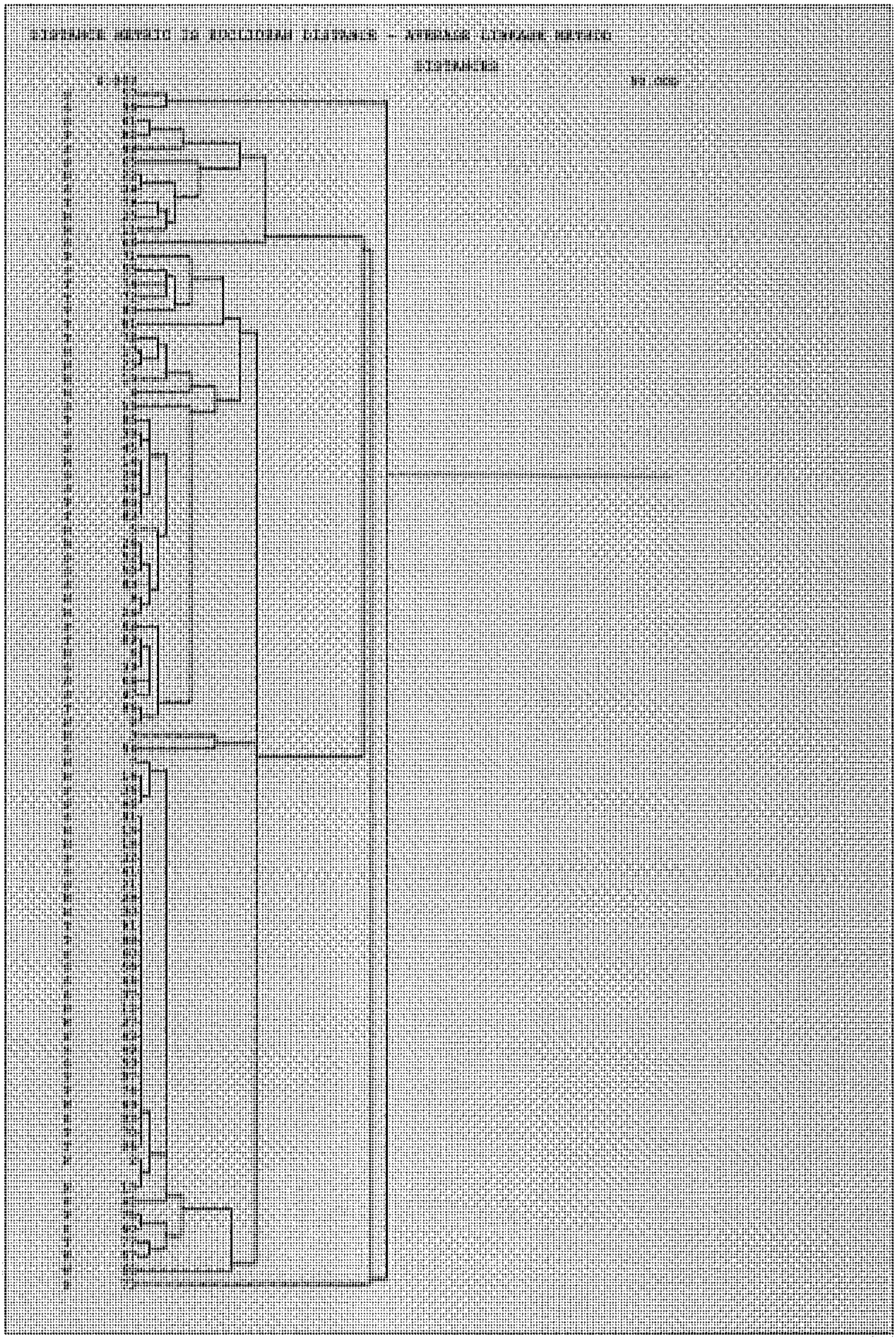

Figure 2.4 Cluster analysis of algal transects throughout Tauranga Harbour using the mean percentage cover commonly occurring species at each of the transects.

component. In Figure 2.3 all the transects in the upper half have a high percentage cover of *Ulva sp.* while those at the bottom have a high level of *Hormosira banksii* present. Figure 2.3 also shows a predominance of Town Basin transects with high *Ulva sp.* cover.

A cluster analysis was also performed on the same data set as the PCA and the results are presented in Figure 2.4. The grouping of sites is very similar to that of the PCA with transects 56 and 57 which plotted out at the bottom of Figure 2.3 having high *Hormosira banksii* cover, and transect 73 having the highest *Ulva sp.* cover. The grouping of transects 61 - 66 in the cluster analysis all have high *Zostera sp.* cover and moderate levels of *Ulva sp.*. Transects 71 - 81 have high cover of *Ulva sp.*, 54 and 3 have a high cover of *Hormosira banksii.*

2.3 DISTRIBUTION AND DENSITY OF *ZOSTERA SP.*

The distribution of sea grass beds within Tauranga Harbour has been mapped from 1:10,000 scale colour aerial photographs flown at low tide in 1990. The maps when digitised (not included in this report) will provide a valuable baseline from which future changes in distribution or overall abundance can be easily assessed. In many other northern harbours of New Zealand sea grass abundance has declined. Several possible factors have been suggested and these include fungal diseases and sedimentation but in nearly all incidences there is insufficient information to quantify possible causes or decline.

Overseas experience has shown water quality to be one factor capable of affecting sea grass abundance. One study in particular (USEPA 1992) monitored the effects of wastewater pollution abatement in Hillborough Bay, Tampa, USA and as nitrogen decreased so did levels of chlorophyll and blue-green algae. As these decreased, dissolved oxygen concentrations and water transparency have increased along with a fourfold increase in sea grass abundance since 1986.

The mean percentage cover of sea grass at each of the transects was matched up where available with the sediment data collected as part of the THRPP. The variable used for correlation with sea grass cover was the percentage of silt in the surficial sediments. Results using Pearson correlation coefficient for these variables was -0.453 (P = 0.000). This negative relationship between these two variables is more accurately described with the transformation of sea grass cover (log10(x+1)) which gave a Pearson correlation coefficient of -0.595 (results in Appendix 4).

The relationship between sea grass cover and silt content of surficial sediments is shown graphically in Figure 2.5. From the available data it appears that sea grass is unlikely to be present once the silt load in surficial sediments reaches a level of approximately 13%.

Observation of black swans feeding on sea grass beds revealed that approximately 1 - 7% of the plants (including rhizome) had been removed in some areas. With the slow growth of sea grass beds there may be a need to monitor swan populations to ensure their impacts do not become excessive.

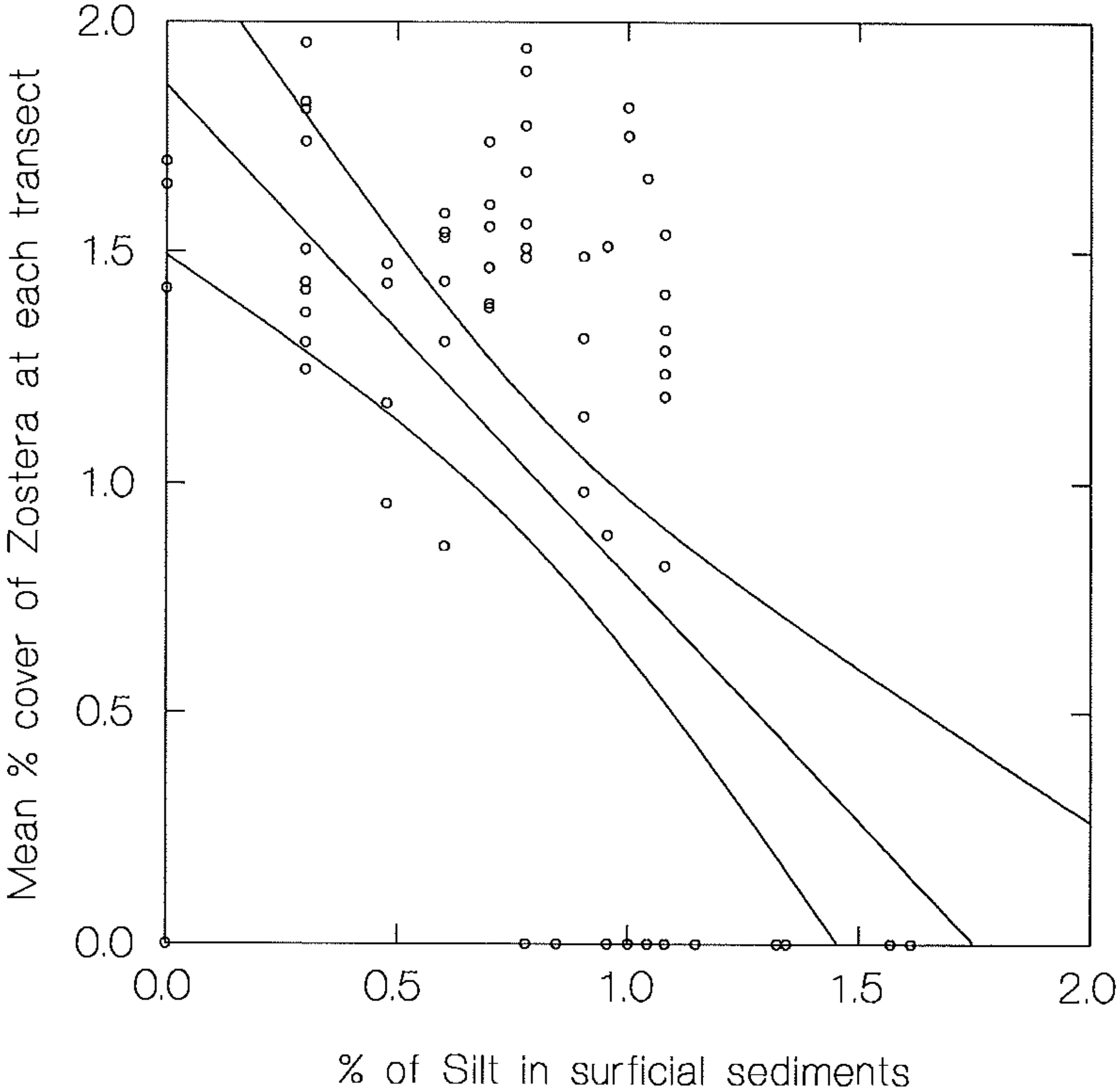

Figure 2.5 The relationship between mean percentage Zostera cover at each of the algal transects and the % of silt recorded in surficial sediments throughout Tauranga Harbour over the summer period in 1990/91 as part of the Tauranag Harbour Regional Plan Project. Log10 (x+1) data presented.

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At several locations throughout Tauranga Harbour 13 cm diameter core samples of sea grass were randomly taken within the beds at about the mean low-water neap tidal level in January/February 1991. All live plant material was then washed and dried to provide dry-weight measurements of biomass at each of the sites. The resulting information is presented in Table 2.3 below.

Table 2.3 Mean biomass (grams dry-weight) of *Zostera sp.* for 13 cm dia. samples (n=6) at five sites within Tauranga Harbour.

Site	mean	min	max	std
Blue Gum Bay	6.3	2.5	9.3	2.59
Duck Bay	8.4	3.1	14.5	4.13
Otumoetai	5.8	3.7	9.2	2.18
Town Reach	4.0	2.5	5.7	1.23
Wairoa Delta	9.7	5.4	14.2	3.17

The results show that the lowest biomass value of sea grass was obtained at the Town Reach site (near Grace Rd) with all other sites showing some variability but similar. Analysis of the results using one-way ANOVA showed a significant difference between the sites ($P = 0.016$). The full results are contained in Appendix 4. This difference can be attributed to the Town Reach site as there is no significant differences between sites when the Town Reach biomass data is dropped.

The sea grass at the Wairoa Delta which recorded the highest biomass also appeared to have one of the highest leaf densities of all the sites visited throughout the harbour.

2.4 DISTRIBUTION AND ECOLOGY OF *ULVA SP.*

2.4.1 Introduction

Due to the high abundance of *Ulva sp.* and in recognition of its nuisance value in parts of the harbour, further studies on relevant growth parameters were incorporated into Environment B.O.P's NERMN Coastal and Estuarine Ecology Programme. The initial results of this monitoring are included along with the findings of this study. As background the following summary of sea lettuce ecology is presented. Parts of this summary were sourced from a report prepared for Environment BOP by the Water Quality Centre of the National Institute of Water and Atmospheric Research (Hawes *et al* 1992). This report summerised information relevant to research requirements for the assessment of the amenability of *Ulva sp.* to management.

Sea lettuce is the collective name given to algae of the genus *Ulva*. Sea lettuce has a world-wide distribution and under some conditions can grow to great size and abundance (eg Sawyer 1965). Once considered an opportunist (ruderal or R-strategist) seaweed, there is now growing appreciation of the resilience and flexibility of the seaweed in withstanding adverse conditions and low light levels (Vermaat and Sand-Jensen 1987, Sand-Jensen 1988). It is now best thought of as a persistent seaweed which is capable of rapid growth responses to favourable conditions rather than simply as an ephemeral "weed".

There is considerable confusion over the taxonomy of *Ulva* species and many of the earlier phsyiological studies and possibly even some later research may assign the findings to the wrong species. Identifications of material from Tauranga Harbour (Dr Wendy Nelson, Museum of New Zealand) show that at least three very similar species *Ulva lactuca, Ulva laetevirens* and *Ulva rigida* are present. Field separation of species with a high degree of certainty, especially for small plants is extremely difficult.

2.4.2 Biology of *Ulva sp.*

Sea lettuce is a leafy green alga, formed of a largely undifferentiated 2-celled thick blade (the thallus) which is initially attached to the substratum by a simple holdfast. Parts of, or entire blades may become detached and continue to grow, forming loose-lying communities. While the thalli are typically annual, the holdfast is frequently perennial and gives rise to new blades during each growing season (Fritsch 1971).

The life cycle is traditionally viewed as an alternation of haploid and diploid generations. Haploid thalli (gametophytes) release motile gametes, which fuse and give rise to diploid thalli (sporophytes) morphologically identical to the gametophytes. Sporophytes release motile zoospores which give rise to new gametophytes. This simple reproductive cycle is complicated by the capacity of gametes to give rise to gametophytes or to sporophytes without undergoing fertilisation. Following germination approximately 2-3 months is required for plants to reach maturity and commence sporulation (Phillips 1990). Sporulation usually commences at the edges, and may involve the whole plant. Areas of plants which have undergone sporulation are devoid of cell contents and white.

2.4.3 Blooms of sea lettuce

Species of *Ulva* are recognised as natural components of the low to mid shore zones of many littoral ecosystems world-wide (eg Round 1981). Profuse growths of *Ulva*, and other green algae, in response to nutrient enrichment from sewage discharges, have also been widely recognised for many years, (eg Cotton 1910; Sawyer 1965; Knox and Kilner 1973; Harlin and Thorne-Miller 1981; Reise 1983; Soulsby *et al* 1985; Sfriso *et al* 1987). Indeed, sea lettuce is so responsive to nitrogen and phosphorus enrichment that it can be used as a monitor of localised enrichment (Levine 1984; Ho 1987).

Accumulation of sea lettuce has been clearly linked overseas with sewage pollution. This, however, may not be the single most important factor involved in Bay of Plenty coastal waters, where the plant grows to nuisance proportions. Biomass accumulates when growth rates exceed loss rates. Growth may be affected by a wide range of factors, including availability of spores in addition to nutrient concentrations. There are few data on loss processes of sea lettuce but Owens and Stewart (1983) estimated total monthly losses of up to 700% of a population of *Enteromorpha* (an alga similar to sea lettuce) from a small Scottish estuary. Loss processes include grazing, advection, washout, sporulation and burial. Many of these processes are interactive and in some cases there is not a clear distinction between losses and gains.

2.4.4 Factors affecting growth and loss processes

Nutrients

There is no doubt that growth of sea lettuce, and related algae, is stimulated by nutrient enrichment. Even very small increases in NO_3-N or NH_4-N can cause massive increases in growth (eg from 1.4 to 2.8 mg m^{-3} NO_3-N led to a many-fold biomass - Harlin and Thorne-Miller 1981). *Ulva lactuca* is not limited to inorganic nitrogen as a nutrient source. Foster (1914) found that urea and acetamide as the sole source of nitrogen could also promote growth and indicated that the observed rapid growth of *Ulva* in sewage polluted water could be the result of a number of additional nitrogen compounds.

N and P status of sea lettuce can be related to ambient concentrations (Ho 1987), but its ability to take up and store nutrients received in pulsed supply (Rosenburg and Ramus 1984; Ramus and Venable 1987; Fujita *et al* 1988, 1989) means that spot measurements of concentrations in water should be interpreted with care.

Problems with variability of spot measurements for nutrients in overlying water can in part be overcome by analysis of the nutrient content in *Ulva* and the use of physiological indicators of nutrient deficiency. The N:P ratio in Tauranga Harbour (close to 10) suggest that either N or P are likely to be limiting. Fujita *et al* (1989) report critical N tissue contents of >3% dry weight for *Ulva rigida* when grown on NH_4-N and >2.4% when grown on NO_3-N as indicating the onset of N sufficiency, with minimal tissue (subsistence) content of 1.2%. Nitrogen-saturated growth rate was 10-15% day^{-1}.

Ulva can use either form of nitrogen (NH_4 or NO_3) and may simultaneously take up both species (Rosenburg and Ramus 1984). Harlin and Thorne-Miller (1981) examined the effects of nutrient enrichment and found that green seaweed *Enteromorpha plumosa* was highly stimulated by the addition of NH_4-N and showed a higher growth response than that for NO_3. Preference for NH_4 without inhibition of NO_3 uptake was found for the alga *Thalassiosira pseudonana* at NH_4 levels up to 1 μ Mol (Dortch *et al* 1991). Above this level inhibition of NO_3 uptake was observed but was not complete and preconditioning caused differences in preference and inhibition. In Tauranga Harbour, sewage disposal provides mostly NH_4-N while river drainage supplies mostly NO_3-N.

Critical tissue phosphorus concentrations of 0.1-0.2% are likely to result in the onset of phosphorus limitations. If Bay of Plenty populations are nutrient limited (either by N or P), control of nutrient-rich discharges may have a rapid effect on population size.

Dense populations of sea lettuce can reduce CO_2 concentrations in sea water, causing a correlated increase in pH (Frost-Christensen and Sand-Jensen 1990). These authors argue that in dense stands of sea lettuce, in stagnant water, limitation of growth due to low dissolved inorganic carbon (DIC) concentrations may be as much as 80%. However, they suggest that under normal field conditions, DIC limitation is unlikely. It is considered that pH or DIC concentration are unlikely to be serious controls of sea lettuce growth in Bay of Plenty waters, except where extensive areas of stagnant water occur with large populations of sea lettuce.

Temperature

Sea lettuce is tolerant of low temperatures and even freezing (Vermaat and Sand-Jensen 1987), but maximum biomass in Puget Sound, USA, can be correlated with maximum temperature (Thorn and Albright 1990). Maximum summer water temperature in the Puget Sound study area was 15-16°C. These data are consistent with the temperature-growth relationship determined for a population of sea lettuce in Christchurch, New Zealand, where growth rate increased with increasing temperature to a maximum of 16-20°C (Steffensen 1976). Above 20°C, growth rate in the Christchurch population fell rapidly, reaching zero at 25°C.

Light

The importance of light in controlling growth rates of sea lettuce is not clear. While temperature was identified as the major factor determining growth rate of sea lettuce in Puget Sound, 48°N, increasing irradiance in spring above a daily average of 46 umol photons $m^{-2}s^{-1}$ initiated the annual increase (Thom and Albright 1990). The compensation light intensity (the level at which energy from photosynthesis is equal to respiration energy requirements) for *Ulva lactuca* is much lower than this, at <1 umol photons $m^{-2}s^{-1}$(Henley and Ramus 1989), though this value varies with previous history of light exposure (Sand-Jensen 1988).

Light saturation of photosynthesis in *Ulva curvata* is also variable according to previous light history but occurred at high light intensities, up to 910 umol photons $m^{-2}s^{-1}$ (Ramus 1983). Adaption to low light in *Ulva lactuca* can reduce saturating radiation flux to <50 umol $m^{-2}s^{-1}$. Adaption to the type of fluctuating light experienced in tidal waters is likely to be to optimise production rate (Henley and Ramus 1989) and will be site-specific. These data suggest that light will have a significant influence on the growth of sea lettuce, particularly where attenuation is occurring by suspended solids in overlying water. Lavery (in Lavery and McComb 1991) found that in dense banks of algae the light compensation depth may be reduced to as little as 5 cm.

Sporulation

The production of spores is both a loss and a growth-related process. While spore settlement is an essential prerequisite to blade formation, spore production involves the loss of cell contents and may result in complete tissue loss from a plant.

The stimulus for spore production in sea lettuce is not clearly understood. In cultures it can be induced by a change of medium. In the field, in Port Phillip, Southern Australia, spores are produced year round, except for late March-early June (Phillips 1990), with plants taking two and a half to three months to reach maturity. Cotton (1911) quotes several sources in support of the view that sporulation only occurs in attached plants (not in loose blades). Other authors have suggested that nutrient rich conditions delay the onset of sporulation and hence enhance vegetative growth. The issue of location, timing, quantity and trigger of sporulation is clearly of critical concern as it represents a significant potential loss of tissue, and the first stage in colonisation.

Desiccation

Sea lettuce is able to withstand desiccation when exposed to air at low tides and to maintain net photosynthesis down to 35% water content (Beer and Eshel 1983). Rate of photosynthesis is lower in air than in water and the balance between rate of desiccation, period of exposure and net growth is likely to determine the maximum vertical extent of the plant in the intertidal zone (Beer and Eshel 1983). Protection from desiccation, either by waterlogged substrata or by persistent flows of water may therefore enhance the potential area for colonisation of sea lettuce in Bay of Plenty harbours.

Grazing

Grazing can be a very important control on population size and structure in intertidal algae. Browsing animals, such as sea urchins and snails, can reduce sea lettuce to a short turf or eliminate it altogether (Round 1981). Some fish, particularly mullet and parore, eat sea lettuce and related algae. There is evidence to show that some algal species employ chemical defenses (polyphenols) to deter grazing by herbivores (Geiselman 1980). However, these compounds are present in *Ulva* at very low levels which are not sufficient to deter grazing.

Most information on grazing of intertidal algae has been gained from rocky shores, where removal of grazers promotes rapid growth of algae. Indirect evidence for grazer control is also gained from the rich growth of fast growing algae, including sea lettuce, following removal of grazers by toxic pollutants (Round 1981). There is little quantitative information on grazer control of sea lettuce on soft shores.

Burial

There is little information on the incorporation of sea lettuce into sediments. Owens and Stewart (1983) estimated monthly loss rates of 700% from an *Enteromorpha* population (a species related to sea lettuce) in a small estuary to be mostly due to burial.

Sea lettuce is likely to be tolerant of extended periods of burial, as it survives exposure to extremely low radiation fluxes, anoxia and sulphide for up to two months (Vermaat and Sand-Jensen 1987). This may be due to heterotrophic uptake of organic substrates (Markagar and Sand-Jensen 1990). However, prolonged burial is likely to result in decomposition, which may represent a significant local source of recycled nutrients (*cf* Birch *et al* 1981).

In one study looking at growth and biomass of *Ulva* mats (Price 1982) 8-20% of the algal biomass could be accounted for in the sediments. Within these dense mats the decomposition and respiration of the algae leads to anoxic conditions at the sediment surface (Lavery and McComb 1991). Anoxic sediment conditions in turn favour the release of phosphate (Sfriso *et al* 1987). Lavery and McComb found that phosphate and ammonium levels were higher within algal banks due to release from the sediments and in experiments algae growing in mats over sediment (versus no sediment) showed the greatest overall increase in biomass.

Advection, Washout and Hydrodynamics

The close linking of these three processes mean that they are best discussed together. The rate and extent to which plants are moved around in estuaries and washed out to sea will depend on the movement of water and meteorological conditions. Hydrodynamics will also determine the distribution of localised nutrient inputs and any pulses of spore production. Influx of coastal water may act as a nutrient dilution (or possible concentration if upwelling is occurring) and the degree of tidal flushing will determine residence times. An understanding of water movement in coastal waters, at coarse and fine scale for sensitive areas, together with the effect of these movements on nutrients and mobile sea lettuce will be needed to understand the dynamics of the populations.

Where changes in water movement, either natural of anthropogenic, result in physical changes in habitats these may affect the development of sea lettuce. Lowthion *et al* (1985), attributed expansion of sea lettuce in Langstone Harbour, UK, more to conversion of marsh to favourable habitat than to sewage pollution.

2.4.5 Impacts of algal mats - ecological and general

Blooms of sea lettuce and similar algae are not only of considerable aesthetic and economic importance (Sawyer 1965), but also have adverse impacts on other benthic biota, including commercially important species. Overseas case studies have shown that the naturally occurring species are displaced and recruitment of polychaete and bivalve larvae is prevented (Reise 1983; Thrush 1986; Olafsson 1988; Price and Hylleberg 1982). The flow-on effect of reducing available food species may be a reduction in bird populations (Montgomery and Soulsby 1980).

Algal mats interfere with the settlement and survival of benthic fauna in a number of ways. The mats prevent water circulation and hence food reaching suspension feeders. There is also likely to be physical interference to any surface feeding deposit feeders. Dense algal mats cause deoxygenation of water and sediments resulting in the release of sulphide from the sediments. Either deoxygenation or high sulphide levels alone could account for the loss of fauna but they may also cause synergistic effects.

Ulva lactuca has also been shown to produce exudates which have toxic effects. Johnson (1980, reviewed in Johnson and Welsh 1985) using water in which *Ulva lactuca* was grown, found a direct correlation between the amount of exudate water added and the time to 100% mortality in larval winter flounder. Further experiments on the toxicity of exudates from *Ulva lactuca* upon crab larvae have shown the effects to be synergistic in combination with low dissolved oxygen levels. A similar mortality effect was observed in manipulative experiments following settlement success of barnacles in tide pools with and without *Ulva lactuca* (Magre 1974).

A number of aesthetic and recreational or commercial problems can also arise as a result of overly abundant macroalgae. Within Tauranga Harbour the problems include *Ulva* drifts accumulating along the shoreline physically spoiling beaches and as decomposition begins there are related odour problems. The drifting *Ulva* also interferes with a number of fishing methods.

In October 1992 the Port of Tauranga Limited reported problems with its shipping operations due to *Ulva*. Drifts up to 70 cm deep on the channel floor near the tanker berth clogged both the cooling intakes on a berthing tanker and on two assisting tugs, with all vessels experiencing engine overheating.

2.4.6 Environment B.O.P's NERMN Coastal and Estuarine Ecology *Ulva* Studies

In addition to the harbour-wide algal survey which was conducted as part of the Tauranga Harbour Regional Plan Project, the following sets out the locations and methods used in Environment B.O.P's Coastal and Estuarine Ecology, *Ulva* monitoring studies.

A total of four sites are monitored for a number of variables relating to the growth of *Ulva*. Three of the sites were positioned in Tauranga Harbour in areas which had been identified in Tauranga Harbour Regional Plan Project - algal surveys as having high abundance of *Ulva*. These surveys had shown that only low abundance of *Ulva* existed in the northern harbour with most high density areas occurring in the southern harbour. Despite the lower abundance in the north of Tauranga Harbour one site was established here to provide information from a region of the harbour which can be considered partially hydrodynamically separated from the southern harbour.

One site was established in Ohiwa Harbour approximately 75 km to the southeast of Tauranga Harbour to act in part as a spacial control to the Tauranga Harbour sites.

Figure 2.6 shows the *Ulva* monitoring sites in Tauranga Harbour. Site 1 is located in the northern harbour at Ongare near the centre of the bay. The shore profile is low and extends nearly 500 m to the spring low tide level. Sediments consist of clean medium-fine sands and sea grass beds cover most of the mid-shore zone. Site 2 in the southern harbour is located along the Otumoetai foreshore approximately 1 km north of the Waikareao Estuary and is very similar to Site 1 in shore profile, aspect, sediments, etc. Site 3 in located

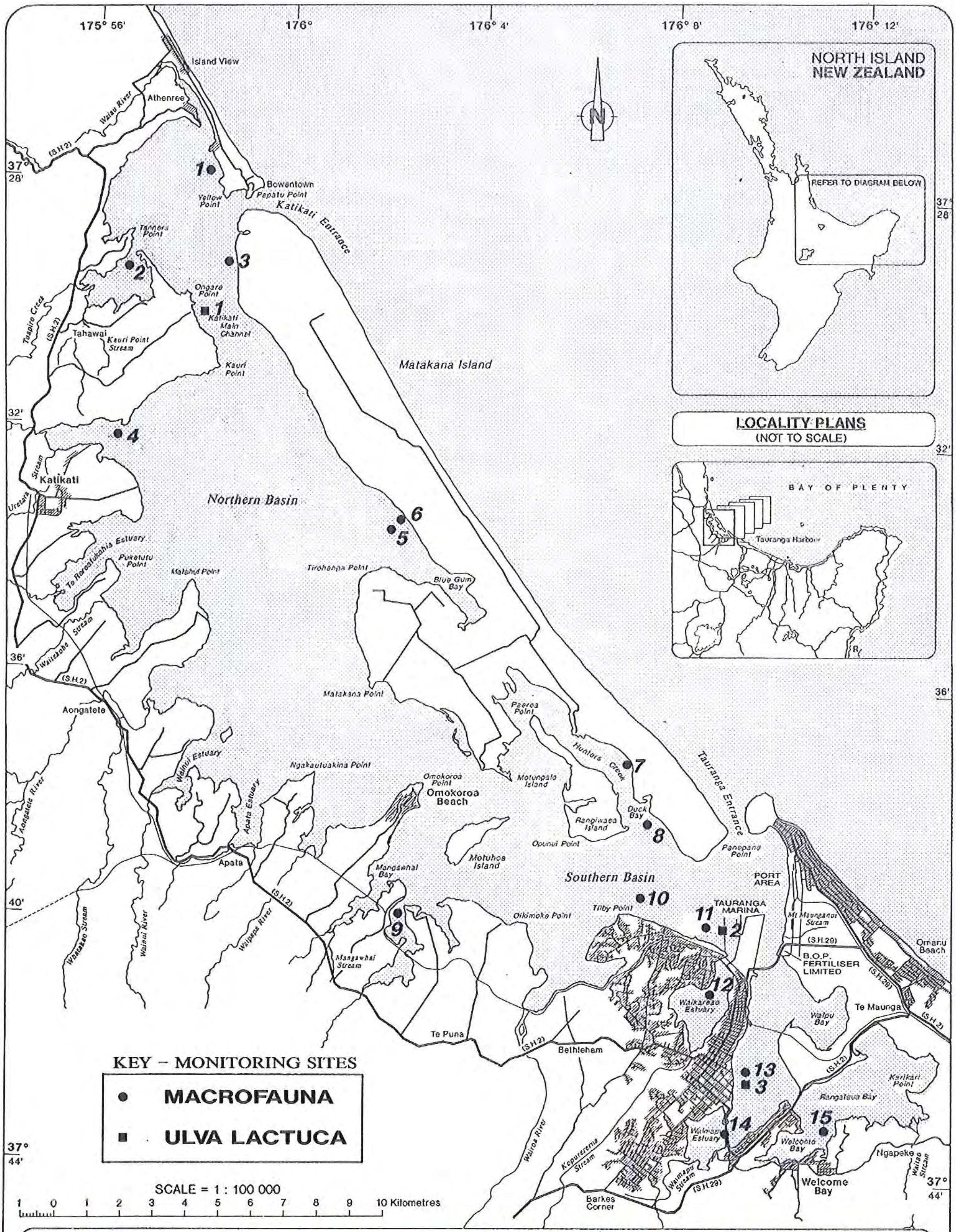

FIGURE 2.6 **LOCATION OF COASTAL ESTUARINE ECOLOGY REGIONAL MONITORING NETWORK SITES IN THE TAURANGA HARBOUR**

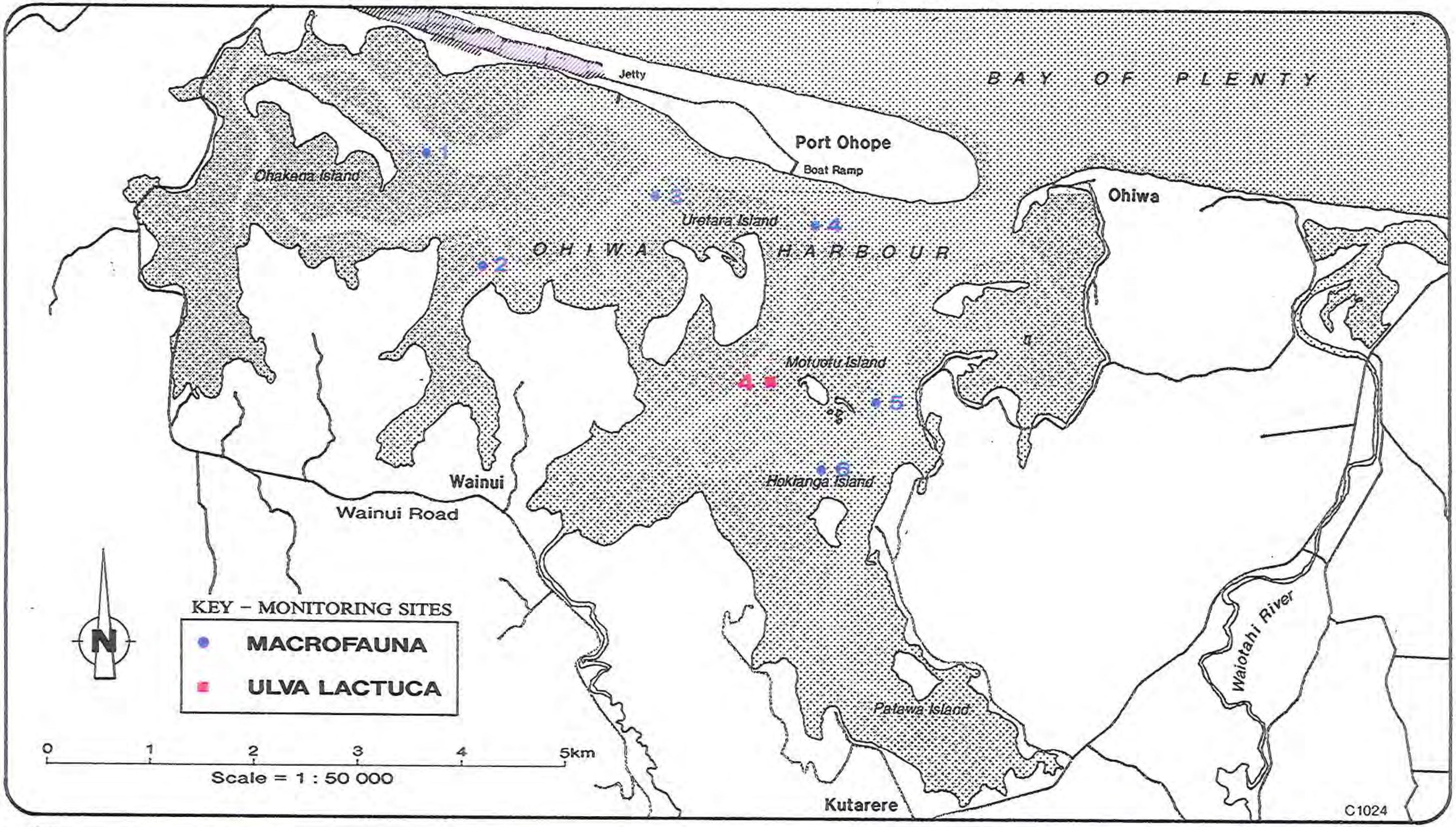

FIGURE 2.7

LOCATION OF COASTAL AND ESTUARINE ECOLOGY REGIONAL MONITORING NETWORK SITES IN THE OHIWA ESTUARY in the Town Basin of the southern harbour near Memorial Park. The shore profile is slightly steeper and extends approximately 350 m to spring low-tide. Sediment characteristics are similar between Sites 1, 2 and 3.

Site 4 in Ohiwa Harbour (Figure 2.7) is located in an area which in the past (1975) has been reported as having the highest densities of *Ulva lactuca* within that harbour (Bioresearches 1975). The shore profile at this site forms an extensive mid-shore platform with a moderately steep bank dropping down to the spring low-tide level. Sediments are predominantely medium-fine sands but there is abundant shell material present. Part of the outflow from the Nukuhou River passes through this channel on the ebb tide creating fluctuations in salinity etc which are normally greater than those for the Tauranga Harbour sites.

2.4.6.1 Methods

Monitoring of the four *Ulva* sites is conducted at least once every two months on days with spring low water occurring around mid-day. At each site except Site 4 in Ohiwa Harbour, mid-lower shore, and spring low water zones are monitored for *Ulva* abundance. At Site 4 there is no mid-shore sampling and two points are monitored along the channel at the spring low water level because of the steep banks. On each monitoring occasion the following information is gathered;

a) *Ulva* cover :- Percentage cover is measured within two permanent 20x20 m blocks at each site by recording 12, 0.25 m^2 grided quadrat counts randomly positioned within each block. As outlined above one block is positioned in the mid-lower shore zone, and one in the spring low water zone. Aerial photography covering regions of high *Ulva* density in the southern and northern harbour is conducted to provide a large scale assessment of variability in abundance between years;

b) Biomass :- Biomass of *Ulva* is recorded at the spring low tide level at each site by collecting material from five randomly positioned 0.25 m^2 quadrats within the permanent block and noting its percentage cover. The samples are later individually washed and air dried at 40°C to provide accurate dry weight records of biomass.

c) Nutrients :- Water samples are collected from surface water close to the time of low tide in a depth of 50-80 cm and analyzed for TP, DRP, NH_4-N, NO_3-N, SS, salinity, conductivity, and temperature.

Sediment samples comprising a minimum of ten sub-samples are collected from the top 2 cm of sediment from within the spring low water sampling area at each site. These sediment samples are analysed for TP, DRP, TOC, TKN, NH_4-N, and NO_3-N. Once every year the sediments are also analysed for grain size composition.

d) *Ulva* tissue nutrients :- From within the spring low water sampling area at each site a minimum of six relatively healthy plants are collected for analysis of nutrient composition. If possible attached plants are selected and if algal mats are present, then plants are taken from the top of the mats. These plants are returned to the lab, washed and air dried at 40°C, then oven dried before analysis of Carbon, Total Nitrogen, and Total Phosphorous content.

e) Recruitment :- attempts to monitor settlement rates at each of the sites is being undertaken by providing settlement plates but to date this has not proved effective because of practical problems which need to be overcome.

In addition to the above investigations, other relevant data gathered as part of the Natural Environment Regional Monitoring Network includes water quality samples collected at two monthly intervals in Tauranga and Ohiwa Harbours. Samples are collected from seven surface water sites in Tauranga Harbour and from two sites in Ohiwa Harbour. These samples are collected at high tide and analysed for salinity, temperature, SS, TP, DRP, NH_4-N and NO_3-N.

A temperature recorder for surface waters in the vicinity of the port at Mount Maunganui is now in place. This recorder will provide data on seasonal and long term variations in Tauranga Harbour coastal water temperatures.

2.4.6.2 Results

Large scale temporal abundance and distribution variations.

From Table 2.2 and results of statistical analysis in Section 2.2 it was shown that based on broad geographic divisions of Tauranga Harbour into the main hydrodynamic basins, at the time of the survey significantly different abundances of *Ulva* existed between the areas. There were significantly higher abundances present in the southern harbour, especially in the Town Basin. Even within the Southern and Town Basins of Tauranga Harbour the distribution of *Ulva* is not uniform but is concentrated into areas where it grows either attached or in areas where hydrological conditions allows its retention in huge drifts.

The results of the algal surveys for *Ulva* density throughout Tauranga Harbour were mapped and digitised. Due to problems of scale it is not practical to reproduce full harbour-wide maps in this report. Instead an area from both the northern and southern harbour covering regions central to high *Ulva* density were selected. These areas measure 3.5 x 4.5 km and are defined by the co-ordinates NZMS 260, U13-710090-710045-745090-745045 and U14-875890-875845-910890-910845 for the northern and southern harbour respectively.

Figure 2.8 shows the area around Ongare - Kauri Point which displayed the highest *Ulva* densities in the northern harbour at the time of the 1990/91 algal survey. At this time there were no areas that exceeded a surface cover of 30%. Figure 2.10 centred on the Otumoetai - Waikareao Estuary - Town Reach area reflects the higher overall abundance found in the southern harbour and also shows areas of *Ulva* exceeding a surface cover of 30%. The densities mapped in each of these figures reflects the findings of significantly higher *Ulva* abundance in the southern harbour.

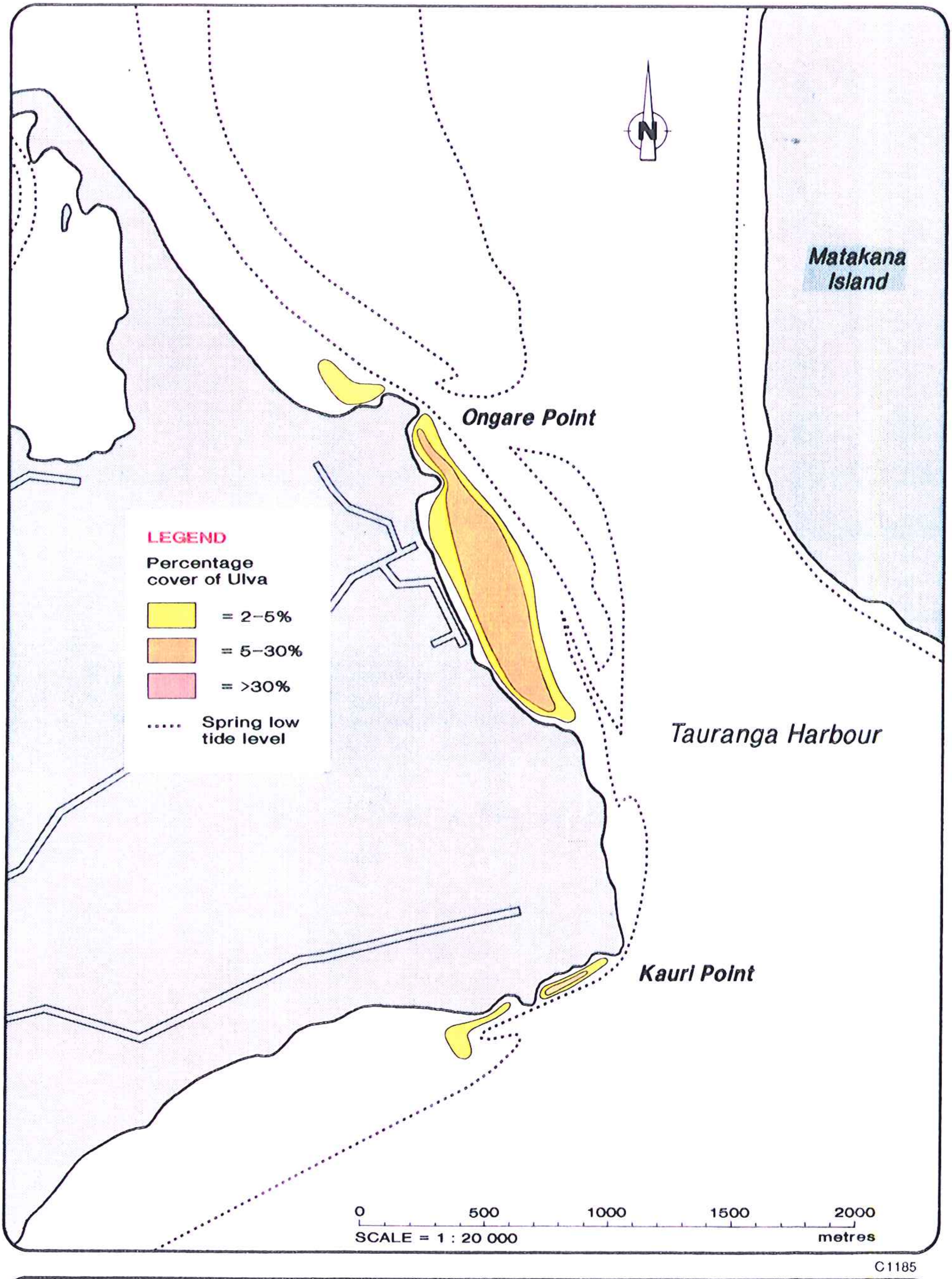

FIGURE 2.8

DISTRIBUTION AND PERCENTAGE COVER OF ULVA LACTUCA (SEA LETTUCE) IN THE NORTHERN TAURANGA HARBOUR NEAR ONGARE AS DETERMINED BY ALGAL TRANSECTS MEASURED IN THE SUMMER 1990–91.

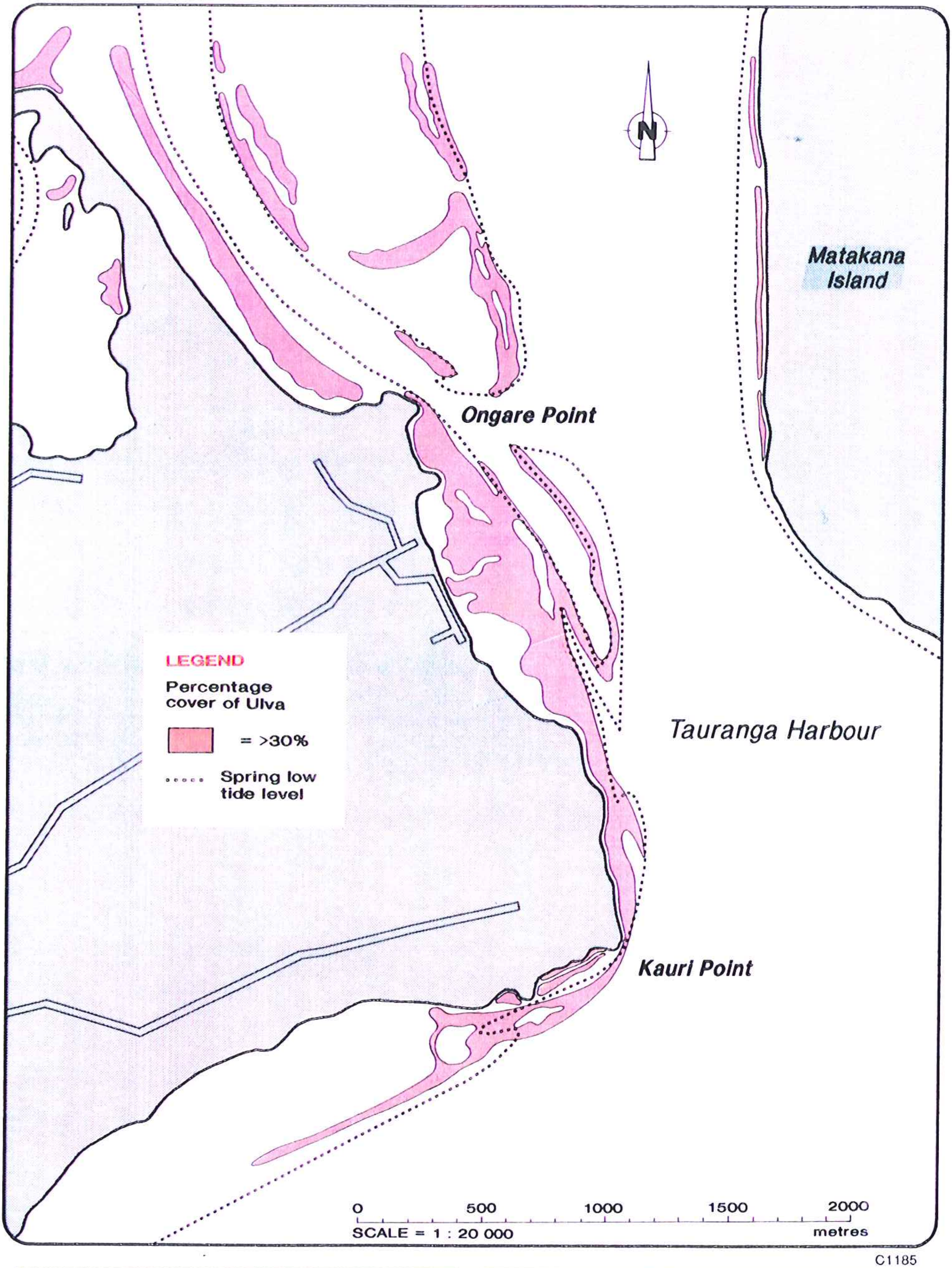

FIGURE 2.9

DISTRIBUTION AND PERCENTAGE COVER OF ULVA LACTUCA (SEA LETTUCE) IN THE NORTHERN TAURANGA HARBOUR NEAR ONGARE AS DETERMINED BY AERIAL PHOTOGRAPHY IN SEPTEMBER 1992.

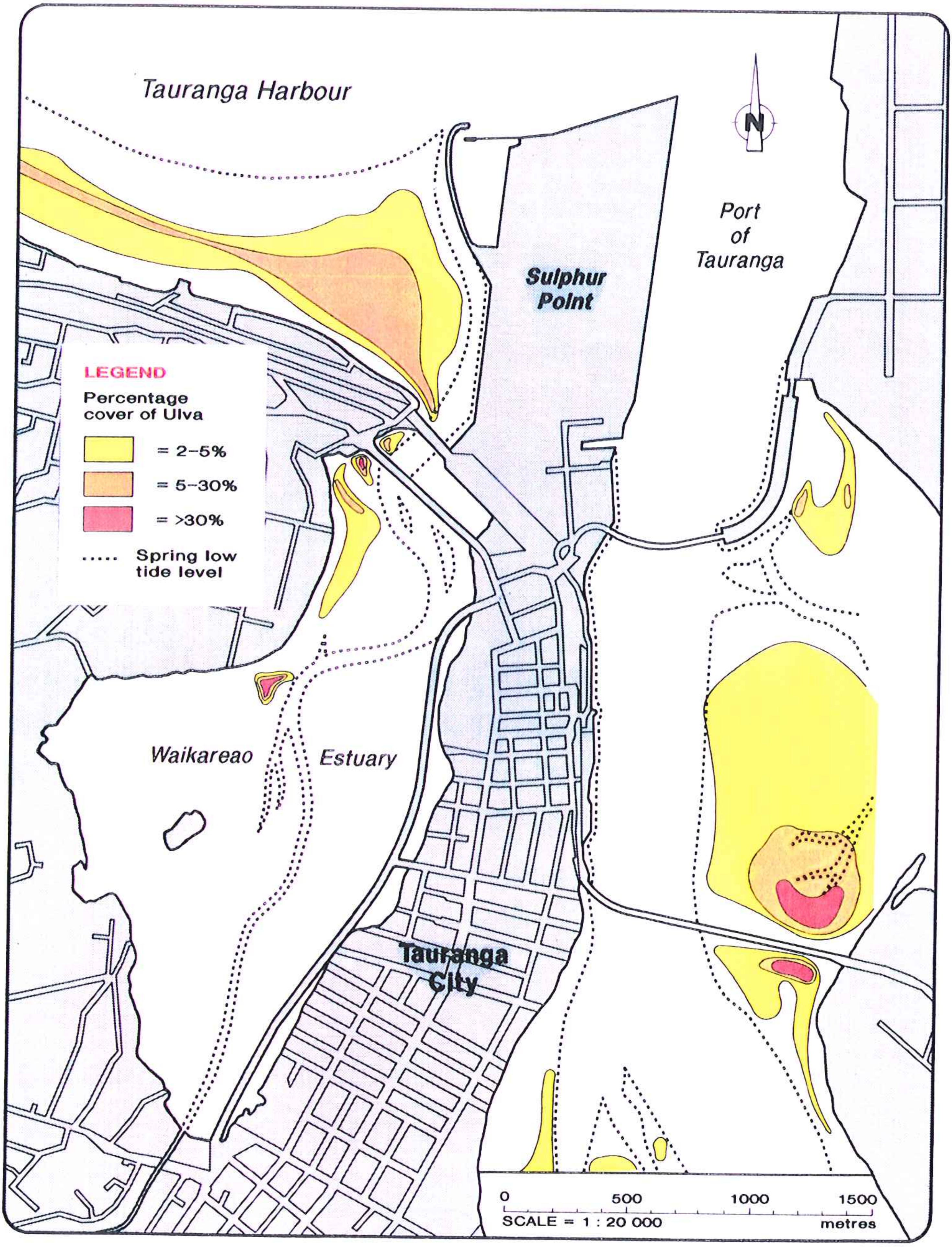

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FIGURE 2.10

DISTRIBUTION AND PERCENTAGE COVER OF ULVA LACTUCA (SEA LETTUCE) IN THE SOUTHERN TAURANGA HARBOUR NEAR THE PORT–CITY AREA AS DETERMINED IN THE SUMMER 1990–91.

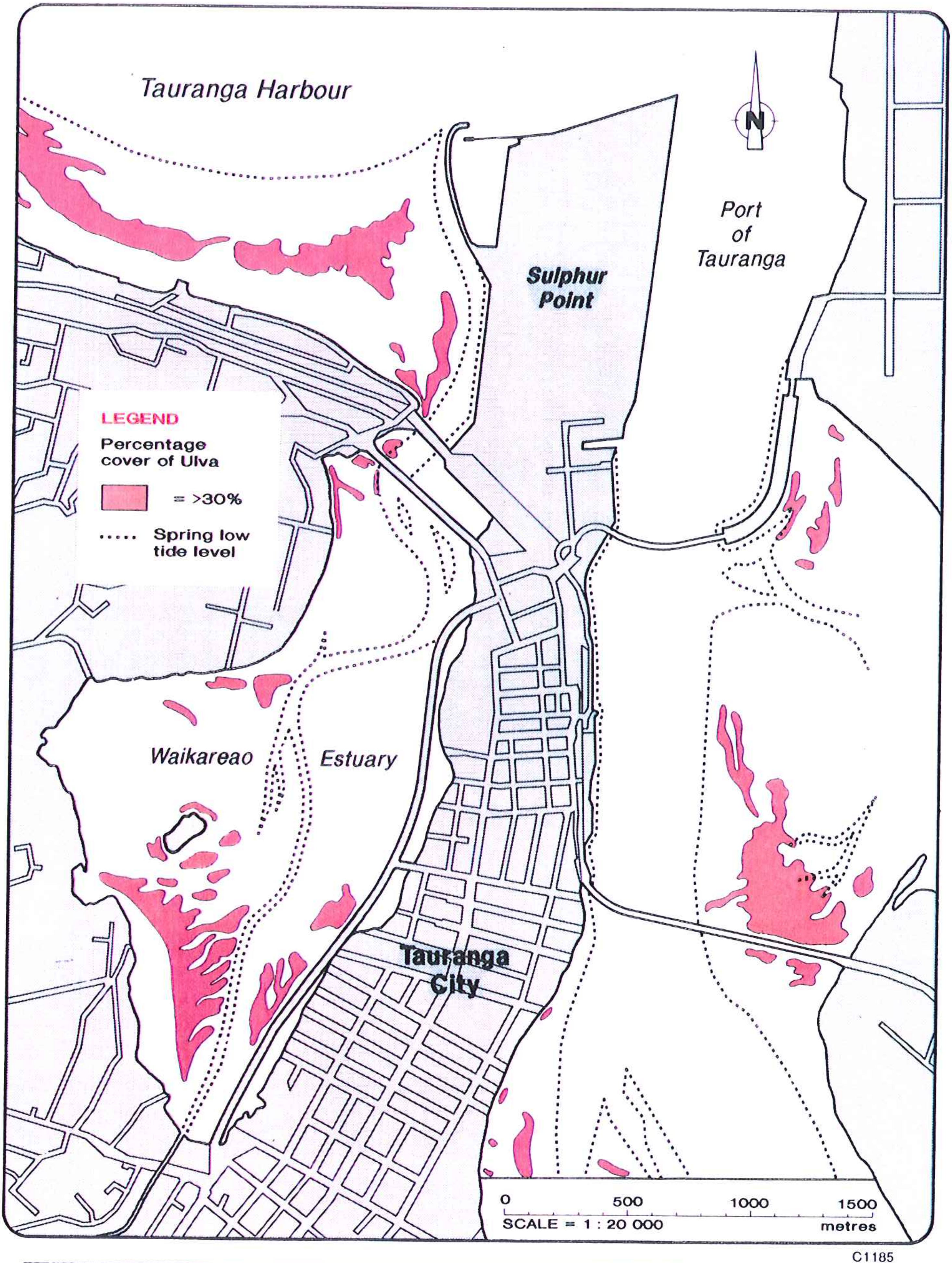

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FIGURE 2.11

DISTRIBUTION AND PERCENTAGE COVER OF ULVA LACTUCA (SEA LETTUCE) IN THE SOUTHERN TAURANGA HARBOUR NEAR THE PORT-CITY AREA AS DETERMINED BY AERIAL PHOTOGRAPHY IN SEPTEMBER 1992.

For each of the two mapped regions, aerial photography flown on the 25th September 1992 was used to estimate the changes in *Ulva* density since the ground survey in summer 1990/91. Only the areas exceeding 30% surface cover were estimated and re-mapped as densities below this could not be determined from the air. The results of the aerial mapping are shown in Figures 2.9 and 2.11.

Increases in the abundance of *Ulva* both in the northern and southern harbour has been dramatic over the one and a half year period depicted by the results of the aerial mapping. In Figure 2.10 the area covered by *Ulva* at densities greater than 30% was approximately 5.98 hectares. In Figure 2.11 this has increased to an area of approximately 77.2 hectares. At Ongare there was no area exceeding 30% cover in the first ground survey and for the latter aerial survey the area is estimated to be 106.3 hectares.

In Figures 2.9 and 2.11 an estimate of dry weight of *Ulva* can be made on the assumption that for the areas of surface cover exceeding 30% there will be an average dry weight value of 80 g m^{-2} (equal to cover of 80-90%). Applied to the results from Figure 2.11 for the Otumoetai - Town Reach region this would provide a conservative estimate of biomass of 61.76 tonnes dry weight. This figure applies only to the intertidal area mapped as being above 30% surface cover. At the time the aerial survey huge quantities of drifting *Ulva* could be seen subtidally in the channels of both the northern and southern mapped regions. Estimated biomass for the Ongare region shown in Figure 2.9 is 85.04 tonnes dry weight.

To further show the conservative nature of the *Ulva* dry weight estimates provided above, the following can be considered. In the northern half of Ongare Bay there is a zone of dense *Ulva* measuring approximately 100 m x 700 m which was inspected on the 28th September 1992. Measurements of biomass from this zone shows an average dry weight of 640 g m^{-2}. This equates to 44.8 tonnes dry weight, around half the total amount biomass estimated for the mapped region. There are some smaller areas near Kauri Point where the mats are even denser and probably exceed 3000 g m^{-2} dry weight. At the time of the ground survey in 1990/91 some dry weight measurements were made and patches of *Ulva* up to 707 g m^{-2} were recorded in the Town Reach. A conversion factor for dry to wet weight, determined for *Ulva* from Tauranga Harbour was 7.17 $\pm$ 0.072 (n=6).

Comparison of biomass values can be made with overseas studies on algal mats where densities have reached levels considered to result in either ecological or aesthetic impacts. Many of the figures are reported in wet weight so all values presented here are converted to wet weight using the conversion factor of 6.8 $\pm$ 0.2 determined by Price and Hylleberg (1982) for *Ulva fenestrata*. Figures for overseas biomass range from 2-3 kg (Johnson and Welsh 1985) and 3-8 kg (Price and Hylleberg 1982) up to 6-9 kg m^{-2} (Sfriso *et al* 1987). Values from the worst affected areas in Tauranga Harbour reach 4-5 kg m^{-2} over moderately extensive areas and reach maximum values around 20 kg m^{-2} in small areas where tidal currents have accumulated the drift *Ulva*.

Relationships between *Ulva* abundance and water chemistry in 1990/91.

The existence of possible relationships between the nutrient status of waters in waters in the selected areas of Tauranga Harbour and *Ulva* abundance was investigated using Pearson and Spearman correlations on data collected as part of the Tauranga Harbour Regional Plan Project.

Ulva abundance used in the correlations was the mean percentage cover of all the sampling points on each of the individual algal transects measured over the summer in 1990/91. Nutrient and other water chemistry data used was based on the mean value of all high and low tide samples combined (n = 12) from the thirty-three sites sampled in Tauranga Harbour from July 1990 to June 1991.

Pearson correlations on the data showed significant results between the mean percentage of *Ulva* cover at each transect and the mean amount of DRP, NO_3-N and turbidity recorded at the water chemistry sites. The probabilities were 0.002, 0.03, and 0.018 respectively with DRP and NO_3-N being positive correlations while turbidity was negative. Other parameters for which no significant correlations were found, included TP, NH_4-N, salinity, and Suspended Solids.

Results of the ranked correlations (Spearman) produced similar results. Significant correlations were found between the abundance of *Ulva* and DRP (P = 0.000), NH_4-N (P = 0.003), NO_3-N (P = 0.003) and salinity (P = 0.037). Salinity was highly correlated to NO_3 levels and in addition was not recorded at levels low enough to inhibit the growth of *Ulva*. It is therefore not a cause and effect relationship. The full set of results is contained in Appendix 8.5

Temporal changes in *Ulva* biomass and percentage cover.

The following presents results for the first two full years of *Ulva* monitoring conducted as an element of Environment B.O.P's Coastal and Estuarine Ecology Programme.

In Figure 2.12 the relationship between the percentage cover and dry weight per 0.25 m^2 is shown. The percentage cover measurements can provide reasonably accurate estimates of biomass up to 90% surface cover. Over 90%, and especially once 100% surface cover is achieved, the biomass values become very wide-ranging and dependant on the depth of the *Ulva*. The only reliable way to achieve accurate estimates of biomass at high percentage surface covers is by making either wet or dry weight measurements. Dry weight measurements are the more accurate of the two.

The results of percentage cover measurements at the mid and spring low tide levels for each of the four monitoring sites are presented in Figure 3.10.

At Ongare Point the plot showing the mid shore cover is not just a reflection of growth and decline at the site in isolation. When monitoring first began the percentage cover at the low tide level was very high and increased slightly on the next sampling occasion but then dropped dramatically due to winds and tide removing nearly all traces from the area monitored.

The later increase of percentage cover shown at the Ongare site from February 1992 onwards appeared to be due to the effects of both growth and accumulation of drift plants. At the low tide level the initial increase was due entirely to growth of attached plants with subsequent increases occurring mainly as a result of drift plants settling onto the site. Sea lettuce cover reduced markedly in late 1992 at both tidal levels due to strong winds having pushed the plants out of the bay.

At Otumoetai both the mid and low tide sites had increases in percentage cover due to growth of *Ulva* at the sites. The large reduction in percentage cover in late summer appeared to be the result of plants being moved away by wind and tides in addition to a seasonal pattern of die-back as a result of desiccation and heat stress. No *in situ* die-back, decomposition, or grazing pressure on the plants was noted.

The Grace Road (Town Reach) upper site displayed a pattern that was influenced by spring growth and reductions over summer. The low tide site is highly influenced by drifting *Ulva* and shows the highest grazing pressure observed at any of the sites in Tauranga Harbour.

The near total absence of sea lettuce at the Grace Road site for the June 1992 monitoring occassion was the apparent result of winds and tide removing all plants (not grazers) from this area of the harbour. The same event also affected sea lettuce abundance at the Otumoetai site and the whole of the southern harbour in general. These results show that wind and tide patterns are capable of having a large influence on *Ulva* abundance in Tauranga Harbour and although they are unpredictable events there could be greater or lesser probabilities of such patterns in association with El Nino type weather patterns.

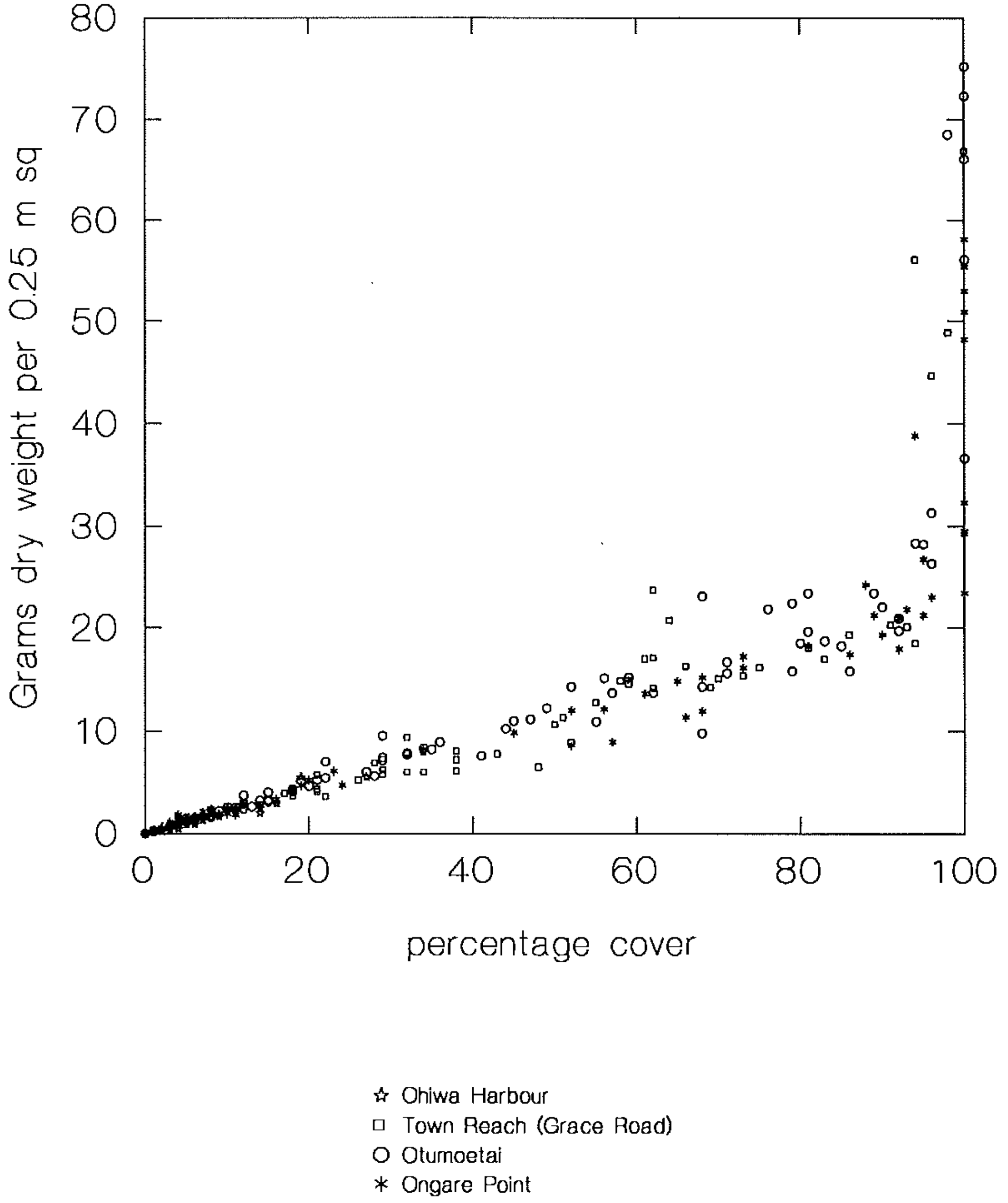

Figure 2.12 Relationship between sea lettuce (Ulva) biomass measured as dry weight per 0.25 m sq and the percentage cover at the same sites. Three of the sampling sites are in Tauranga Harbour and one is in Ohiwa Harbour.

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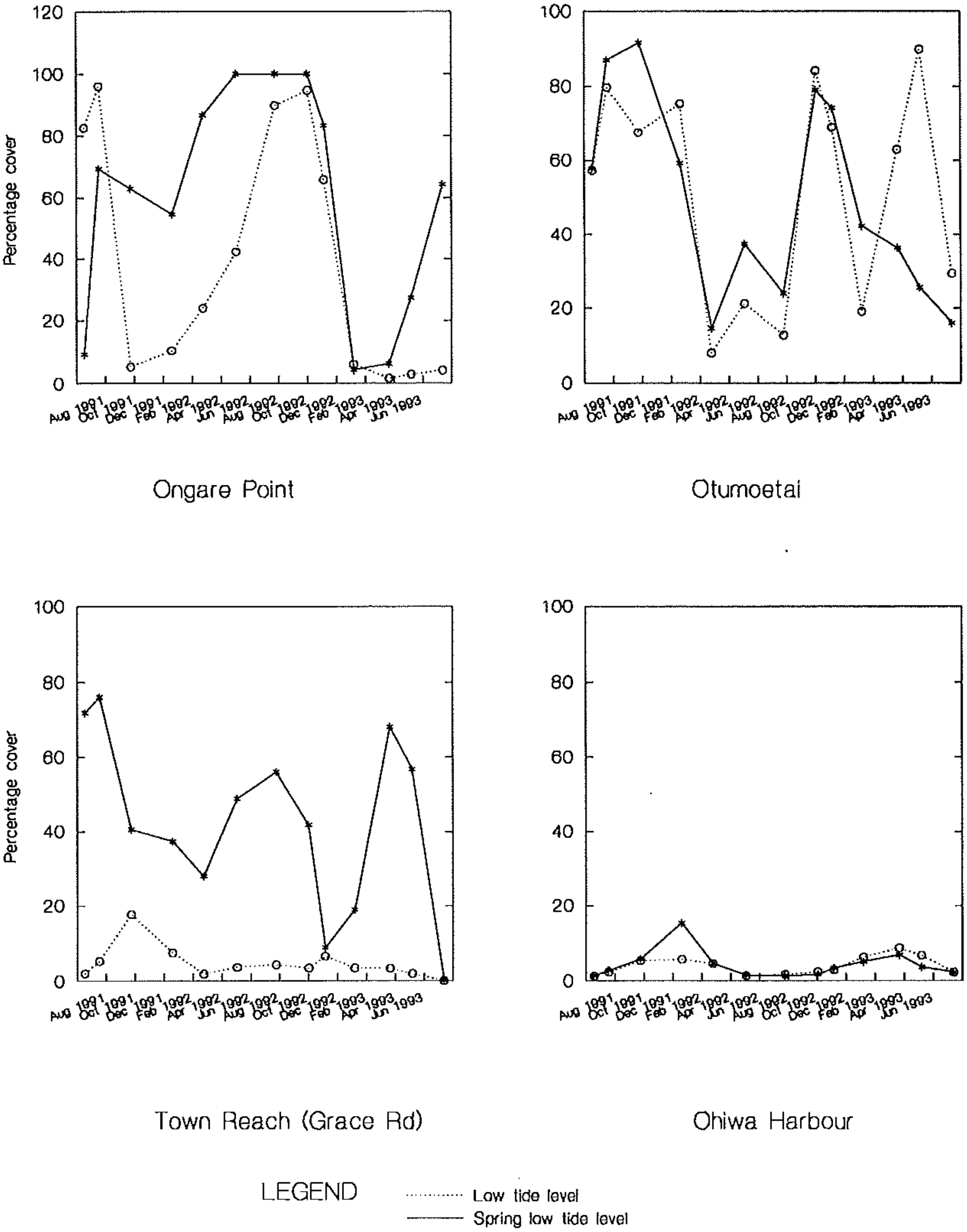

Figure 2.13 Percentage cover of sea lettuce (Ulva) at each of the four Coastal and Estuarine Ecology Regional Monitoring sites in Tauranga and Ohiwa Harbours. At each site results from 12 (0.25 m sq) replicate counts at both the low and spring low tide levels are presented for the first two years of monitoring.

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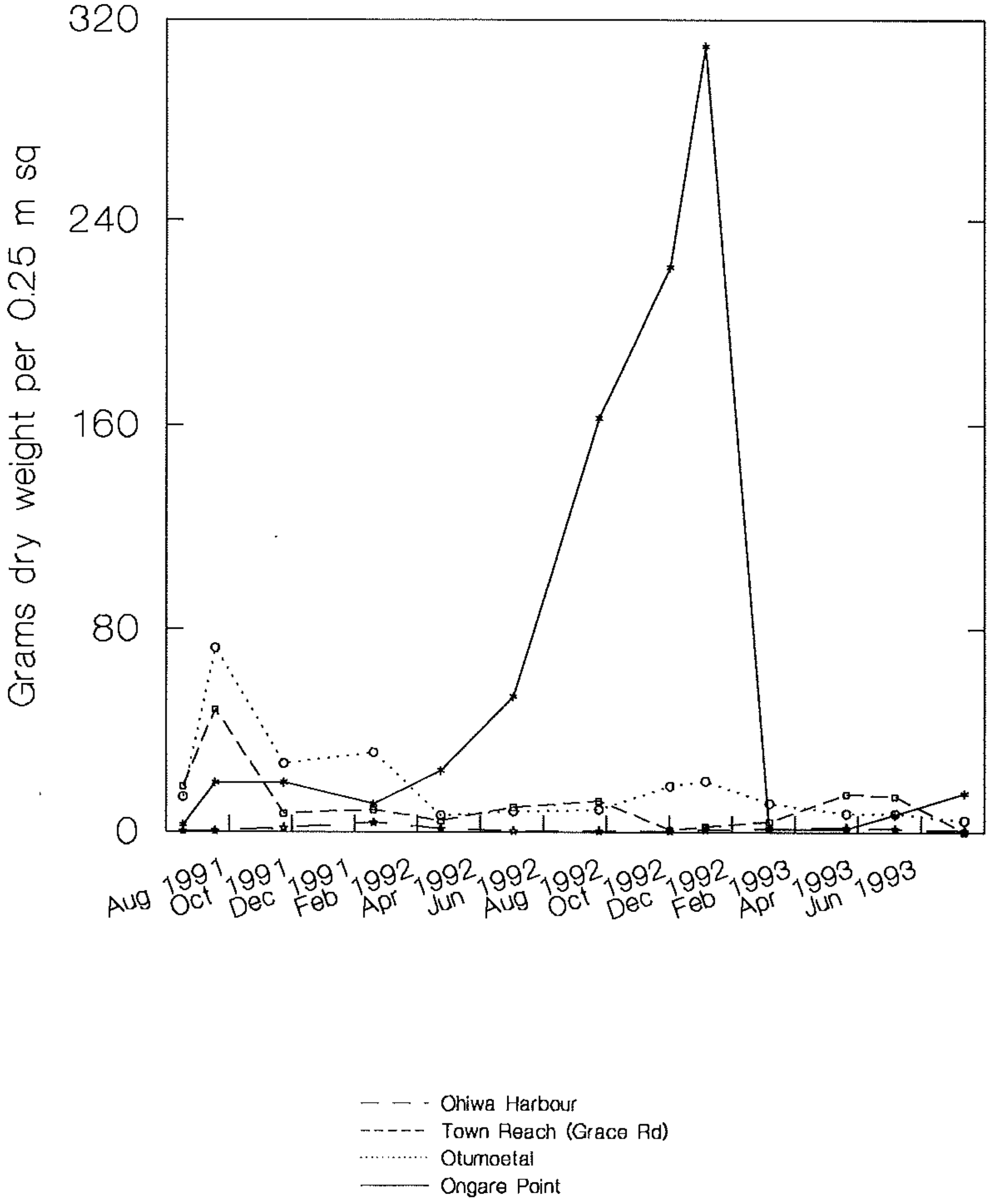

Figure 2.14 Mean biomass of sea lettuce (Ulva) over time measured as dry weight per 0.25 m sq from five replicate samples at the low tide level. Three of the sampling sites are in Tauranga Harbour and one is in Ohiwa Harbour.

R:/pc/systat/coms/rmn/cee/ulva/biomplt.cmd

In Ohiwa Harbour small plants were very numerous but grazing pressure is possibly the highest of all the monitoring sites and appeared to be sufficient to keep the percentage cover very low. The seasonal trend showing an increase during spring and late summer decline is the most apparrent and consistent of all sites monitored.

Biomass results for each of the low tide monitoring sites are presented in Figure 2.14. There is a consistently low biomass in Ohiwa Harbour in comparison to sites in Tauranga Harbour. The trends at both the Otumoetai and Town Reach sites were similar with a general pattern of decline in biomass over the two year period. The extent of the very high build up in sea lettuce biomass at the Ongare site and subsequent dissapearance almost overnight just before the December 1992 sampling occassion is most clearly seen in the biomass plot.

Ulva tissue nutrient analysis

The carbon content of *Ulva* collected from each of the four monitoring sites over time is presented in Figure 2.15. The seasonality in the level of tissue carbon content suggested in the results from the first year of data collection has become far more apparent now that two growing seasons have been covered. The concentration of carbon in sea lettuce tissue tends to be lowest in mid summer and highest over winter. The slightly higher values for the Ohiwa Harbour samples disapeared over the second year of sampling. The suggestion made in the first year that this could be a result of very small plants with the thickened thallus attachment zone nearly always incorporated in the samples may have been correct. Over the latter period of monitoring in Ohiwa Harbour the sea lettuce plants tended to be slightly larger with no differences in tissue carbon content between other sites.

Figure 2.16 presents the results of the analysis of tissue nitrogen content for plants from all sites over time. For all the sites there is now an obvious seasonal trend with Total Nitrogen content being lowest over the warmest period of the year when the plants are generally growing most rapidly. During mid-winter when growth is slow Total Nitrogen is present at levels in excess of critical growth requirements (the internal concentration that just limits maximal growth, see Table 3.5).

The results for the plants from Ongare Point show the lowest Total Nitrogen levels (Table 3.4). The Nitrogen tissue concentrations recorded over the summer sampling occasions indicates from other studies (Fujita *et al* 1989) that nitrogen was only present at subsistence levels (concentration insufficient to allow growth). At the other monitoring sites the Total Nitrogen content of *Ulva* tissue is at levels high enough for growth but on average below the critical level. The ratio of Carbon to Total Nitrogen (Figure 3.14) showed a similar trend to the result for Total Nitrogen alone.

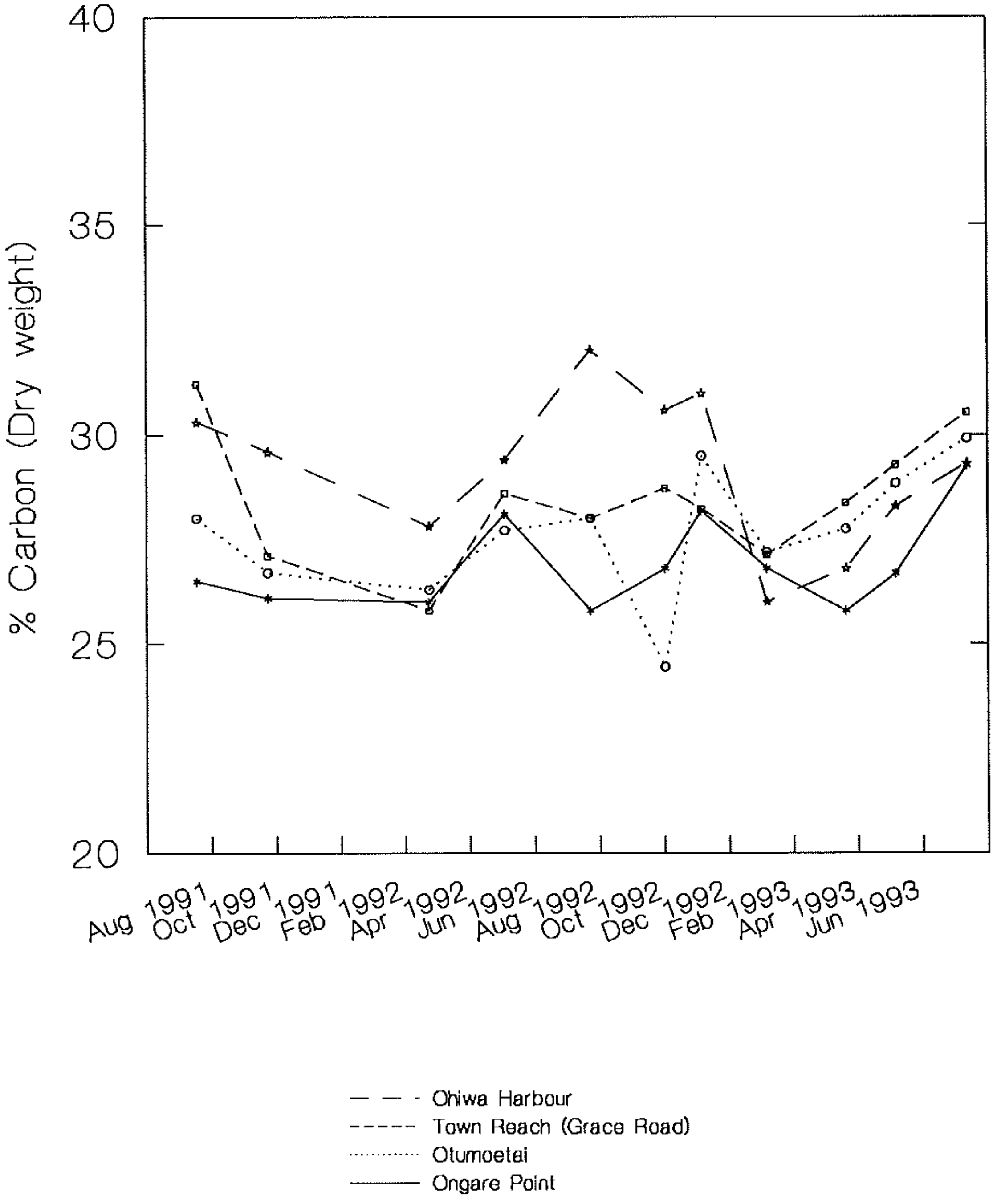

Figure 2.15 Carbon content of sea lettuce (Ulva spp) tissue samples from the low tide level recorded over time for each of the four Coastal and and Estuarine Ecology Ulva monitoring sites in Tauranga and Ohiwa Harbour

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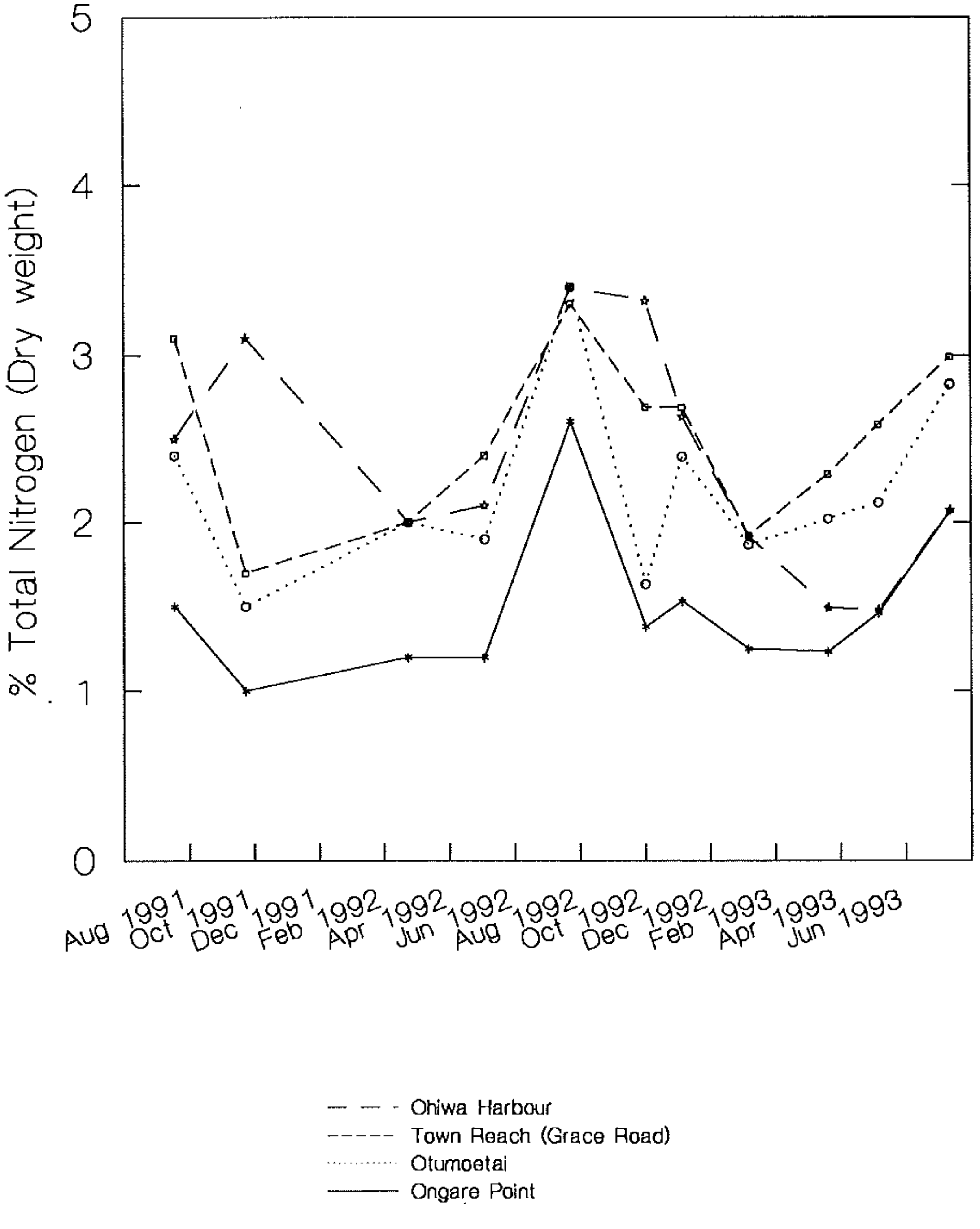

Figure 2.16 Total Nitrogen content of sea lettuce (Ulva spp) tissue samples (dry weight) from the low tide level recorded over time for each of the four Coastal and Estuarine Ecology Ulva monitoring sites in Tauranga and Ohiwa Harbours.

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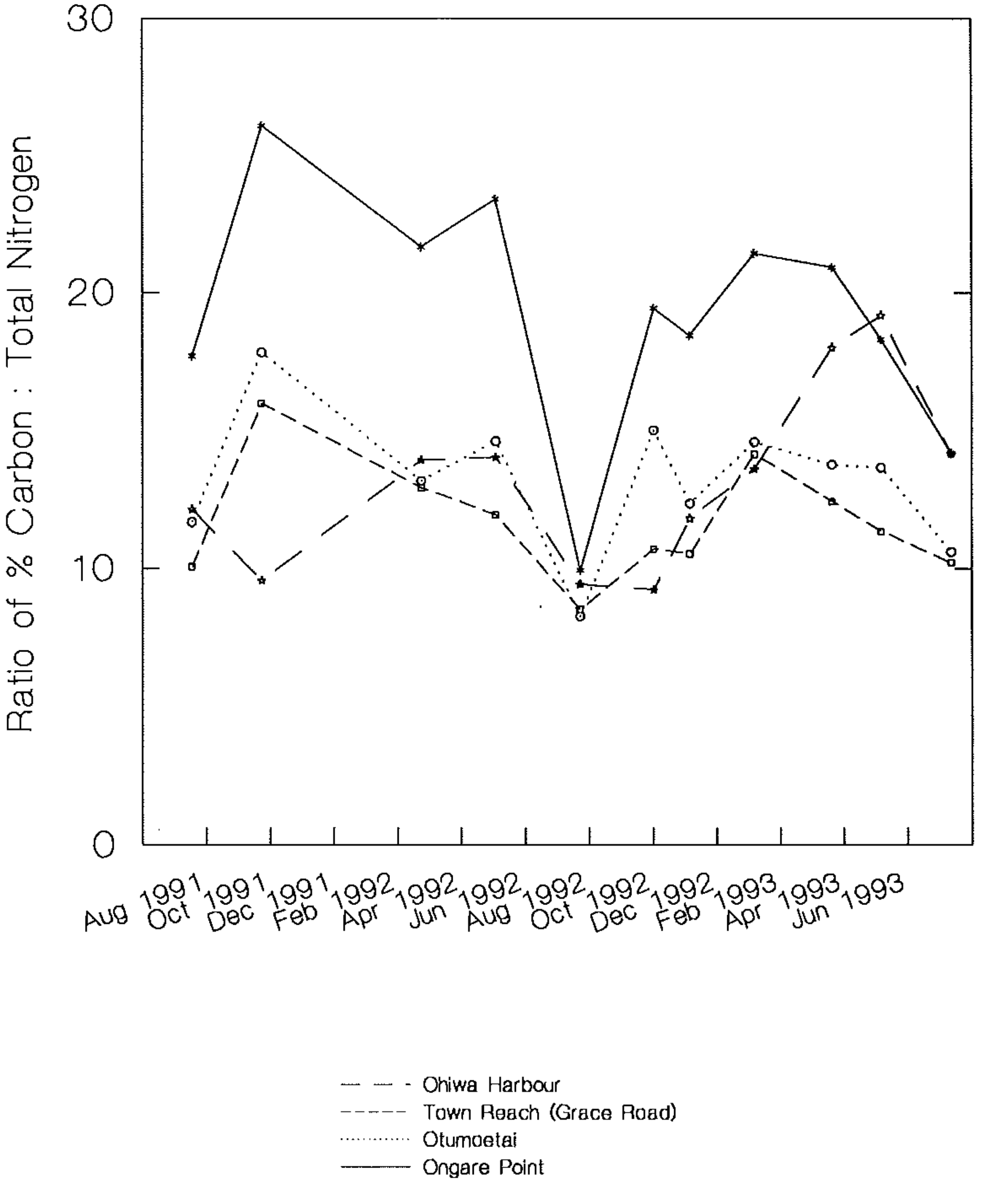

Figure 2.17 Ratio of the Carbon : Total Nitrogen content of sea lettuce (Ulva spp) tissue samples from the low tide level recorded over time for each of the four Coastal and Estuarine Ecology Ulva monitoring sites in Tauranga and Ohiwa Harbours.

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Results for Total Phosphorous content of *Ulva* over time at each of the four CEE *Ulva* monitoring sites (Figure 2.18) recorded levels between 0.05 and 0.18% dry weight. At these levels, previous studies suggest that phosphorous availability could be nearing critical levels and restricting growth. As with carbon and nitrogen, the Total Phosphorous content of sea lettuce from the four sites shows a seasonal trend.

Figure 2.19 presents the dry-weight and atomic ratios of Total Nitrogen to Phosphorous content of sea lettuce monitored at the four CEE *Ulva* sites. The results show that nitrogen is more abundant in proportion to phosphorous during the winter when plants are growing more slowly and conversely lowest when sea lettuce is growing rapidly in the warmer summer conditions.

Tables 2.4 and 2.5 below present the mean nutrient concentrations from the sea lettuce samples for each site and provides comparisons with other studies. Table 2.4 suggests that nitrogen is near or below the critical level while phosphorous is below for all sites.

Table 2.4 Mean tissue nutrient concentration as % dry weight in *Ulva* spp collected from Coastal and Estuarine Ecology monitoring sites in Tauranga and Ohiwa Harbours between August 1991 and June 1993 (n=11, standard error shown) with comparisons to other studies.

Site	Carbon	Nitrogen	Phosphorus	% N:P (atomic)
Town Reach	28.5 (0.46)	2.51 (0.15)	0.14 (0.01)	17.9 (40.9)
Otumoetai	27.7 (0.46)	2.19 (0.17)	0.13 (0.01)	16.8 (37.0)
Ongare Pt.	26.9 (0.34)	1.49 (0.14)	0.11 (0.01)	13.5 (30.1)
Ohiwa Har.	29.2 (0.55)	2.36 (0.21)	0.15 (0.01)	15.7 (34.9)
Ulva lactuca Fujita (1985)				
Field plants	25.6	1.02		
Grown Low N	29.2	1.15		
Grown high N	30.1	3.59		
Canterbury Regional Council (1992)				
Avon-Heathcote Est. 1953		3.93		
Avon-Heathcote Est. 1960		4.20		
Avon-Heathcote Est. 1969		2.92		
Ulva rigida				
Fujita *et al* (1989)		2.1 - 4.2		
Lavery *et al* (1991)		0.9 - 3.4	0.4 - 2.5	
Ulva curvata Duke *et al* (1989)				
Experimental range		0.71 - 2.13		
Ulva fasciata Subbaramaiah & Parelch (1965)				
Field plants		1.76	0.18	
Field " " - nutrient enriched		3.40	0.11	

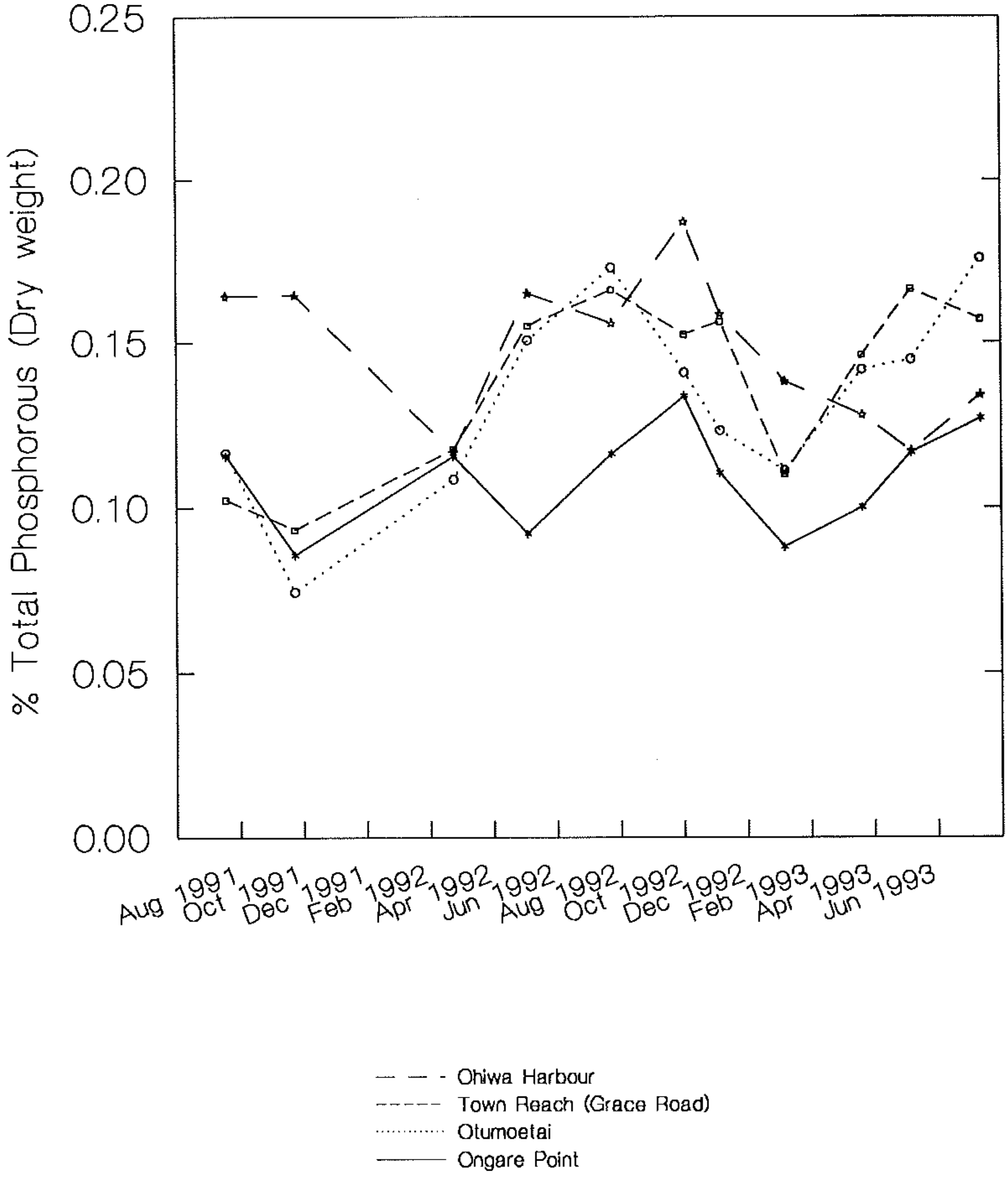

Figure 2.18 Total Phosphorous content of sea lettuce (Ulva spp) tissue samples (dry weight) From the low tide level recorded over time for each of the four Coastal and Estuarine Ecology Ulva monitoring sites in Tauranga and Ohiwa Harbours.

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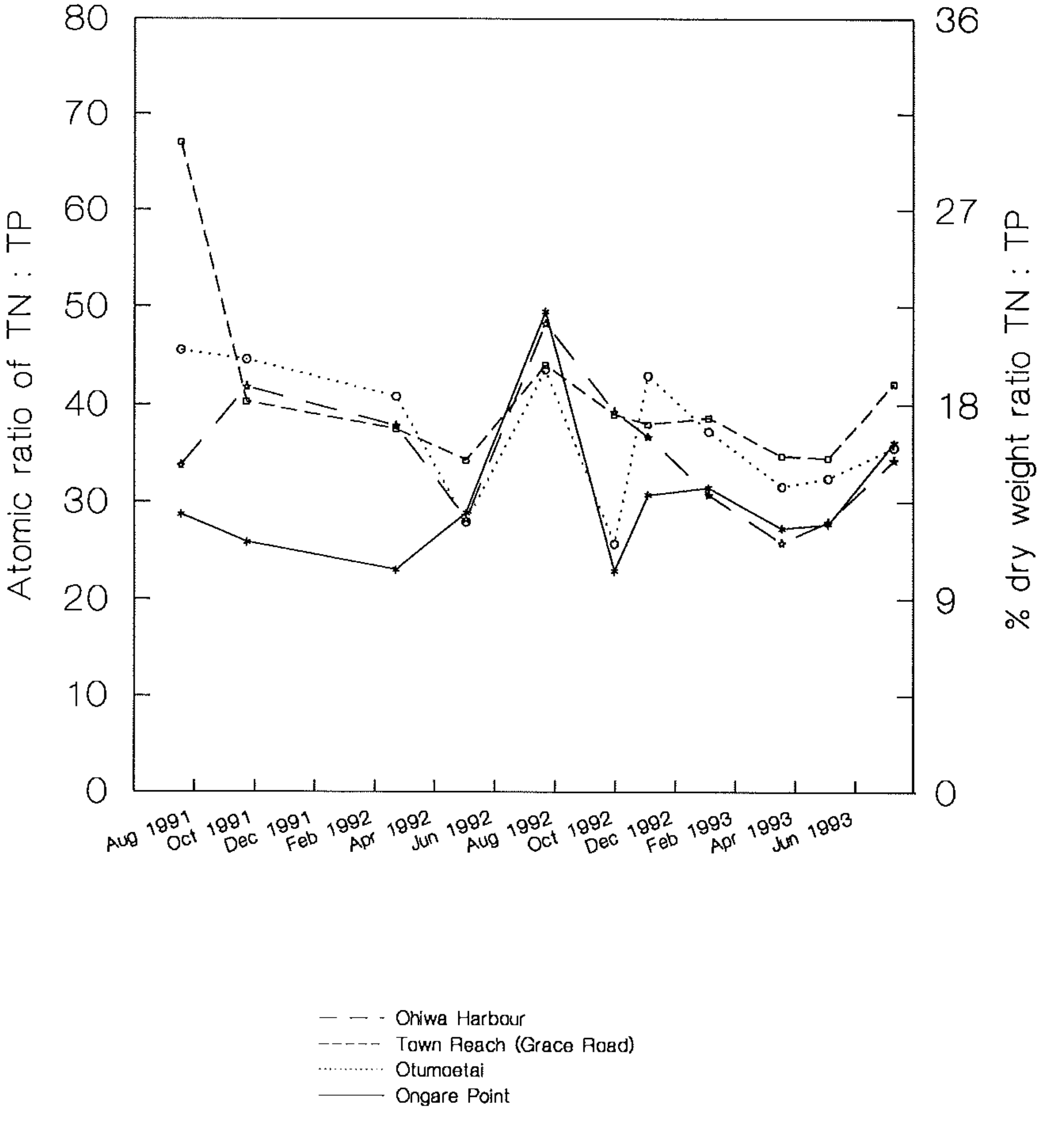

Figure 2.19 Ratios of the Total Nitrogen : Phosphorous concentration of sea lettuce (Ulva spp) tissue samples from the low tide level recorded over time for each of the four Coastal and Estuarine Ecology Ulva monitoring sites in Tauranga and Ohiwa Harbours.

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Table 2.5 Critical (and minimal subsistence) tissue concentrations (% dry weight) of Total Nitrogen and Phosphorus recorded for other species of green algae.

Species/source	Nitrogen	Phosphorus	N:P Ratio
Ulva rigida			
Lavery *et al* (1991)	2.0	0.37	5.41 : 1
Fujita *et al* (1989)	2.4 (1.2)		
Cladophora aff. *albida*			
Gordon *et al* (1981)	2.1 (1.2)	0.33 (0.05)	6.36 : 1
Codium fragile			
Hanisak (1979)	2.1		

Sediment chemistry

The sediment particle size distributions for each of the sites is presented in Figure 2.20. For the Tauranga sites there is an additional set of particle size analyses because of the need to quantify observed changes. At the Ongare Point sampling site it was noticed during the May 1992 visit that changes in the sediments were taking place. The mats of *Ulva* were causing large quantities of fine sediment and organic matter to settle out of the water column and become trapped. Results of sediment samples taken on the July 1992 visit show the change from clean fine sands to mud. The later sediment sample taken in June 1993 shows some recovery of the sediment particle size characteristics back toward the original state of sediments before the formation of the *Ulva* mats.

Both the Otumoetai and Town Reach sites were re-sampled as a result of observable impacts in the southern harbour from dredging operations. The Otumoetai site showed only very minor increases in silt content. The greatest impact occurred at the Town Reach site with a marked increase in very fine sands and silts.

Changes in Total Organic Carbon (TOC) content of the surficial sediments at each of the four monitoring sites is shown in Figure 2.21. The large increase of TOC at the Ongare Point site coincides with the formation of the thick *Ulva* mat. Not only did the *Ulva* appear to be decomposing at the sediment surface, but the mats were trapping considerable quantities of drifting organic matter from the water column. With the later loss of sea lettuce cover at the Ongare site, TOC levels have been falling back toward previous concentrations in the sediments. The only other change of any significance appeared to be a slight increase in TOC at the Town Reach site. This increase may have been related to the changes in the sediment.

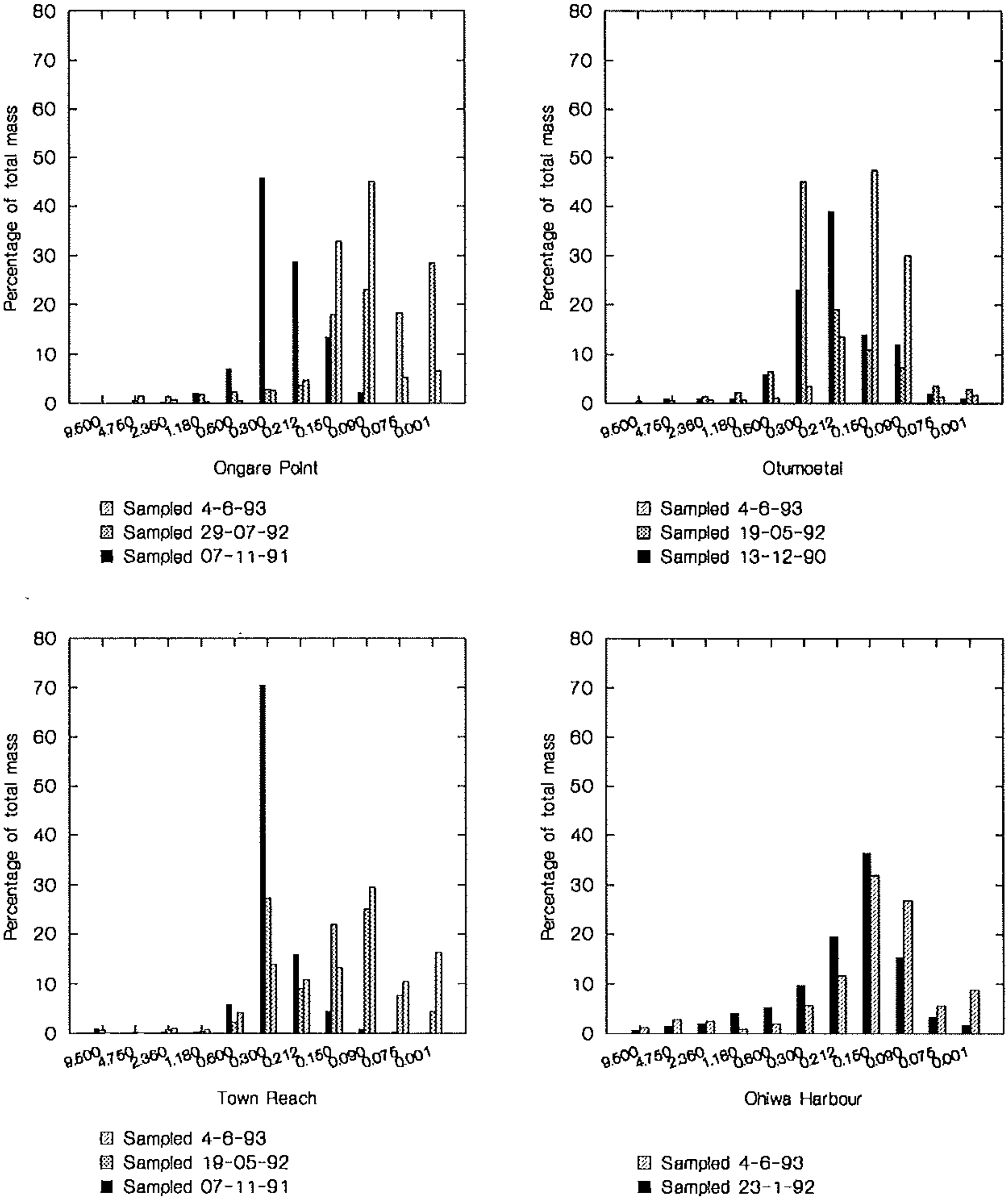

Figure 2.20 Sediment particle size distribution (in mm) at each of the four Coastal and Estuarine Ecology Ulva Monitoring sites in Tauranga and Ohiwa Harbours. For all sites, samples are from the low tide level and results are presented for sampling dates indicated.

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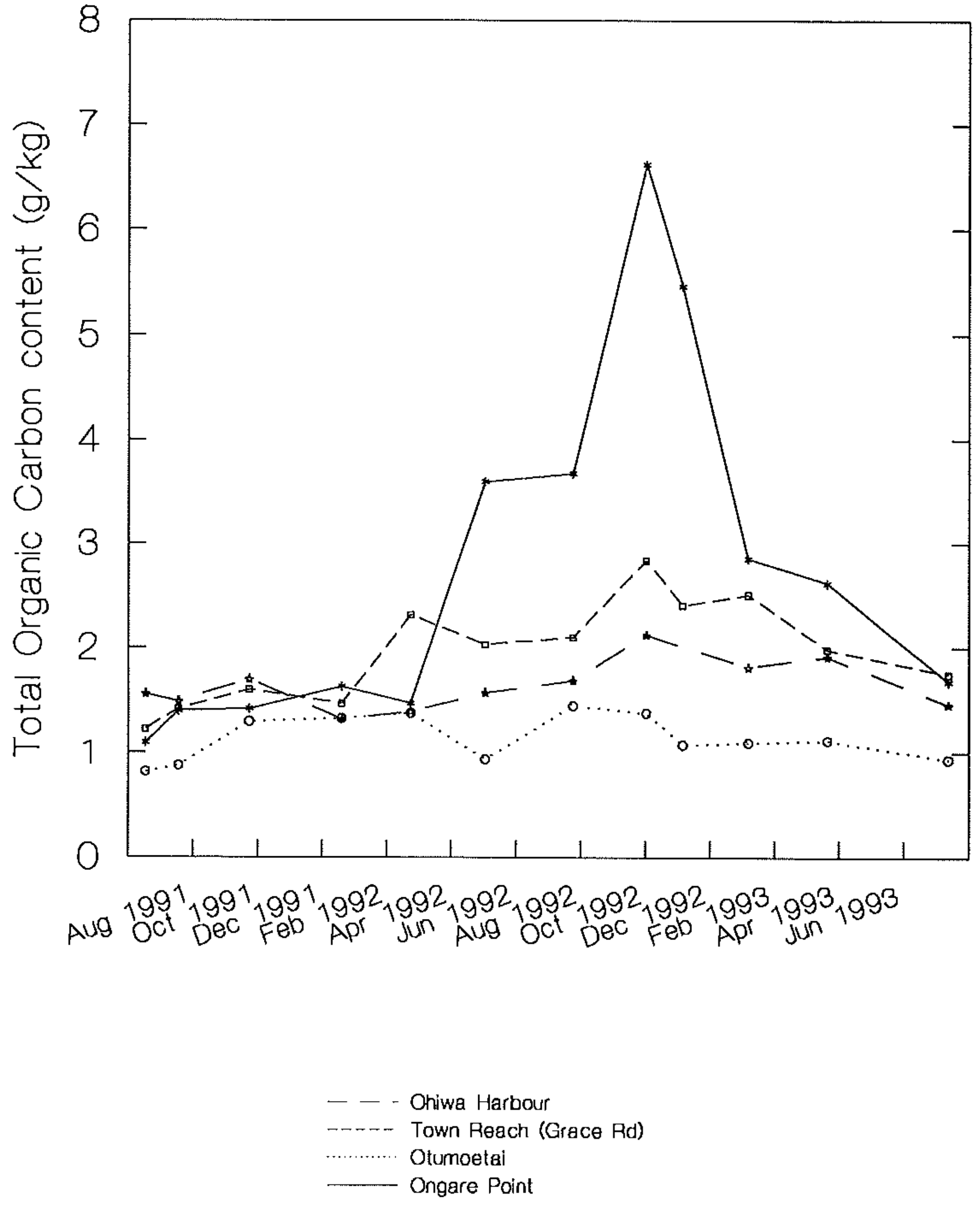

Figure 2.21 Total Organic Carbon content recorded in surficial sediment samples at each of the four Coastal and Estuarine Ecology Ulva monitoring sites in Tauranga and Ohiwa Harbours. For all sites, samples are from the low tide level and results are for the first two years of monitoring.

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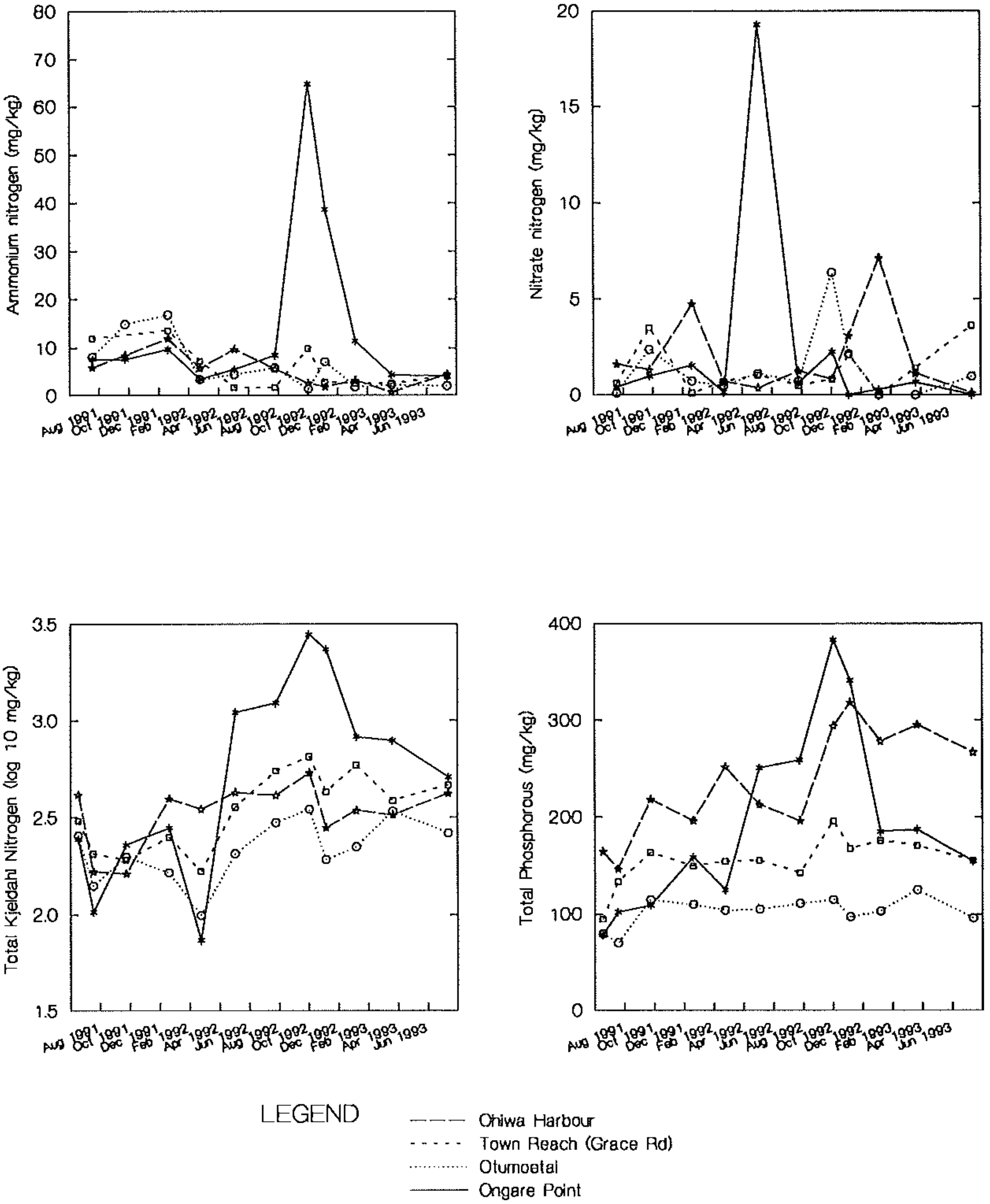

Figure 2.22 Nutrient levels recorded in the surficial sediments at each of the four Coastal and Estuarine Ecology Regional Ulva Monitoring sites in Tauranga and Ohiwa Harbours. For all sites samples are from the low tide level and results are presented for the first two years of monitoring.

Table 2.6 Mean nutrients concentrations in surface sediments from Environment BOP Ulva monitoring sites in Tauranga and Ohiwa Harbours for the period July 1991 to June 1993 with comparisons to other studies (harbour wide means).

Site	Organic content			Total Nitrogen mg/kg			Total phosphorus mg/kg			Nitrate - nitrogen mg/kg			Ammonia - nitrogen mg/kg		
	mean	min	max	mean	min	max	mean	min	max	mean	min	max	mean	min	max
Ongare point	0.28	0.11	0.66	888	77	2869	196	79	383	2.208	0.001	19.283	14.54	3.34	64.70
Otumoetai	0.11	0.08	0.14	237	100	361	103	71	125	1.330	0.001	6.370	6.08	1.35	16.81
Town Reach	0.20	0.12	0.28	397	170	671	158	95	196	1.243	0.001	3.670	5.96	1.63	13.66
Ohiwa Harbour	0.16	0.13	0.21	365	164	558	242	147	318	1.862	0.001	7.147	5.31	0.67	11.95
Moutere Inlet Gillespie et al 1992	3.30	1.00	6.50	745	196	1583	499	248	743				45.00	4.00	108.00
Waimea Inlet Gillespie et al 1992	2.40	1.30	5.60	488	190	1302	331	219	498	0.037	0.020	0.480	23.50	12.10	69.10
Avon-Heathcote Est. Robb 1974					73	4142		216	1235					44.00	1157.00
Canterbury R. C. 1992	1.88	0.80	5.80	580	174	2396	202	140	360	0.100	0.002	0.300	16.55	3.70	96.00
Maketu Estuary EBOP 1992	0.10	0.03	0.16				189	103	293						
Tauranga Harbour EBOP in prep	0.10	0.02	0.42				111	35	302						

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Concentrations of ammonium nitrogen, nitrate nitrogen, TP, and TKN within the surficial sediments at the four CEE *Ulva* monitoring sites over time are shown in Figure 2.22. The most distinct changes shown are those which have taken place at Ongare Point with the formation of the *Ulva* mat and increased mud content of the sediments. At this site TKN, ammonium nitrogen, nitrate nitrogen and TP have all shown marked increases. All these nutrient parameters have fallen back near previous levels following the disapearence of the thick *Ulva* mats.

All the sites initially displayed low sediment nutrient concentrations characteristic of many other comparable sites in Tauranga Harbour (Environment B.O.P Environmental Report 94/10). Table 2.6 provides a comparison of the nutrient status of the four CEE *Ulva* monitoring sites with a range of other studies from within New Zealand. Generally the CEE sites are cleaner sandy sediments with low nutrients and good oxygenation of the surface layer down to the 2 cm depth sampled.

Water chemistry

The physical nature of the *Ulva* monitoring sites in respect of temperature, conductivity, and suspended solids is shown in Figure 2.23. The main difference between the sites appears to be the greater variability of conductivity at the Ohiwa Harbour site as a result of freshwater flow from the Nukuhou River passing through this channel. On the first sampling occasion at the Otumoetai site the influence of freshwater inflows were also recorded.

One point worthy of note for the Suspended Solids (SS) results is that at the Town Reach site, the three highest levels recorded were during that period (10 January - 5 July 1992) in which dredging took place in this channel. The impact of dredging activity on SS at the Otumoetai site appears to be very slight. These results are in agreement with the observed changes of sediment particle size. Because of the shallow nature of the shore sampling most results are above the overall mean SS value (15.03 g m^{-3}) for all sites included in the Tauranga Harbour study.

Results of the overlying water nutrient concentrations at each of the sites (Figure 2.24 and Table 2.7) shows that the Ohiwa Harbour site has consistently recorded marginally higher concentrations of DRP, TP, NH_4, and NO_3 in comparison to the Tauranga Harbour sites. The Ohiwa Harbour and Town Reach sites tend to be above the overall mean DRP value of 0.005 g m^{-3} for all sites in the Tauranga Harbour study while Ongare Point recorded concentrations below the mean. Other mean nutrient values from the Tauranga Harbour study (all as g m^{-3}) were 0.022 for TP, 0.021 for NH_4, and 0.115 for NO_3. At all sites TP values tended to be above the Tauranga Harbour mean value while results for NO_3 and NH_4 showed moderate variability around the mean. Table 2.7 below shows that the Ongare site at low tide recorded the lowest mean nutrient concentrations.

Table 2.7 Mean nutrient concentrations (g m^{-3}) of surface waters at the four CEE *Ulva* monitoring (June 1991-1993) with comparative data from near-by Tauranga high tide water quality sites (Oct 1991-Apr 1993).

Site	DRP	NO3-N	NH4-N	DIN:DRP Ratio
Ongare Point	0.006	0.090	0.013	111.0
Matakana	0.005	0.032	0.005	23.0
Otumoetai	0.009	0.190	0.019	62.5
Mid-Otumoetai	0.005	0.066	0.011	64.2
Grace Rd	0.011	0.124	0.019	44.7
Maungatapu	0.005	0.090	0.013	37.6
Ohiwa Harbour	0.015	0.216	0.036	38.3

Figures 2.25-2.28 provide a comparison of the variation of both physical and nutrient parameters between the low tide surface waters at each CEE *Ulva* site and high tide water quality from Environment B.O.P monitoring sites in the same general area. Temperature and suspended solids (Figures 2.26 & 2.28) tend to be higher while conductivity/salintiy is lower at low tide. Results for the nutrients (Figures 2.25 & 2.27) show Total phosphorous recorded the highest concentrations at low tide while Dissolved Reactive Phosphorous concentrations tend to be highest for the Ongare/Matakana area on the high tide over the time period compared. The later trend was not observed at the Grace Road site where DRP concentrations were often highest at low tide. Nitrate and ammonia-nitrogen also tended to be highest at low tide.

Overall the results shows the influence of catchment impacts on water quality and the Ongare Point site appears to be the most oceanic or least impacted site followed in order by the Otumoetai, Grace Rd and Ohiwa sites.

The atomic ratio of bio-available nitrogen to phosphorous within the water at each of the sites over time is shown in Figure 2.23. Values for the average ratio of nitrogen to phosphorous found in algae is 1P:7N:40C per 100 dry weight (Wetzel, 1983). As an atomic ratio this equates to an N:P value of 15.47 and a shift in either direction will result in N or P becoming the limiting nutrient if all other nutrients are available in excess of the plants physical needs. The ratios shown in Figure 2.23 tend to shift between N and P as a growth limiting nutrient. Another interesting feature of the results is the oscillation between high phosphorous and low nitrogen concentrations and conversely, that it tended to be the same for all of the Tauranga Harbour sites.

The highest mean nitrogen to phosphorous ratio (Table 2.7) of nutrients in the overlying waters occurs at the Ongare site while the nearest high tide site recorded the lowest DIN:DRP ratio. Both the Otumoetai and Grace road sites have a higher ratio than the Ohiwa Harbour site and the ratios from near-by high tide sites are similar.

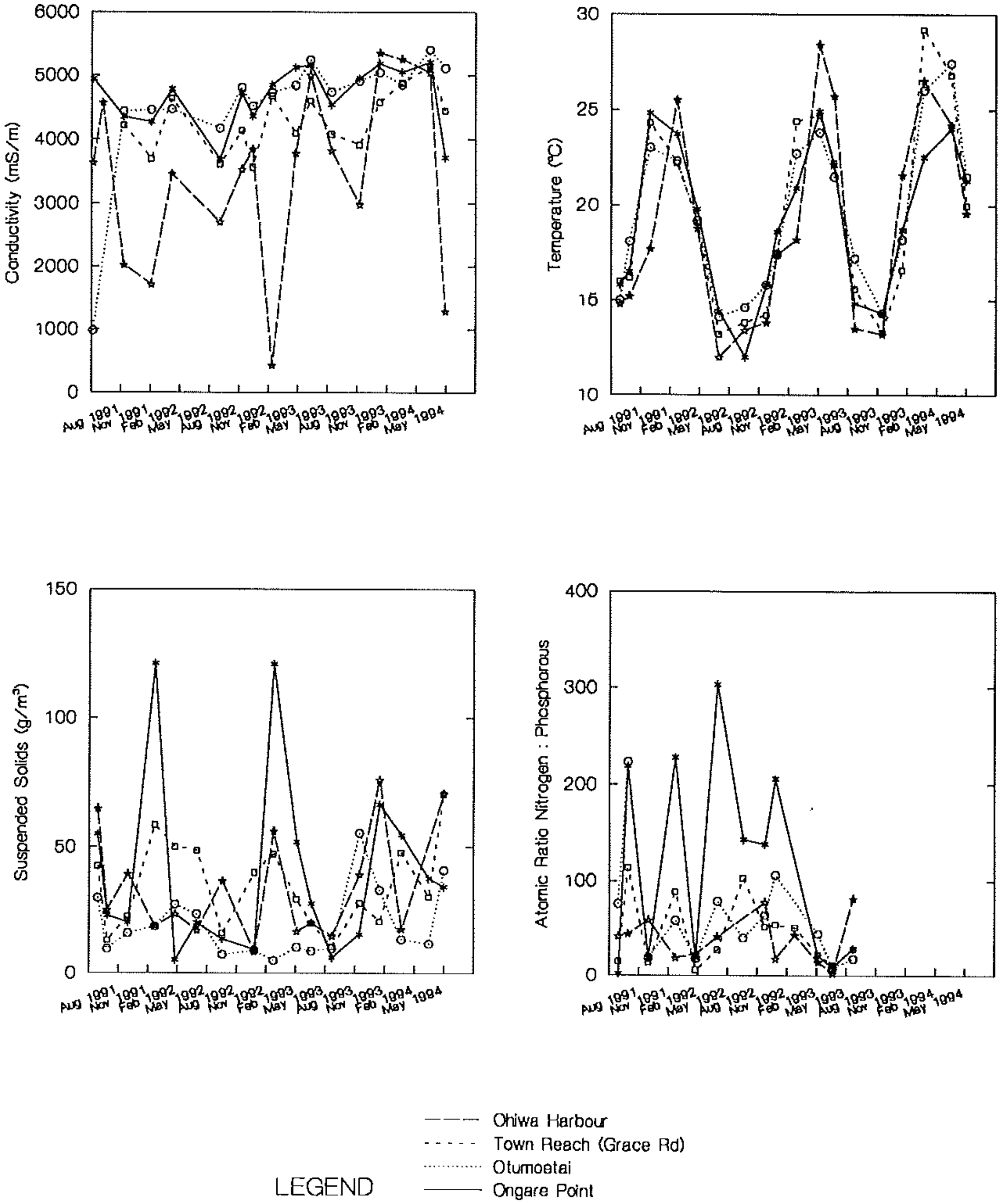

Figure 2.23 Physical parameters of the overlying waters at each of the four Coastal and Estuarine Ecology Regional Ulva Monitoring sites in Tauranga and Ohiwa Harbours. For all sites samples are from low tide surface waters and results are presented for the first two years of monitoring.

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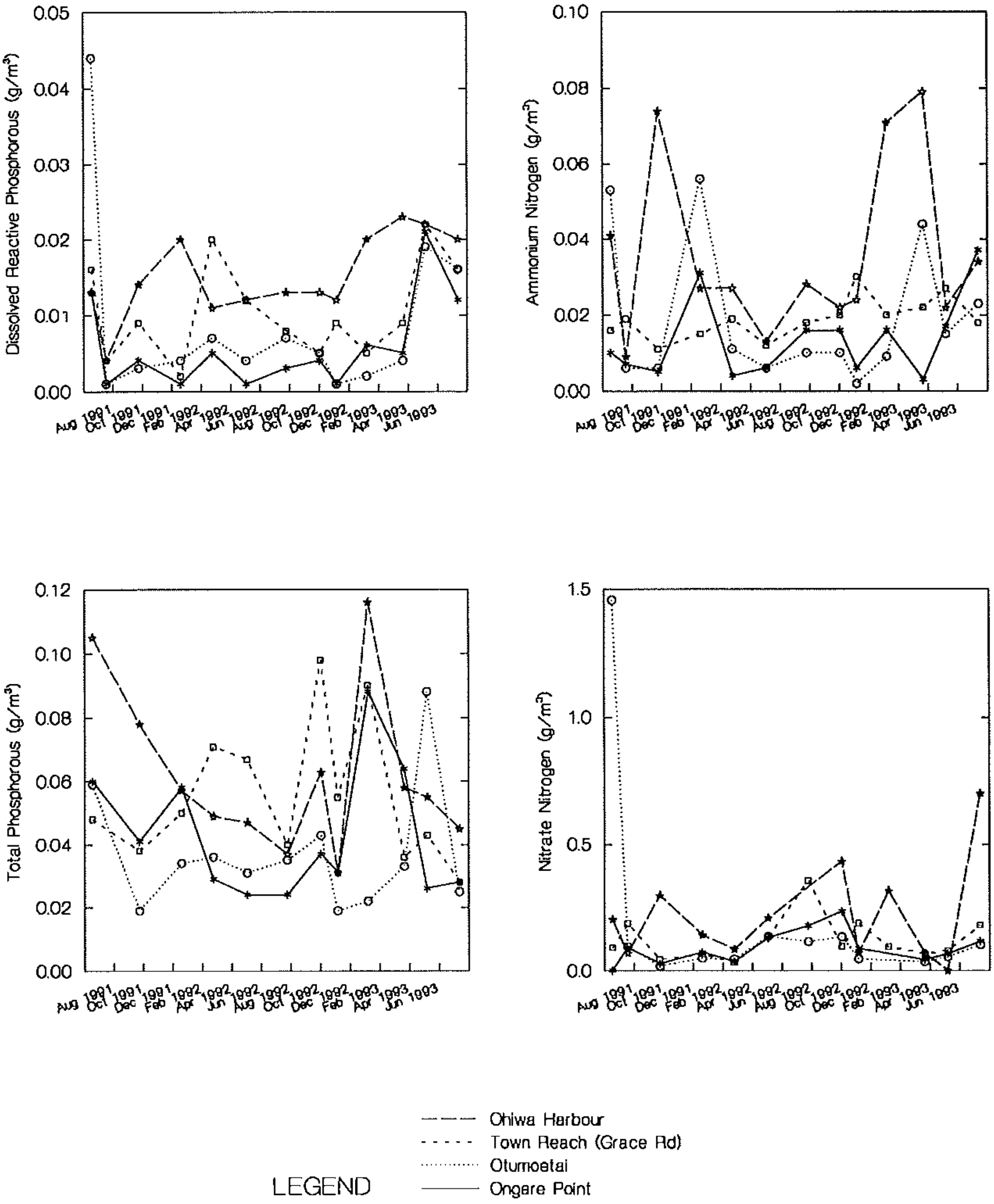

Figure 2.24 Nutrient levels recorded in the overlying waters at each of the four Coastal and Estuarine Ecology Regional Ulva Monitoring sites in Tauranga and Ohiwa Harbours. For all sites, samples are from low tide surface waters and results are presented for the first two years of monitoring.

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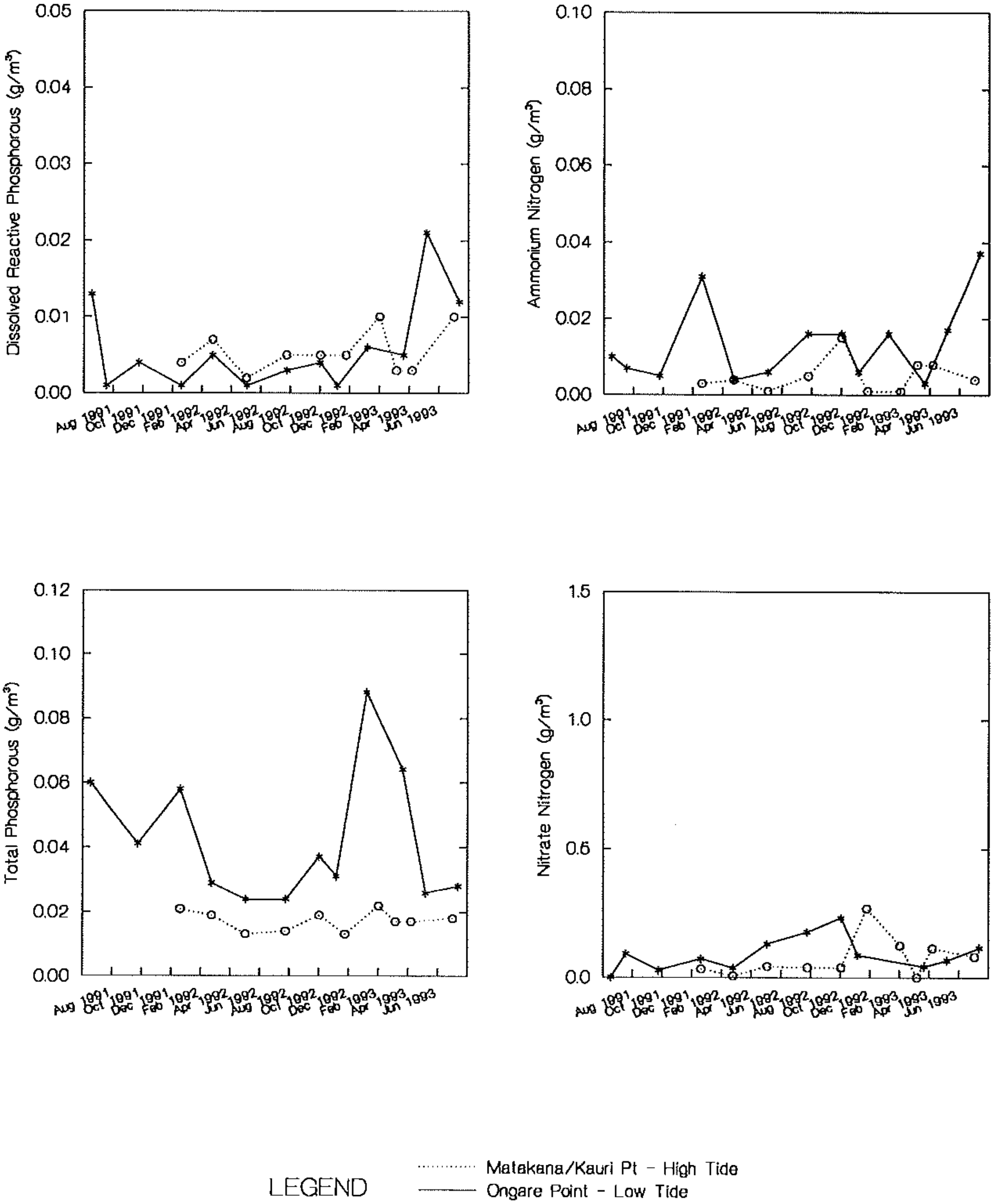

Figure 2.25 Nutrient levels recorded in the overlying waters at the Ongare Point Ulva monitoring site for low tide compared to the closest high tide water quality site in Tauranga Harbour. The first five data points match within a day of the low tide samples.

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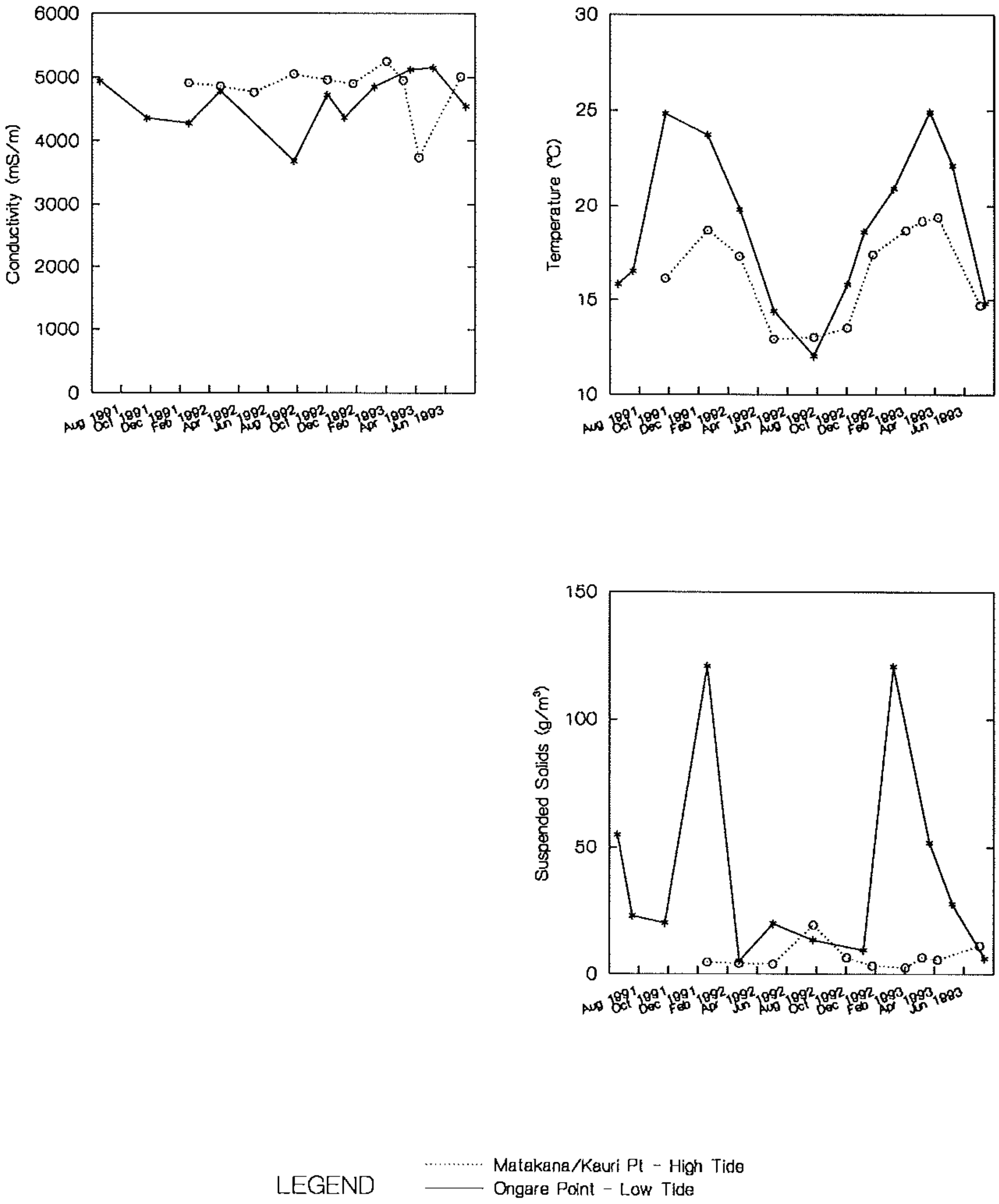

Figure 2.26 Physical parameters of the overlying waters at the Ongare Point Ulva monitoring site at low tide compared to the closest high tide water quality monitoring site in Tauranga Harbour. The first five high tide data points match within a day of low tide samples.

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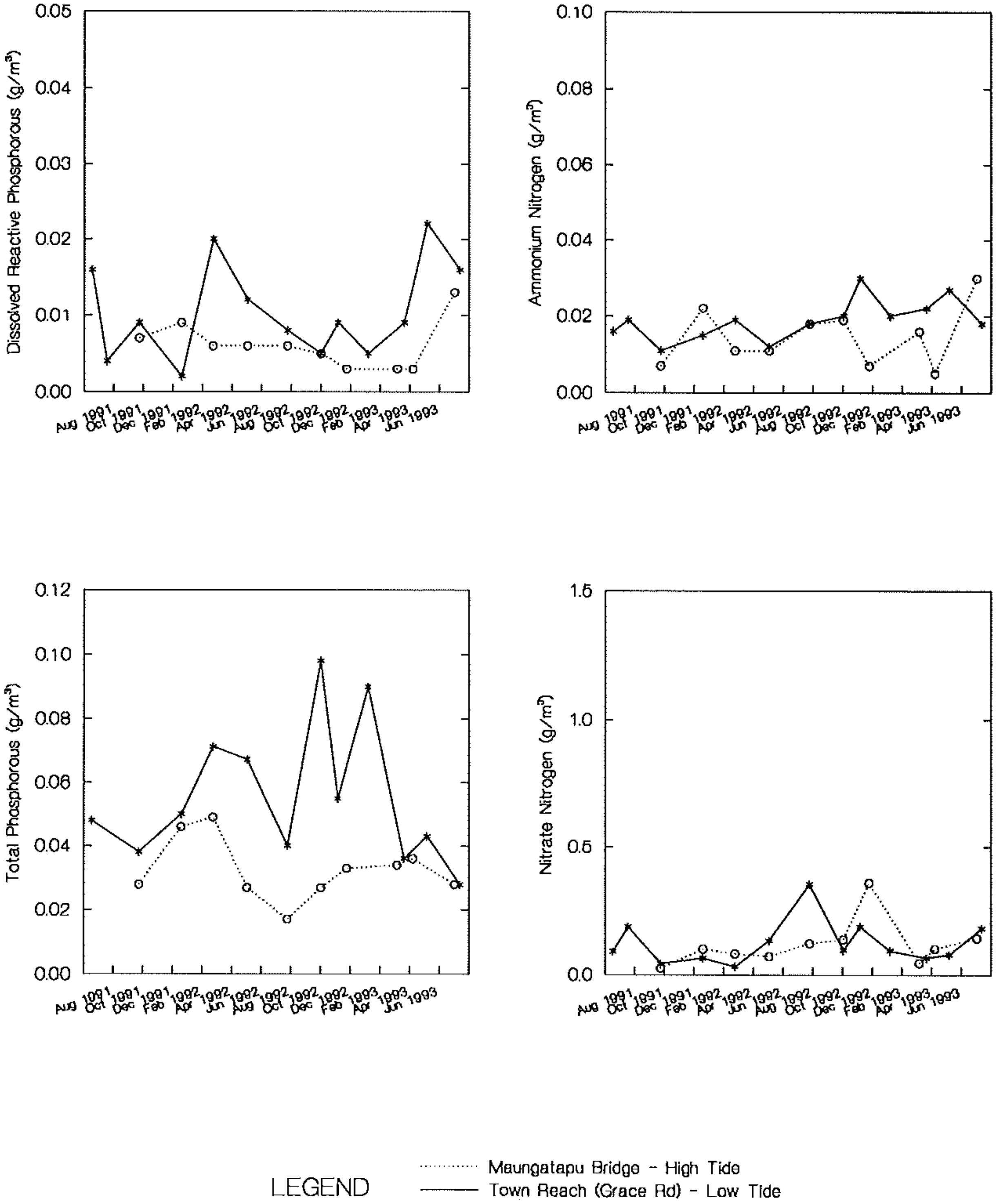

Figure 2.27 Nutrient levels recorded in the overlying waters at the Town Reach Ulva monitoring site for low tide compared to the closest high tide water quality site in Tauranga Harbour. The first five data points match within a day of low tide samples.

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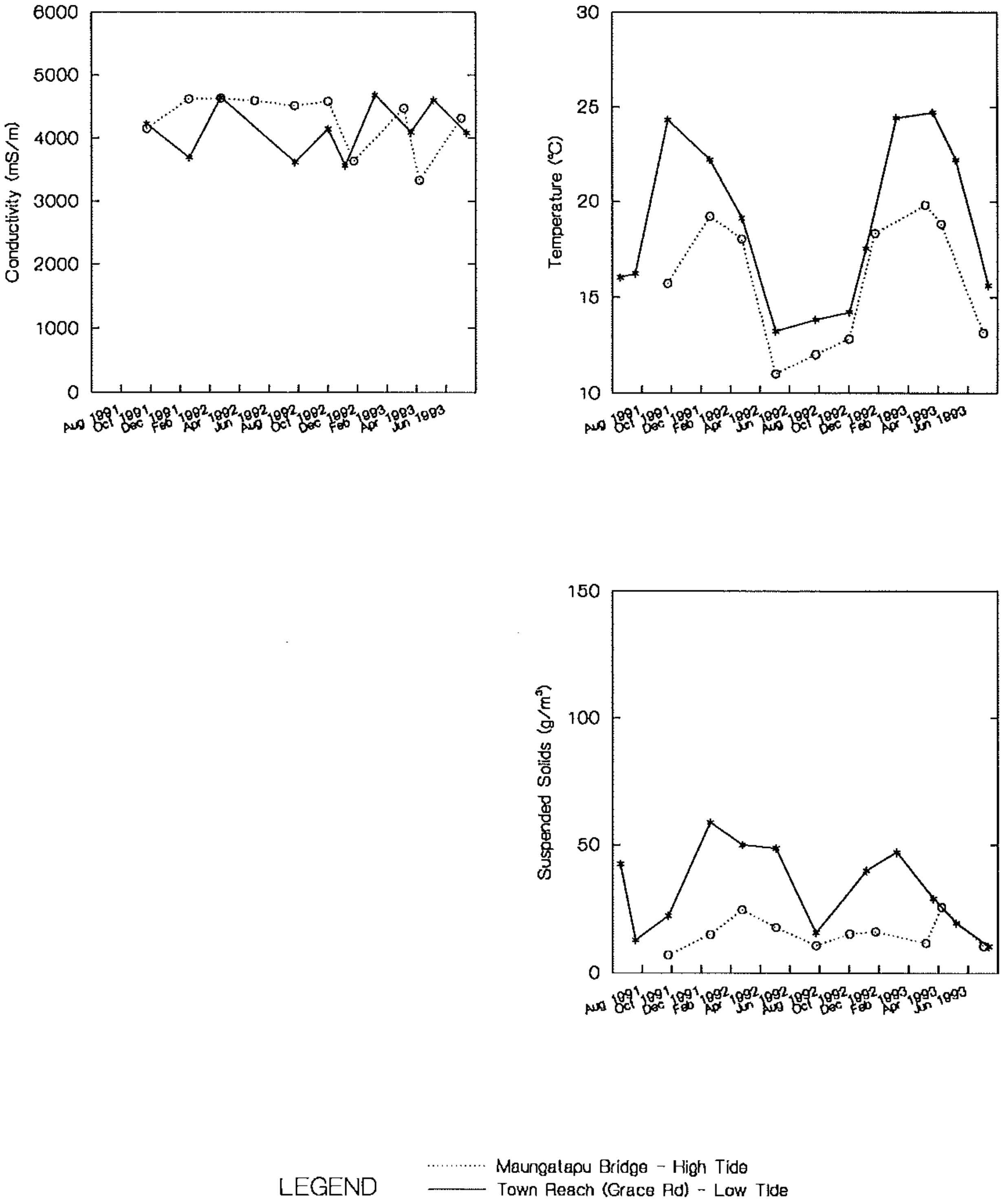

Figure 2.28 Physical parameters of the overlying waters at the Town Reach Ulva monitoring site for low tide compared to the closest water quality site at Maungatapu Bridge in Tauranga Harbour. The first five data points match within a day of low tide samples.

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Long-term environmental changes affecting sea lettuce growth

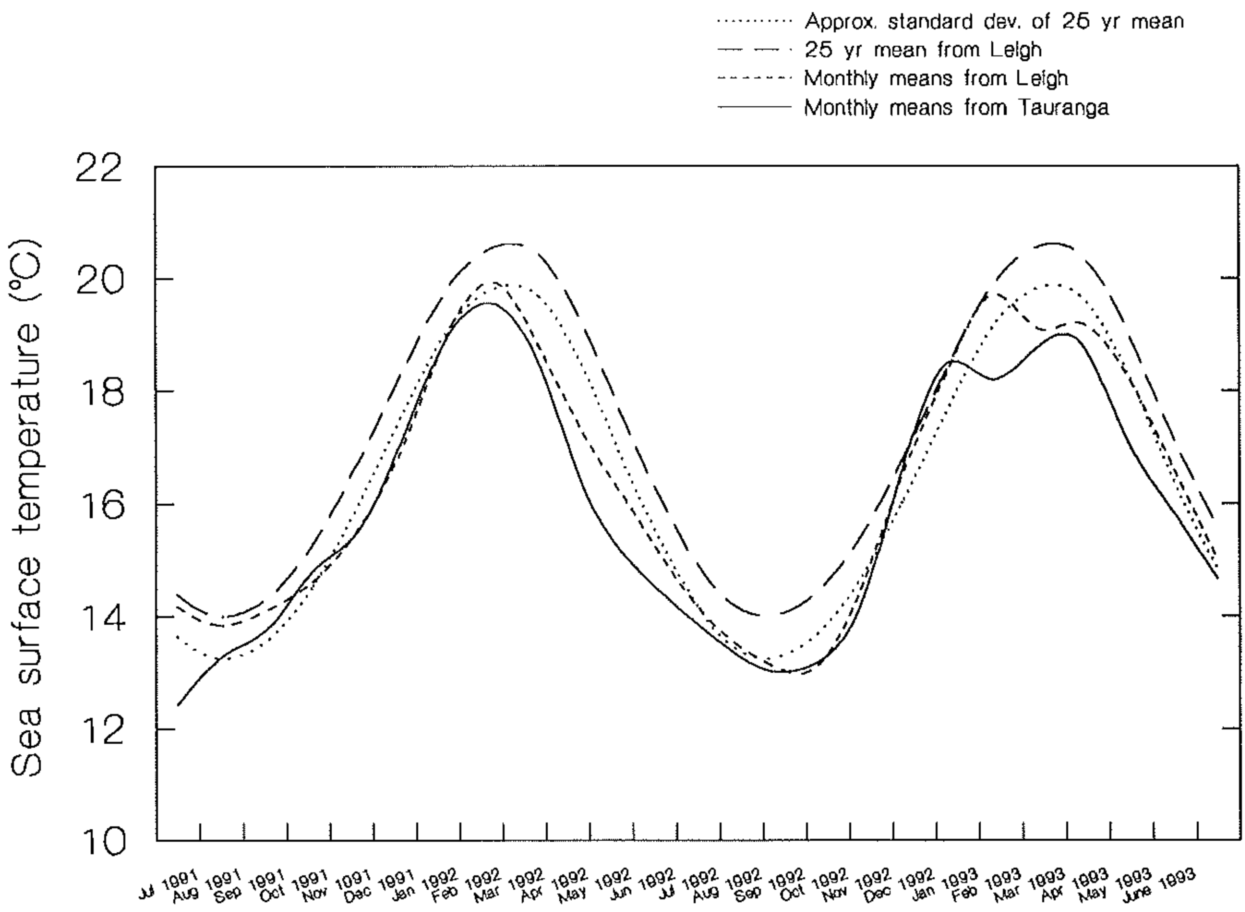
As covered in the background information, factors such as light intensity and duration, temperature, and many other physical attributes of the environment can influence the overall growth rate of *Ulva*.

The Southern Oscillation Index measures the pressure differential between Darwin and Tahiti. When the index shifts to a strongly negative phase a particular climatic pattern known as El Nino exists. Alternately when the index is strongly positive the climatic pattern called La Nina exists. Over the last three years the index has shifted to a strong negative point (Figure 3.27a) with a El Nino event taking place. Within the Bay of Plenty this appears to result in colder land temperatures, longer sunlight hours, strong off-shore winds, increased coastal upwelling and colder sea temperatures. Coastal upwelling often results in an increase of nutrients brought up from the ocean floor.

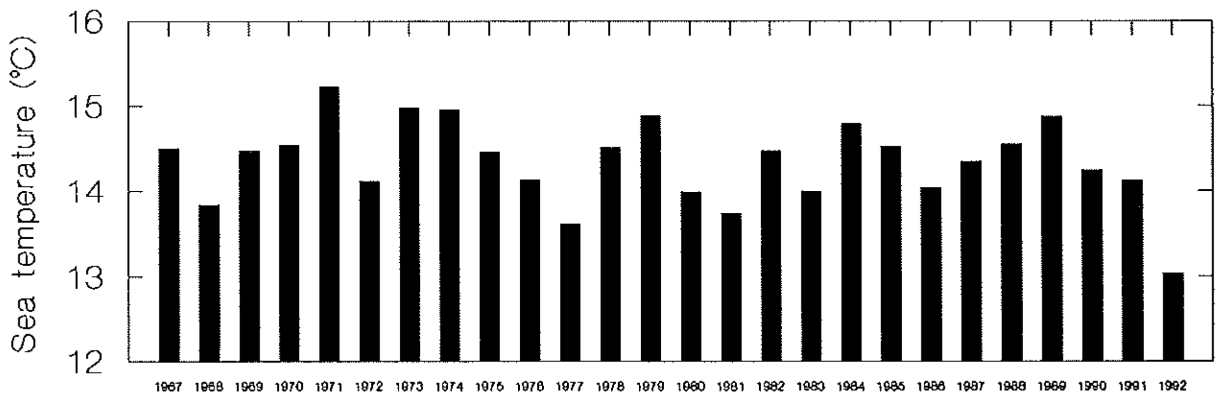
Figure 2.30(b) shows the variation of monthly sea surface temperatures from the long-term mean of the 25 year period from 1967 - 1992, recorded at the Auckland University marine laboratory at Leigh. The record shows that in the last three years there have been colder than average sea temperatures. Figure 2.30(c) overlays the Southern Oscillation Index and the variation in sea temperature data, and shows how closely related the two are.

Over the winter of 1992, the coldest water temperatures for the whole of the 25 year record from Leigh were recorded. Using the full length of Environment B.O.P's sea water temperature data from Tauranga Harbour, the monthly means have been plotted in Figure 2.29(a) along with the 25 year monthly mean and actual temperatures recorded for the same period at Leigh. Presented as monthly means the Tauranga Harbour sea temperature data is considerably smoothed out and matches the Leigh data quite closely. The May June and July 1992 values have either limited or no records from a period in which maintenance of the temperature logger was being conducted and have been omitted from the data set. The very low mean temperature for July 1991 (12.41 °C) in Tauranga Harbour is reliable. It is well below the Leigh temperature and is the coldest recorded at this site to date.

In Figure 2.29(b) the full set of winter temperatures from the 25 year Leigh record (using the month of September) have been plotted to show the very low sea temperature in comparison to previous years. The greatest drop from expected average sea temperature occurred in 1983 (Figure 2.30(b)) when monthly mean temperatures 2.5 °C lower than normal occurred during a summer period.



(a)



(b)

Figure 2.29 (a) Sea surface temperatures showing the 25 year mean and approximate lower standard deviation recorded at Leigh, and the mean monthly temperature recorded at Leigh and Tauranga Harbour over the period July 1991 - June 1993. (b) Winter water temperatures (September) recorded at Leigh for the period 1967 - 1992.

Sea temperature data for Leigh supplied by University of Auckland.

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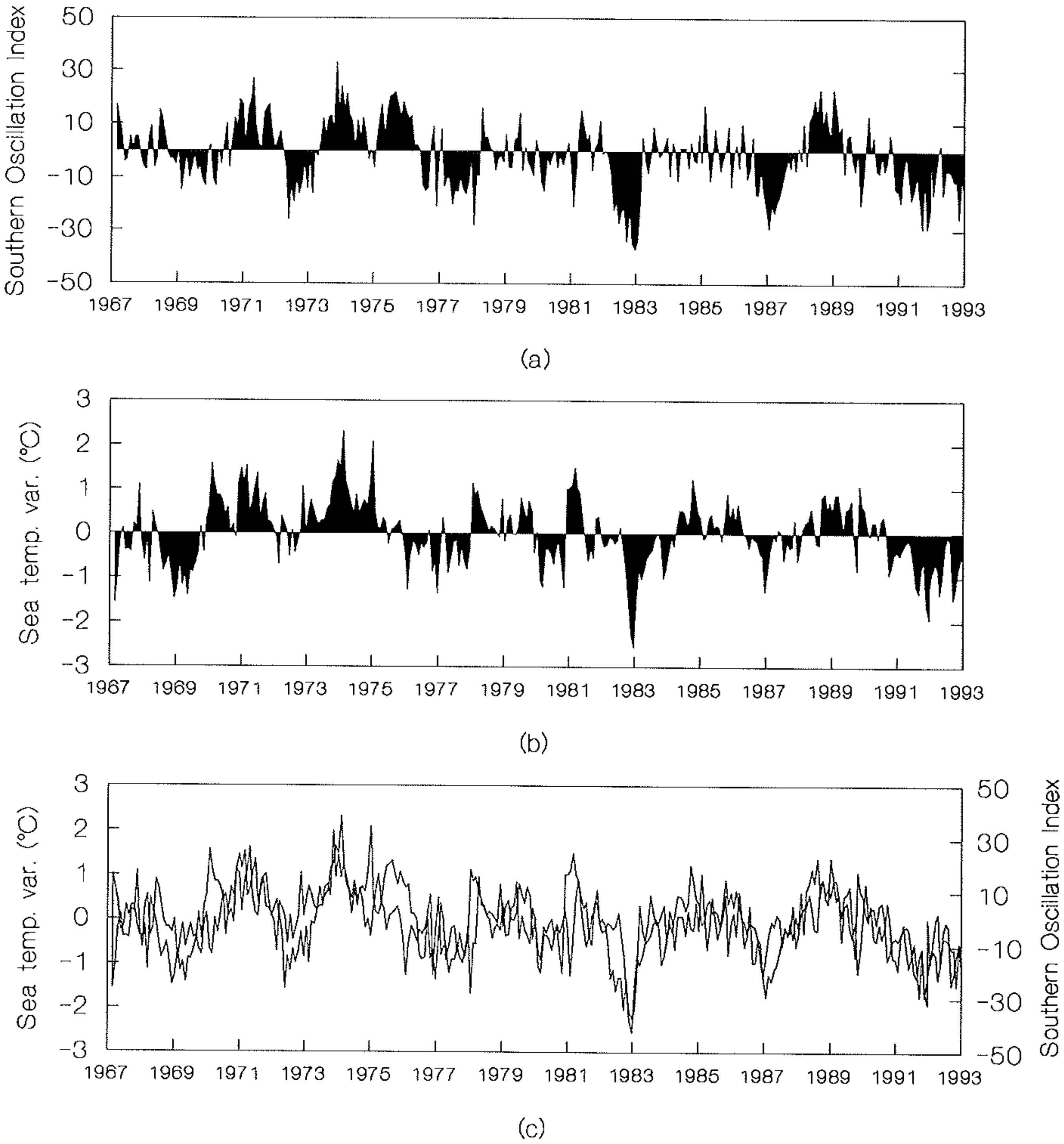

Figure 2.30 (a) Southern Oscillation Index for the period 1967-1993. (b) Variation of sea surface temperature recorded at Leigh from a 25 year mean for the period 1967-1993. (c) Southern Oscillation Index and sea surface temperature variation overlaid.

Sea temperature data for Leigh supplied by University of Auckland.

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The 1992 bloom of sea lettuce in Tauranga Harbour coincided with the occurrence of a strong and sustained El Nino. Apart from a ten year monitoring period (1980-90) as required under Water Right 347, no long-term historical baseline of sea lettuce biomass in Tauranga Harbour exists. This lack of extensive baseline data means that it is not possible to test for historical relationships with any confidence. However, an attemt to find early records of historical sea lettuce blooms of nuisance proportions was undertaken by researching the Bay of Plenty Times.

As it was not possible to research all newspapers, selected periods were investigated. Only the late spring and summer months were researched as this is the period in which most problems occur. The following years were included in the search; 1883/84, 1889/90, 1896/97, 1905/06, 1940/41, 1948-50, 1978, and 1982 - 1992. The first newspaper reportings of nuisance blooms of sea lettuce found to date occurred in 1988.

Anecdotal reports of sea lettuce blooms by members of the general public indicate blooms have occurred before 1987. One such bloom took place in the northern harbour between 1948 and 1952 but no newspaper reports of these were found for the years researched. This bloom if accurately placed in relation to its period of occurrence does not appear to have been associated with an El Nino event.

At the time of the first newspaper reports of sea lettuce blooms in Tauranga Harbour in 1988 a strong El Nino event had occurred over the whole of 1987. For the previous and stronger El Nino of 1982/83 during which there was a greater influence on sea temperatures, no reports of sea lettuce blooms were found.

The monitoring data submited for Water Right 347 also shows a greater abundance of sea lettuce in October 1988 recording peak biomass over the ten year period. Following the El Nino which occurred over 1982/83 the same monitoring programme had recorded a previous peak in sea lettuce abundance in December 1983. Although some correlation appears to exist between El Nino events and sea lettuce blooms, current baseline data is not extensive enough to show a clear relationship or the mechanisms through which El Nino conditions may influence sea lettuce growth, if at all.

2.4.6.3 Discussion

Algal reproduction is an annual event, and little useful ecological information can be gained by studying any plant (or animal for that matter) for just a few months, or one year. Variations in reproductive success, settlement success, nutrient-related growth rate, detachment from substrates, coastal water temperatures (and hence growth rates) can all vary to differing degrees from one year to another.

It is not entirely beyond the realms of possibility that much larger scale influences than those which human activities have control over, such as deep water nutrient-enriched upwelling during *El Nino* events, and associated cooler coastal water temperatures and increased sunshine hours may contribute significantly to harbour nutrient status and environmental conditions conducive to the growth of sea lettuce at certain times of the year, during some years.

Unfortunately, due to the woeful lack of environmental monitoring in the region in years past and prior to the formation of the Bay of Plenty Regional Council, the long-term historical data which would help in the assessment of the significance of such events simply does not exist.

It is interesting to note that coastal water temperatures in New Zealand for the summer of 1989/90 were the warmest for at least twenty years, and a number of sub-tropical fish larvae survived passage to New Zealand, and grew to adults. During such warm-water events, growth rates of algae such as sea lettuce can increase markedly providing that seawater temperatures remain within the tolerable range for the species, to give high biomass generation.

In contrast, coastal water temperatures for the last two summers (1990/91 and 1991/92) were substantially cooler than the long-term average. Indeed, coastal water temperatures during August/September 1992 have been the coldest yet recorded during the past 25 years. Sea lettuce is generally a southern algal species, with growth effectively ceasing at temperatures above 25 °C, and during these cooler conditions, is apt to move north in response to attractive temperature conditions.

During *El Nino* events such as that which we have experienced over the past two years, these cooler-than-average seawater temperatures are also accompanied by higher-than-average sunlight hours. Sea lettuce responds extremely well to enhanced sunlight hours. So, it would appear that quite apart from the nutrient question, coastal water temperatures and available sunlight may have a marked impact on the behaviour of the sea lettuce in Tauranga Harbour.

For this and several other purposes, Environment B.O.P has installed an automated seawater temperature datalogger in the Southern Basin of the harbour, which records water temperature every 15 minutes so that this data can be electronically transferred to Environment B.O.P's computer in Whakatane. This data will prove very helpful to us as our knowledge of the ecology and behaviour of sea lettuce in Tauranga Harbour improves with time.

Results from investigations conducted into the possible relationships between sea lettuce blooms and climatic conditions remain tenuous due to the limited historical records of any sort on sea lettuce abundance. Available data have shown a possible relationship as most blooms have been preceded by, or occurred during an El Nino event. Anecdotal reports also indicate that extensive blooms have occurred in the northern Tauranga Harbour over forty years ago when El Nino conditions did not exist.

As discussed above, Environment B.O.P now holds a considerable amount of reliable environmental data on the Tauranga Harbour. Some members of the community believe that Tauranga Harbour suffers from 'a pollution problem'. When one refers to a 'pollution problem', it is important to focus on exactly what one means by the phrase 'pollution problem'. The first step in assessing options for the control of sea lettuce is to determine whether the major factors which control the growth and distribution of sea lettuce can in fact be influenced by human activity.

With respect to sea lettuce, the most important potential influence over which communities have some degree of control (as opposed to the effects of other factors such as *El Nino*, sunlight hours etc) is that of nutrients. Consequently, detailed nutrient data was first awaited from the Tauranga Harbour Regional Plan Project before commencing any more detailed physiological/ecological work on sea lettuce. This data is now available, and Environment B.O.P officers are presently finalising their analysis of the nutrient information gathered for the Tauranga Harbour Regional Plan Project.

The Tauranga District Council Wastewater Treatment Plant effluent is very important from a phosphorus (which is gradually increasing from this source each year) and ammonium nitrogen perspective, but not important at all from a nitrate nitrogen perspective.

The relative nutrient status of the rivers and streams entering the Tauranga Harbour will be compared with others. It can be noted that while the Wairoa River contributes 43% of the nitrate nitrogen entering the Southern Basin of the Tauranga Harbour under typical conditions, this river is not particularly 'polluted'.

It is, in fact, a fairly average river in terms of the nutrient content of its waters in relation to the size of the catchment which it drains, which is relatively large.

Environment B.O.P is progressing with assessments of the significance of harbour water nutrient levels for the growth of sea lettuce in Tauranga Harbour. Results of analysis from this report showed that in 1990/91 there was a significant correlation between some nutrients and *Ulva* abundance. However if measurement of *Ulva* abundance had been repeated for 1992 (no data is available) it appears unlikely that a significant relationship between *Ulva* abundance and harbour water nutrient levels would have been evident, as *Ulva* is now very abundant in the northern basin of Tauranga Harbour in localities with low nutrient levels.

Monitoring results of the last two years have shown that sea lettuce has bloomed extensively in the northern Tauranga Harbour despite tissue nutrient results showing that these plants (Ongare Point site) were the most limited in nutrients. Analysis of both high and low tide water samples from this area also show very low nutrient levels in comparison to the other CEE *Ulva* sites. Available literature also suggests that during a large part of the monitoring period, the Ongare sea lettuce tissue nutrient N and P concentrations were below critical levels and for a more limited period were below that level required for basic subsistence (no growth potential). During this same period monitoring results show that sea lettuce was growing profusely at Ongare Point.

Unfortunately, available studies related to this which have been undertaken in New Zealand or overseas have been conducted using unrealistically high nutrient levels, not at all related to reality and the nutrient regime which sea lettuce enjoys in Tauranga Harbour.

Figures 2.31 and 2.32 provide three-dimensional response surfaces indicating the growth response of sea lettuce to various nutrients. The shaded area indicates the range of data that are in fact relevant to Tauranga Harbour. The two studies represented by these data indicate an apparent 300% difference in acceleration in growth rate over similar nutrient ranges. A more reliable estimate of the influence of nutrients on growth rate is required.

Those management options which have the capacity to positively affect the quality of Tauranga Harbour waters will be implemented through the Tauranga Harbour Regional Plan.

Specifically in relation to sea lettuce, Environment B.O.P initiated a Sea Lettuce Project in the 1992/93 financial year which it continues to coordinate. Contributors include the Tauranga District Council, NIWA Ecosystems (National Institute of Water and Atmospheric Research), and the University of Auckland.

A number of basic questions surrounding the physiology and ecology of sea lettuce remain to be answered. Without this information, Environment B.O.P is not in a position to definitively state the management options for sea lettuce in Tauranga Harbour, and place these options before the community.

Studies of the response of sea lettuce to realistic ranges of nutrient levels as monitored in Tauranga Harbour are about to commence.

Other studies related to sea lettuce remain to be set in place, as the various parties discuss the most efficient means of undertaking these studies. These include assessments of the importance of the removal of grazing pressure from sea lettuce in Tauranga Harbour. Many members of the community believe that historically, parore were far more abundant in the harbour. Parore and other herbivorous fish would be quite effective at grazing sea lettuce. Other smaller grazers may also be present in insufficient numbers now to cope with rising sea lettuce densities. It is possible that without adequate grazing pressure, a 'critical mass' of sea lettuce is able to build up, beyond which the efforts of grazers to control it are futile.

Detailed analysis of levels of the highly toxic antifouling compound tributyl tin (TBT) in Tauranga Harbour have indicated that the Port and Waikareao Estuary areas display elevated TBT. In the absence of international bans on the use of TBT-formulations for commercial craft, increased port shipping activity over the years is likely to have been associated with gradually rising TBT contaminant levels in waters, sediments and biota.

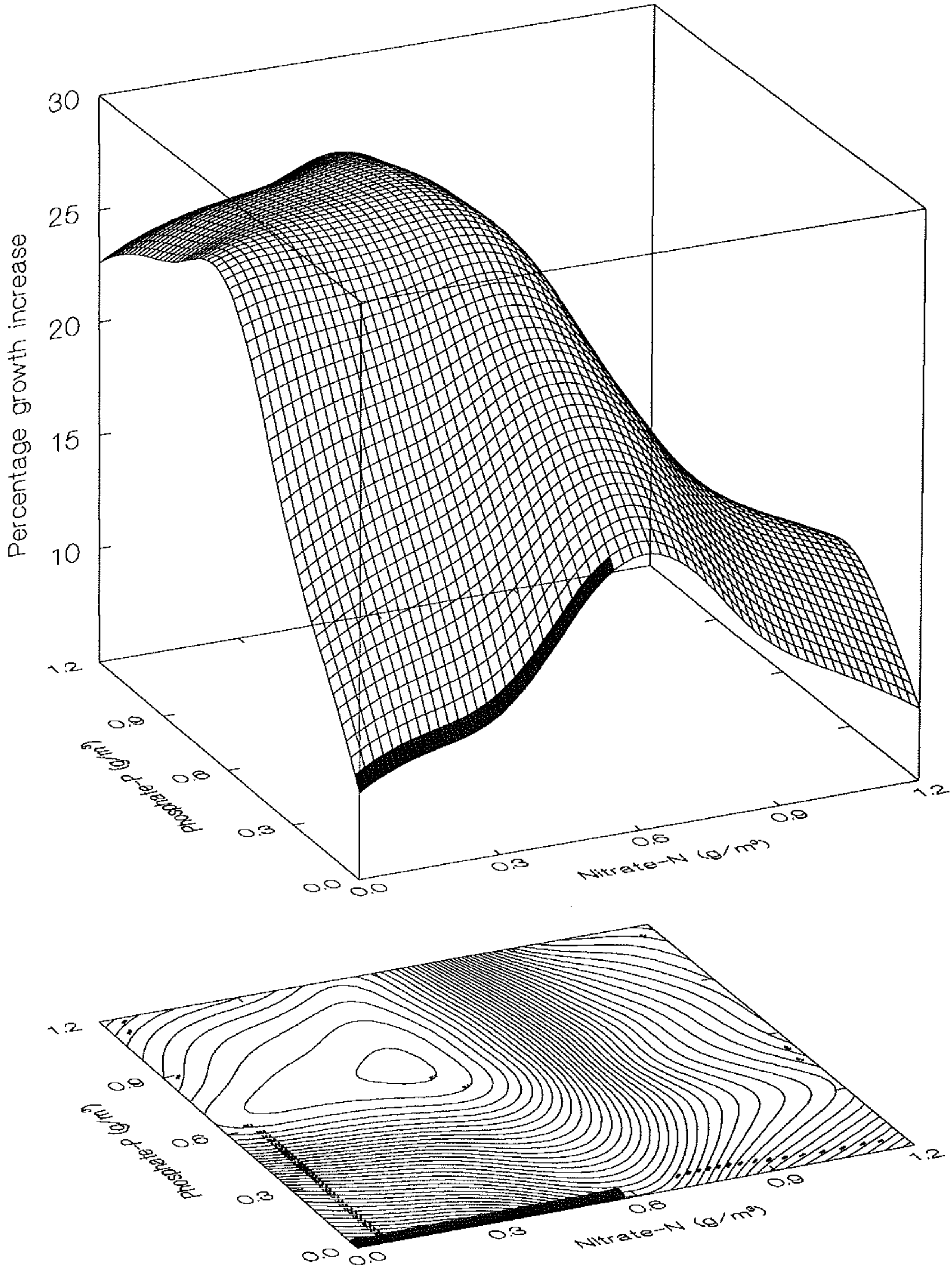

Figure 2.31 Relationship between PO_4-P, NO_3-N, and percentage increase in growth of sea lettuce. After Steffensen (1976). The solid black area represents nutrient conditions relevant for Tauranga Harbour.

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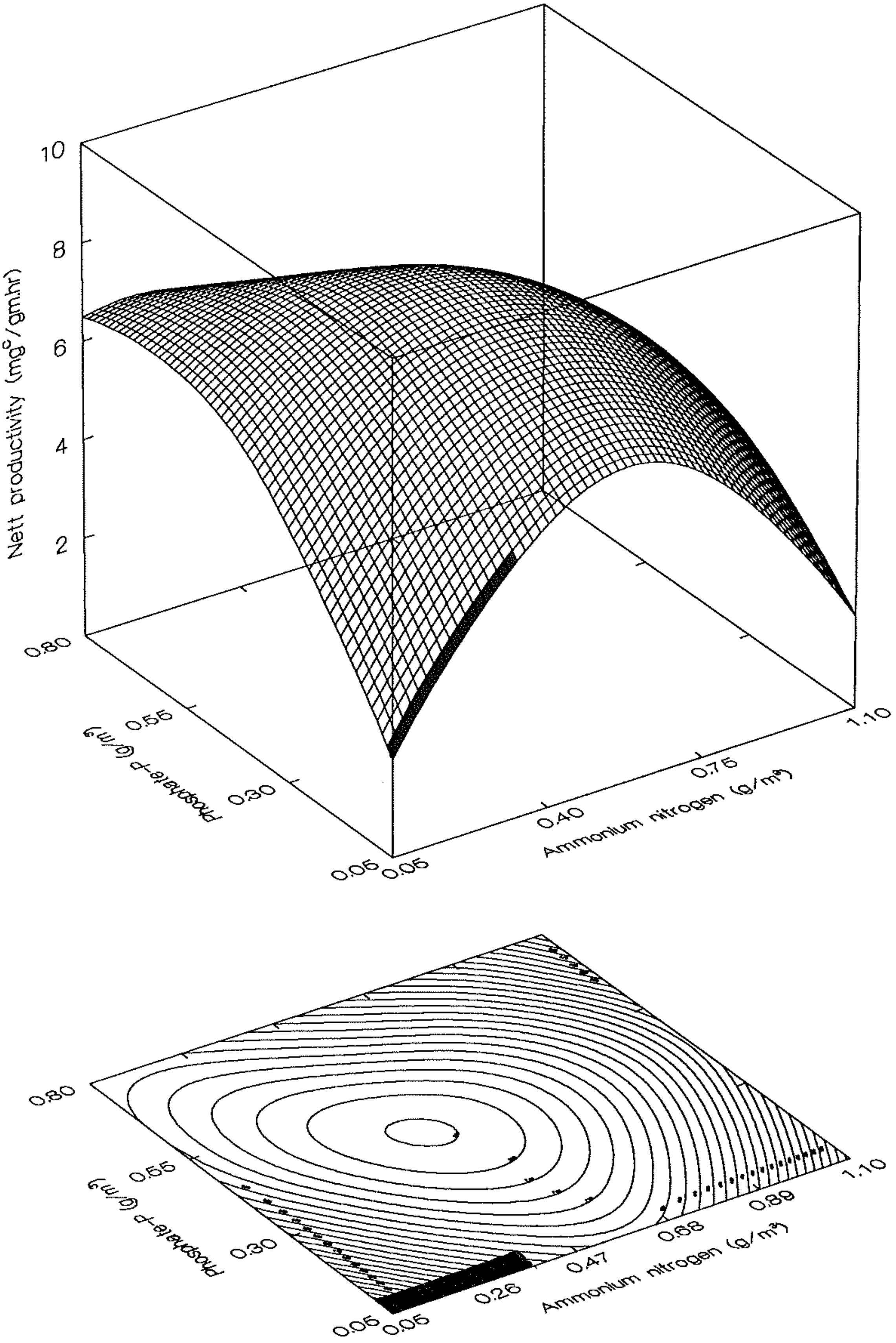

Figure 2.32 Relationship between PO_4-P, NH_4-N, and nett productivity of sea lettuce. After Waite and Mitchell (1972). The solid black area represents nutrient conditions relevant for Tauranga Harbour.

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Some marine species (particularly the neogastropods) are highly sensitive to TBT. A condition known as imposex (where females of the species exhibit a male penis, which can grow to occlude the cloacal opening and can also be associated with internal organ changes) is induced in some species by TBT. This leads to reproductive failure and eventual population decline.

Reduction in the density of some grazing species in Tauranga Harbour may be associated with rising TBT levels, and this is yet another possible partial explanation for the rise in the proliferation of sea lettuce in Tauranga Harbour.

Many members of the community pose the question 'What will be the extent of increase in proliferation of sea lettuce in Bay of Plenty coastal waters before management options have been adequately defined?'.

An answer to this question presupposes that the important controlling factors for sea lettuce are actually known. This is not the case.

The single most important nutrient-contributor to the Southern Basin of Tauranga Harbour is the Tauranga District Council Wastewater Treatment Plant effluent. However, at this point in time it is not at all clear that following the removal of this effluent from the harbour that the sea lettuce problem will 'disappear'. This has been made clear by the phenomenal increase in the biomass of *Ulva* in the northern Tauranga Harbour over the last two years and the sudden and almost total disapearence in the southern harbour over the winter period in 1993. The disapearence of sea lettuce from the southern harbour appears to have been the result of wind/tide combinations clearing all large plants from the intertidal and subtidal areas.

Sea lettuce is a natural inhabitant of harbours such as Tauranga. The problem with the Tauranga sea lettuce is one of degree and extent of proliferation.

Settlement and recruitment of new plants is another complex issue. Reproductive success and settlement may be higher in some years than others. No historical data is available for comparison. Settlement must occur on a hard substrate (such as an imbedded cockle shell) in order for the plant to continue to attach and grow. Eventually, the plant reaches a size where wave action (particularly in storms) rips the cockle or other settlement surface out of the sediment, or the plant tears and drifts.

These drift algae can themselves continue to grow. Eventually, they are either washed out to sea, or accumulate on the shore. In some slack-tidal areas, they accumulate in large drifts in shallow waters, where they tend to remain for long periods, even though not attached. Some of these drifts have been measured as being in excess of 10 metric tonnes wet weight.

Once stranded and subjected to desiccation, or at the conclusion of the growing season, the algae rots. This can bring about anoxic conditions in the sediments below, and can kill all marine life in large tracts of the intertidal zone.
These anoxic conditions can also result in release of sediment-bound nutrients to the water column.

In addition, living sea lettuce stands can induce lethally low levels of oxygen at night. Coupled with this, the habit of sea lettuce to release toxic exudates which are extremely toxic to larval forms of marine life and more adult forms as well mean that excessive sea lettuce accumulations can cause mass mortalities and severely depress recruitment of juveniles into large area of a harbour.

Detached sea lettuce can be progressively 'rolled' into harbour sediments, buried, and decompose. This can bring about a marked change in the nature of harbour sediments, which become extremely muddy, black (anoxic), and highly contaminated with dimethyl sulphide, a highly-odorous gas reminiscent of repulsive fresh diarrhoea.

With respect to nutrients, agricultural discharges to rivers and streams also need to be properly controlled. It is appropriate that if other sectors of the community, such as the District Council and Industry, make significant efforts to reduce or remove their nutrient contributions to the harbour, that the farming community does likewise.

Many people query the importance of the Tauranga District Council's Wastewater Treatment Plant effluent discharge with respect to the proliferation of sea lettuce within the harbour.

Phosphorus and nitrogen are important plant nutrients, and consequently Environment B.O.P undertaken a great deal of monitoring of these in the Tauranga Harbour environment. They are also monitored closely in the Wastewater Treatment Plant's effluent.

The results of the Tauranga Harbour Regional Plan Project indicate that under typical conditions, the Tauranga District Council Wastewater Treatment Plant <u>presently</u> contributes around 56% of the average daily total phosphorus mass discharge to the Southern Basin of Tauranga Harbour, while the BOP Fertiliser company presently contributes around 3%.

The Tauranga District Council Wastewater Treatment Plant contributes only around 1% of the nitrate-nitrogen entering the Southern Basin of the harbour.

On the other hand, under typical conditions it contributes around 80% of the ammonium-nitrogen (an important plant nutrient for the sea lettuce) entering the Southern Basin of Tauranga Harbour.

Until the complex factors affecting the behaviour of sea lettuce in Tauranga Harbour are fully understood, it is not possible to predict whether the removal of the Tauranga District Council Wastewater Treatment Plant effluent from the harbour will eliminate the sea lettuce blooms.

Other members of the public have expressed concern about the Bardfield Piggery discharge. It should be noted that the coastal permit granted for this discharge will equate, under typical conditions, to negligible Dissolved Reactive Phosphorus (DRP) input to the Southern Basin of Tauranga Harbour (this is the form most relevant to plant growth), 1.6% of the total phosphorus input, negligible nitrate nitrogen input, and only 0.1% of the ammonium nitrogen input.

The high level of treatment of the Bardfield effluent required by Environment B.O.P under the terms of its new Coastal Discharge Permit will result in the discharge being extremely insignificant from the perspective of nutrient input to the harbour.

Examination of plant tissue nutrient levels and available water nutrient concentrations can provide a useful indication the Tauranga Harbour growing environment for sea lettuce. The most important and often limiting nutrients for plants are nitrogen and phosphorous. Studies of the ratios of these nutrients in relation to carbon content has shown mean atomic ratios of C:N:P of 103:15.5:1 for fresh water plants (Wetzel 1983), 106:16:1 (Redfield ratio) for marine plankton and 550:30:1 for a study of marine macroalgae and seagrasses by Atkinson and Smith (1983). The redfield ratio is often used to infer the nutrient limiting growth. Phosphorous limitation generally results in N:P ratios >30:1 and nitrogen limitation during growth results in N:P ratios <10:1.

The study by Atkinson and Smith (1983) included a large number of marine plants and study results from varying nutrient conditions and seasons but did conclude that the higher carbon content and nitrogen levels were the consequence of the plants structual requirements and not nutrient limitation. Further studies by Lapointe *et al* (1992) showed that differences also exist between macroalgae from tropical habitats and temperate zones. Atomic C:N:P ratios were 976:43.4:1 and 430:14.9:1 respectively with percentage dry weight nutrient concentrations of 20.1 and 22.6 % carbon, 1.2 and 1.0 % nitrogen and 0.07 and 0.15 % phosphorous respectively.

Comparing these results to Environment B.O.P's data for tissue N:P ratios shows all sites to be well above Lapointe *et al's* (1992) mean value for temperate plants but only slightly higher than the value provided by Atkinson and Smith (1983) which indicates most sites tend towards possible phosphorous limitation of growth. The site with lowest N:P ratio and hence the least likely to be limited by phosphorous was the Ongare site. Even the Otumoetai and Grace road sites with the N:P ratio between 37 and 41 are marginal for being classified as phosphorous limited.

Comparing the mean tissue nutrient results on the basis of percentage dry weight concentrations shows that carbon (CEE sites range from 26.9 - 29.2%) is similar to the mean value of 31% for Atkinson and Smith (1983) and Fujita (1985), but well above Lapointe *et al*'s (1992) mean values (20.1 and 22.6) for both tropical and temperate zones. The nitrogen tissue concentrations are high compared to results of Lapointe *et al* (1.2 and 1.0) but spread about the median value (1.97) obtained by Atkinson and Smith (1983). The Ongare site is below this median value while all other sites are slightly above. It is also interesting to note that Lapointe *et al*'s mean nitrogen value from field studies of temperate macroalgae is well below the critical and minimal subsistence values suggested by Fujita *et al* (1989).

The mean phosphorous % dry weight tissue values of CEE sites is very close to both the values obtained by Lapointe *et al* (1992) and Atkinson and Smith (1983) of 0.15 (temperate algae) and 0.145% respectively. The Ongare site value is low but the N:P ratio is the most favourable of all CEE sites studied and as with the other nutrient values, results point more to an overall low nutrient environment resulting in the low concentrations.

Analysis of the available nutrients in the surface waters of each site also results in inorganic N:DRP (ie bioavailable) mean ratios >30:1 indicating a tendancy towards phosphorous limitation. The one exception to this was the high tide site closest to Ongare has the lowest N:P value which is in agreement to the tissue values but the results for the low tide results indicate that the ratio shifts towards phosphorous as the limiting nutrient.

The concentration of Total Phosphorous measured in the water at each CEE *Ulva* site on the low tide (0.037-0.062 g/m^3) is about the acceptable maximum level of 0.04 g/m^3 suggested by Knox and Kilner (1973) to avoid nuisance algal growths and less than half the 0.15 g/m^3 suggested by Williams and Rutherford (1983) in a study of New Zealand estuaries. The mean high tide TP concentrations near each of these sites are lower again and approximately half the low tide values.

Studies of macroalgae productivity in temperate waters generally indicate that nitrogen is more often the limiting nutrient while phosphorous is the limiting factor to growth in tropical waters. In this respect the results of the CEE *Ulva* monitoring programme have to date suggested the opposite trend to what might be expected in temperate waters.

Once the complex of factors which control the dynamics of populations of sea lettuce in Bay of Plenty waters has been quantified, management decisions aimed at reducing nuisance accumulations can be made. If, for example, nitrogen concentrations are limiting growth, measures targeting reduction of phosphorous loading will be of little value. If nitrogen is not limiting to growth, it may not be appropriate to consider reducing nitrogen loadings unless they can be reduced to a level which will limit growth. While economic harvesting of sea lettuce may be a possible control option (Frederiksen 1987) environmental manipulation, either to increase flushing, reduce areas of stagnation, reduce nutrient loadings or enhance grazer activity are possible options which may be identified by the research programme.

In summary, to effectively manage sea lettuce growth in the Bay of Plenty coastal waters, studies on nutrient limitation, temperature, light, sporulation, desiccation, grazing, burial and hydrodynamics need to be undertaken. This will be best achieved using an hierarchal approach, based on the likely importance of a process and its potential value in management, as outlined below.

Highest Priority	Major Questions
Nutrients	- do nutrients limit growth - which nutrient - what are the major sources of this nutrient
Temperature	- what is the long-term record of temperature - can this be related to biomass
Sporulation	- when and where are spores produced - how are they distributed - is high biomass due to absence of sporulation
Advection, washout	- transport rates from and around the harbour
Desiccation	- what are rates of desiccation - how does desiccation affect distribution
Grazing	- how does grazing affect growth at high and low plant densities
Light	- what are the light fields encountered by sea lettuce - how does light affect growth
Burial	- how much biomass is lost to burial and where does this occur

Environment B.O.P is committed to finding answers to these questions, and this Technical Report is an important step towards developing a full understanding of the ecology of sea lettuce in Bay of Plenty coastal waters.

CHAPTER THREE

MACROFAUNA OF TAURANGA HARBOUR

3.1 BENTHIC MACROFAUNA OF TAURANGA HARBOUR

A list of species that were noted during the investigations of intertidal and subtidal habitats of Tauranga Harbour is presented in Table 3.1 below. The investigations concentrated on conducting the set quantitative sampling programme on the soft-bottom communities, so the list is not expected to include all the macrofaunal species present in the harbour. Descriptions and species lists specific to the small area of rocky shore at the harbour entrances can be found in reports by Harrison and Grierson (1982), Healy *et al* (1988) and Port of Tauranga Limited (1991) which all present environmental impact assessment reports for developments in this area.

Table 3.1 Macrofauna and fish species found in Tauranga Harbour - either previously documented or found during BOPRC investigations of sandy intertidal and subtidal habitat.

Bivalves			
	Austrovenus stutchburyi	cockle	very abundant
	Tellina liliana	wedge shell	very abundant
	Nucula hartvigiana	nut shell	very abundant
	Paphies australis	pipi	very abundant
	Cylomactra ovata	trough shell	very abundant
	Felaniella zelandica		very abundant
	Hiatula siliqua		common
	Divaricella huttoniana		rare
	Myllita stowei		rare
	Solemya parkinsoni	razor shell	rare
	Corbula zelandica		rare
	Arthritica bifurca		common
	Ruditapes largillierti		common
	Myadora striata		rare
	Saccostrea cucullata	rock oyster	localised abundance
	Crassostrea gigas	pacific oyster	common
	Tiostrea lutaria	bluff oyster	common
	Atrina zelandica	horse mussel	very abundant
	Pecten novaezelandiae	scallop	very abundant
	Chlamys zelandiae	fan shell	rare
	Gari stangeri	sunset shell	localised abundance
	Tawera spissa	morning star shell	localised abundance
	Perna canaliculus	green-lipped mussel	common
	Xenostrobus pulex	small black mussel	rare
	Hiatella arctica		rare
Gastropods			
Snails	Amphibola avellana	mud snail	very abundant
	Cominella adspersa	common sand whelk	very abundant
	Cominella maculosa	common shore whelk	very abundant
	Cominella gladiformis	mud whelk	very abundant
	Diloma subrostrata	top shell	very abundant
	Micrelenchus huttoni	small opal shell	very abundant
	Zeacumantus lutulentus	horn shell	very abundant
	Zeacumantus subcarinatus		very abundant
	Turbo smaragdus	cats eye snail	common
	Xymene plebius		common
	Xymene ambiguus		rare

	Neoguraleus sinclairi		common
	Amalda australis	olive shell	very abundant
	Epitonium tenellum		common
	Potamopyrgus estuarinus		localised abundance
	Melagraphia aethiops	speckled top shell	localised abundance
	Nerita melanotragus		localised abundance
	Nodilittorina antipodum	periwinkle	common
	Pisinna zosterphila		very abundant
	Eatoniella limbata		common
	Trochus tiaratus		common
	Calliostoma (Maurea) tigris	tiger shell	very rare
	Thais orbita	white rock shell	rare localised
	Maoricolpus roseus	turret shell	common
	Phenatoma zelandica		rare
	Phenatoma rosea		rare
	Cymatium parthenopeum		rare
	Cabestana waterhousei		very rare
	Cabestana spengleri	trumpet shell	very rare
	Penion dilatatus		very rare
	Penion dilatatus (adustus form)		rare
	Haustrum haustorium	dark rock shell	localised abundance
	Scutus breviculus	ducks bill limpet	localised abundance
	Onchidella nigricans		localised abundance
Chitons	Chiton glaucus	green shield chiton	very abundant
	Acanthochitona zelandica		common
	Ischnochiton maorianus	variable chiton	rare
	Chiton pelliserpentis	snake-skin chiton	localised abundance
	Notoplax cuneata		common
	Callochiton crocinus		very rare
	Cryptoconchus porosus		common
Limpets	Notoacmea helmsi		very abundant
	Notoacmea helmsi scapha		very abundant
	Cellana radians		localised abundance
	Crepidula monoxyla	smooth slipper limpet	very abundant
	Crepidula costata	slipper limpet	rare
	Sigapatella novaezelandiae	saucer limpet	rare
Opisthobranchs			
	Haminoea zelandiae	bubble shell	very abundant
	Bulla quoyii		rare
	Aplysia juliana	black sea hare	very abundant
	Doriopsis flabellifera	yellow nudibranch	common
	Philine auriformis		common
	Philinopsis taronga		rare
	Melanochlamys cylindrica		common
	Bursatella leachii		rare
Cephalopods			
	Octopus maorum	common octopus	common
Crustacea			
Crabs	Macrophthalmus hirtipes	hairy mud crab	very abundant
	Helice crassa	tunneling mud crab	very abundant - localised
	Hemigrapsus crenulatus	hairy-handed crab	very abundant
	Hemigrapus edwardsi	purple shore crab	very abundant
	Halicarcinus whitei	pill box crab	very abundant
	Halicarcinus cookii	" "	common
	Halicarcinus innominatus	" "	rare
	Halicarcinus varius	" "	rare
	Pagurus sp.	hermit crab	very abundant
	Pinnotheres novaezelandiae	pea crab	very abundant
	Ovalipes catharus	paddle crab	very abundant
	Plagusia chabrus	red rock crab	abundant - localised
	Leptograpus variegatus	purple rock crab	abundant - localised
	Petrolithes novaezelandiae	red false crab	rare
	Petrolithes elongatus	blue false crab	rare - localised
	Notomithrax minor	camouflage crab	common
	Notomithrax peronii	" " "	common
	Cancer novaezelandiae	cancer crab	rare
	Nectocarcinus antarcticus	hairy red paddle crab	rare

crayfish	Jasus edwardsii	spiny red crayfish	juveniles locally abundant
Shrimps	Callianassa filholi	ghost shrimp	common
	Upogebia hirtifrons	burrowing shrimp	localised - rare
	Upogebia danai	burrowing shrimp	rare
	Lysiosquilla spinosa	mantis shrimp	common
	Alpheus sp.	snapping shrimp	common
	Pontophilus australis		rare
	Decapod sp.		
Amphipods	Waitangi brevirostris	Phoxocephalidae (spp A)	
	Ringaringa littoralis	Phoxocephalidae (spp B)	
	Patuki breviuropodus	Oedicerotidae (spp D)	
	Chaetocorophium lucasi	Corophidae (spp E)	
	Cephalophoxus regium	Phoxocephalidae (spp F)	
	Liljeborgia barhami	Liljeborgiidae (spp G)	
	spp H		
	spp I		
	spp J Paramoera chevreuxi and Melita awa		
	sp. K		
	Parawaldeckia karaka	Lysianassidae (spp L)	
	sp. M		
Isopods	Exosphaeroma obtusum		
	Exosphaeroma planulum		
	Exosphaeroma sp. B		
	Isocladus spiculatus		
	Isocladus reconditus		
	Cirolana arcuata		
	Cirolana australiense		
	(Valvifera) Idotea marina		rare
Malacostraca	Cumacean sp.		common
	Nebalia sp.		common
Ostracods	Ostracod sp.		common
Barnacle	Elminius modestus	small acorn barnacle	common
	Balanus decorus	giant pink barnacle	rare

Ceolenterates

Anemones	Anthopleura aureoradiata	common grey anemone	very abundant
	Edwardsia tricolour	burrowing anemone	very abundant
	Isactinia olivacea	red shore anemone	rare
Holothurian	Trochodota dendyi	burrowing sea cucumber	very abundant
	Stichopus mollis	common sea cucumber	rare

Echinoderms

Starfish	Patiriella regularis	cushion star	very abundant
	Coscinasterias calamaria	eleven-armed starfish	common
	Stichaster australis	sun star	common
	Astropecten polycanthus	comb star	rare
	Ophionereis fasciata	brittle star	common
	Ophionereis antipodum	brittle star	very rare
Urchins	Evechinus chloroticus	sea egg	localised abundance
	Echinocardium australe	heart urchin	common
	Fellaster zelandiae	cake urchin	very abundant

Polychaetes

Nereidae			
	Perinereis nuntia var vallata	rag worm	very abundant
	Nicon aestuariensis		very abundant
Nepthyidae			
	Aglaophamus macroura		very abundant
	Aglaophamus sp.		
Glyceridae			
	Glycera lamellipoda		very abundant
	Glycera americana		very abundant
Polynoidae			

	polynoid sp. a	scale worms	
	Lepidonotus jacksoni	" "	very abundant
	polynoid sp. b	" "	
	Lepidasthenia accolus	" "	very abundant
	Lepidasthaniella comma	" "	very abundant
	Psammolyce antipoda	" "	common
Maldanidae			
	Macroclymenella stewartensis		very abundant
	Asychis theodori		common
Orbiniidae			
	Orbinia papillosa		very abundant
	Aonides oxycephala		very abundant
	Orbinia sp. (E)		
	Scoloplos cylindifer		very abundant
Spionidae			
	Scolecolepides benhami		common
	Scolecolepides sp.		common
	Boccardia syrtis		common
	Spionid sp.		
	Scolelepis sp. a (c)		
	Scolelepis sp. b (11)		
	Aonides sp.		
	Aquilaspio aucklandica		very abundant
Phyllodocidae			
	Eteone sp.		
	Eulalia sp.		
Magelonidae			
	Magelona dakini		common
Pectinariidae			
	Pectinaria australis		common
Cirratulidae			
	Cirriformia tentaculata		
	Cirralulid sp.		
	Cirriforma sp.		
	Chaetozone platycera		common
Opheliidae			
	Armandia maculata		common
	Ophelia sp.		
Oweniidae			
	Owenia fusiformis		very abundant
Capitellidae			
	Heteromastus filiformis		very abundant
	Notomastus sp. b		rare
	Capitellid sp.		
Terebellidae			
	Thelepus plagiostoma		very abundant
	Amphitrite sp.		common
	Thelepus spectabilis		common
Scalibregmidae			
	Hyboscolex longiseta		very abundant
Serpulidae			
	Pomatoceros caeruleus		very abundant
Lumbrinereidae			
	Marphysa depressa		common
	Lumbrinercis sphaerocephala		common
Paraonidae			
	Aricidea sp.		rare
Syllidae			
	Syllis sp.		rare
Sabellidae			
	Oriopsis sp.		
	?????????		
Sabellaridae			
	Sabellaria sp. (Idyanthrysus quadricornis)		
Ctenostomata			
	Zoobotryon pellucidum		common
Sea squirt	Asterocarpa coerulea	solitary sea squirt	rare
	Botryllus schlosseri	colonial sea squirt	rare
	Pyura pachydermatina	sea tulip	localised - rare

Peanut worm	Dendrostoma aeneum		localised - common
	Sipnculus mandanus		rare
Sponge	Hymeniacidon perlevis	orange sponge growing on sandy substrate	
	???	small columnar cream coloured, subtidal	
Fish			
sharks	Galeorhinus australis	school shark	rare
	Mustelus lenticulatus	rig	rare
stingrays	Dasyatis brevicaudatus	short-tailed stingray	
	Dasyatis thetidis	long-tailed stingray	
	Myliobatis tenuicaudatus	eagle ray	rare
eels	Conger verreauxi	conger eel	localised abundance
finfish	Hyporhamphus ihi	piper	common
	Pseudolabrus celidotus	spotty	common
	Aldrichetta forsteri	yellow-eyed mullet	very abundant
	Mugil cephalus	grey mullet	common
	Acanthoclinus fuscus	rock fish	rare - localised
	Forsterygion varium	variable triplefin	rare
	Forsterygion sp.	common triplefin	common
	Favonigobius lateralis	common goby	very abundant
	Peltorhamphus latus	speckled sole	juveniles very abundant
	Rhombosolea leporina	yellowbelly flounder	very abundant
	Rhombosolea plebeia	sand flounder	very abundant
	Rhombosolea retiaria	black flounder	rare - localised
	Genyagnus monopterygius	spotted stargazer	common
	Leptoscopus macropygus	stargazer	common
	Diplocrepis puniceus	orange clingfish	rare
	Girella tricuspidata	parore	very abundant - localised
	Cheilodactylus spectabilis	red moki	abundant - localised
	Latridopsis ciliaris	blue moki	rare
	Upeneichthys lineatus	goatfish	abundant - localised
	Arripis trutta	kahawai	very abundant
	Seriola lalandi	kingfish	common
	Trachurus novaezelandiae	jack mackerel	common
	Chelidonichthys kumu	red gurnard	juveniles abundant
	Caranx georgianus	trevally	common
	Zeus faber	john dory	rare - localised
	Chrysophrys auratus	snapper	common
	Scorpis lineolatus	sweep	rare - localised
	Scorpis violaceus	blue maomao	rare - localised
	Pempheris adspersa	bigeye	very rare - localised
	Scorpaena cardinalis	scorpion fish	rare
	Helicolenus percoides	scarpee	rare
	Hippocampus abdominalis	sea horse	common
	Solegnathus spinosissimus	spiny sea dragon	rare
Chordates			
	Epigonichthys hectori	amphioxus	common - localised

3.2 SUBTIDAL MACROFAUNA

3.2.1 Introduction

There have been very few previous studies conducted on the subtidal communities of Tauranga Harbour. The earliest studies were purely qualitative with brief descriptions of the very shallow harbour margins presented in an overview of the harbour ecology by Bioresearches (1976a). A later study of the Omokoroa - Motuhoa Island area (Bioresearches 1977) included detailed qualitative mapping of the subtidal edible shellfish species.

Quantitaive studies of subtidal soft-bottom benthos in Tauranga Harbour have been confined to environmental impact studies within small geographic areas. The earliest of these studies is that of Harrison and Grierson and partners (1982) in Pilot Bay. Within the port area another limited study provided information on the communities in the deeper waters found in this area (Healy *et al* 1988). The Water Quality Centre has also conducted studies in the Otumoetai Channel to assess the possible impacts from the outfall of Tauranga's waste water treatment plant.

In all these studies there are variations on the sampling methods used making direct comparison between studies difficult. Additional studies are currently being undertaken in the port area by consultants for the Port of Tauranga Limited.

3.2.2 Methods

Subtidal macrofauna was sampled at sixteen sites throughout Tauranga Harbour. These locations are based on the same subtidal sites and numbering as used for the sediment sampling conducted in the harbour and reported in Environment B.O.P's Report 94/10. The sediment sampling provides a range of physical parameters which have also been used to investigate biotic - abiotic relationships in the harbour. The methods and results of sediment studies are presented in detail in Environment B.O.P's Environmental Report 94/10.

At each macrofauna/sediment site, six replicate core samples of the harbour floor were randomly taken using a 13 cm diameter stainless steel corer. The cores were taken to a sediment depth of 15 cm and immediately enclosed in plastic bags with individual labels. The core samples were later sieved back in the Laboratory using 1 mm mesh sieves. The sorted animals were then preserved in 5% formalin in seawater and counts later made of all species down to the lowest taxonomic level using a stereo microscope.

The use of 1 mm mesh for sieving the core samples conforms to overseas standards and also allows direct comparison to the extensive body of data gained as part of the Environment B.O.P's Coastal and Estuarine Ecology Programme (1992).

3.2.3 Common subtidal species and macrofaunal communities in Tauranga Harbour

The most commonly occurring species that were collected in the subtidal macrofauna samples in Tauranga Harbour are presented below in Table 3.2. The dominant taxonomic group was the polychaetes worms with bivalves being far less numerous compared to intertidal samples. The commonest bivalve was the pipi (*Paphies australis*) which can frequently be found in large beds in sheltered shallow subtidal habitat. Two of the other bivalves which occurred frequently in samples, the nut shell and cockle (*Nucula hartvigiana, Austrovenus stutchburyi*) prefer the low intertidal zone and were only well represented in these samples because of the shallow nature of the harbour at many of the sites.

Table 3.2 The numerically dominant macrofauna species recorded in the subtidal surveys using 1 mm mesh sieves. The percentage composition of the total number of individuals from the 96 (13 cm diameter) core samples collected is also given.

	taxonomic group*	% composition of total
Aonides oxycephala	p	14.0
Paphies australis	b	10.2
Heteromastus filiformis	p	8.3
Owenia fusiformis	p	8.3
Aglaophamus macroura.	p	4.6
Oriopsis sp.	p	3.2
Aquilaspio aucklandica	p	3.0
Felaniella zelandica	b	2.4
Magelona dakini	p	2.3
Nucula hartvigiana	b	2.2
Lumbrinereis sphaerocephala	p	2.0
Elminius modestus	c	1.8
Macroclymenella stewartensis	p	1.7
Sabellidae sp.	p	1.7
Chaetozone platycera	p	1.7
Paramoera chevreuxi	c	1.6
Amphipod sp. m	c	1.6
Perinereis sp.	p	1.5
Thelepus plagistoma	p	1.4
Trochodota dendyi	a	1.3
Gari stangeri	b	1.3
Urechis sp.	o	1.3
Patiriella regularis	e	1.1
Austrovenus stutchburyi	b	1.1
other remaining species (64)		20.4

*p - polychaetes, b- bivalves, c - crustacea, a- anemones, e - echinoderms, o - others.

The robust sunset shell (*Gari stangeri*) was present in high numbers at the deepest site sampled (3) at Yellow Point near the northern Bowentown entrance. These shells are commonly found in strongly-scoured harbour channels with coarse shell gravels. The benthic communities in the harbour entrances may be very similar to the *Tarwera-Corbula-Glycymeris* bivalve-dominated communities described by Morton and Miller (1968) at the entrance to Whangarei Harbour.

Near the northern Bowentown entrance there was evidence of extensive former mussel beds with only very small isolated patches of green lipped mussels (*Perna canaliculus*) found during this study. These beds stabilize the bottom in areas of strong current flow and build up an associated community. Species which were commonly found amongst the mussels included the holothurian (*Stichopus molis*), the blue false crab (*Petrolisthes elongatus*) and several species of fish including spotties and scorpion fish.

In the vicinity of Site 9 further up the main channel in the northern harbour the benthic macrofaunal community appeared to be similar to turritellid communities which have been described from similar habitat elsewhere in northern New Zealand (Morton and Miller 1968). These communities are dominated by the horn shell (*Maoricolpus roseus*) which feeds by filtering food particles from the water column.

Progressing further up the harbour there are extensive benthic communities associated with scallop (*Pecten novaezelandiae*) and horse mussel beds. These large bivalves provide a stable substrate for a large number of fauna and flora. There was no opportunity to investigate the latter in detail during this study. The scallop shells often supported the red algaes, *Delesseria* and *Rhodymenia leptohylla* which in turn had rich associations of amphipods and minute rissoid snails.

The smaller upper reaches of the harbour still support low densities of juvenile scallops and horse mussels but the communities tend towards those species which are also common in the lower intertidal zone. In some of the shallow channels with higher silt content, moderate densities of the heart urchin (*Echinocardium australe*) were present.

In the shallower subtidal areas of the Tauranga Harbour, especially where the sediments are free of silt and shell gravel the dominant species are the olive shell (*Amalda australis*), cushion starfish (*Patiriella regularis*) and the cake urchin or snapper biscuit (*Fellaster zelandiae*). Inshore of the subtidal sediment/macrofauna Site 9 the cushion star was present at a mean density of $24/m^2$ with a maximum of $35/m^2$. At the spring lowtide level near the entrance to the Waikareao Estuary an almost identical density of cake urchins was noted.

The numerical dominance of the polychaete worms in the subtidal regions of Tauranga Harbour in comparison to the intertidal zone is illustrated in Figure 3.1. Other variations in the proportions of taxonomic groupings between the subtidal and intertidal habitats is the higher number of crustacea (mainly amphipods) and echinoderms (starfish) in the subtidal habitat. Overall the number of gastropods and bivalves was much lower subtidally.

3.2.4 Relationship between subtidal species communities and abiotic factors

Sediment particle size characteristics, carbon and nutrient content mean values and other descriptive statistics for the surficial substrates at all the subtidal sites combined is provided in Appendix 6. In comparison to the intertidal sites the overall mean silt value of 0.85%, Total Organic Carbon content of 0.057 (g/100g) and nutrient concentrations were much lower. There was also a far higher gravel content with an overall mean value of 9.0%.

Mean species diversity (number of taxa present in each sample) for all the subtidal sites sampled was 6.9. Individual sites varied in species diversity from a low of 0 at Site 46 south of Motuhoa Island up to 13.8 at Site 33 north of Omokoroa Point.

The levels of species diversity for the subtidal sites was similar to species diversity found at the fifteen Environment B.O.P Coastal and Estuarine Ecology low tide sites in Tauranga Harbour (Environment B.O.P 1992) which are based on the same size of core sample and sieve mesh. The species diversity for these intertidal sites ranged from 3.8 - 13.2 with an overall mean of 7.8 taxa per sample.

The subtidal macrofauna site (46) south-west of Motuhoa Island with no fauna present was in an area of active saltation where the sand was being shifted along the bottom by the currents. The extremely active movement of the sediments at this point would have either buried any fauna present or it would have been winnowed out of the sediments by the strong currents. The active movement of bottom sediments observed at this sampling point would not be characteristic of the whole channel. The mapping of subtidal shellfish beds in this area by Bioresearches (1977b) indicates that most of this channel is more stable. In the shallower channels of the Tauranga Harbour, strong currents and the dynamic movement of large deltas (mega ripples) and sand bars is a common feature.

At Site 33 where the highest mean site species diversity was recorded there were large numbers of horse mussel shells providing additional habitat complexity and greater stability of the substrate.

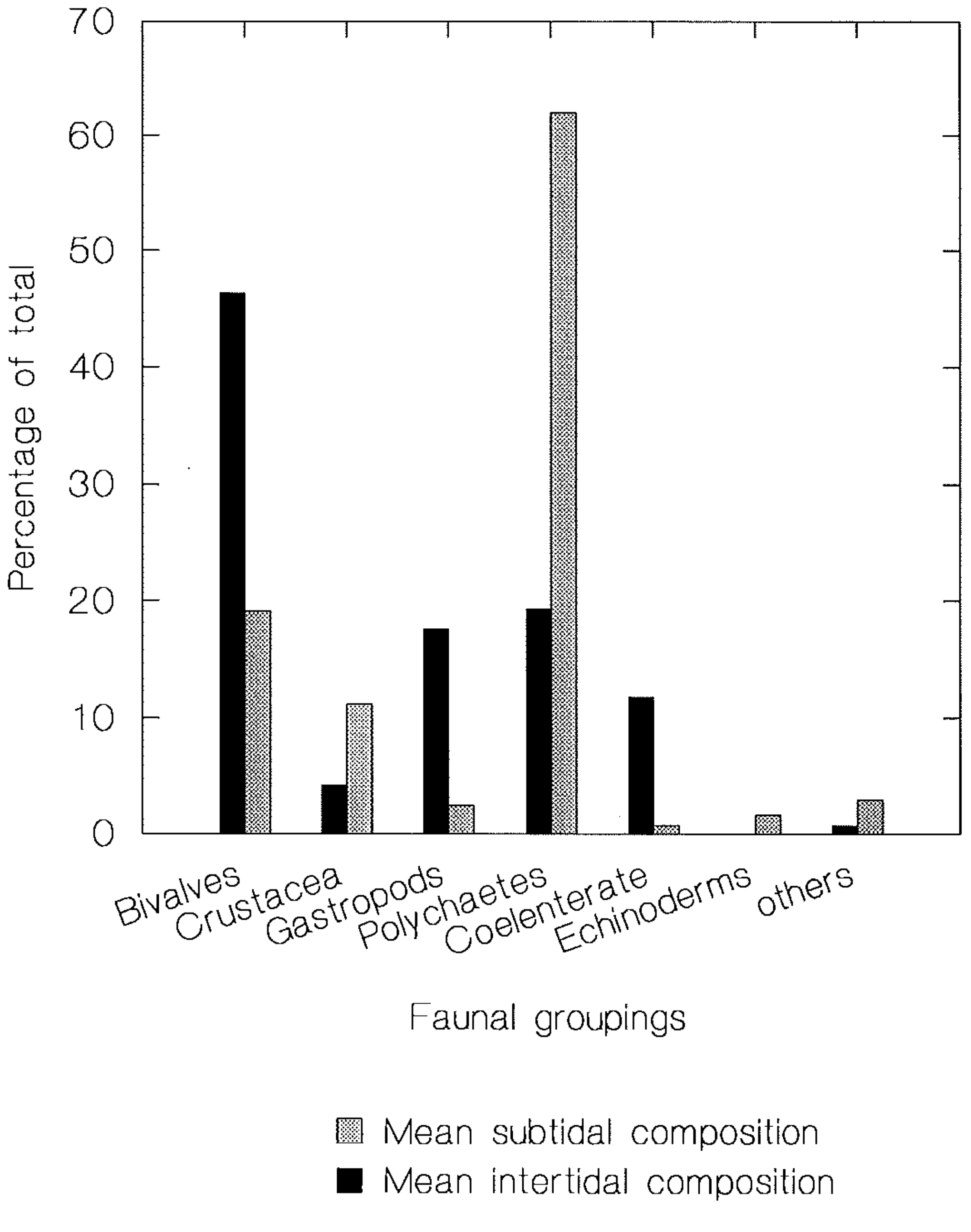

Figure 3.1 Comparison of faunal groups between intertidal and subtidal macrofauna sampled at descriptive sites throughout Tauranga Harbour as part of the Tauranga Harbour Regional Plan Project.

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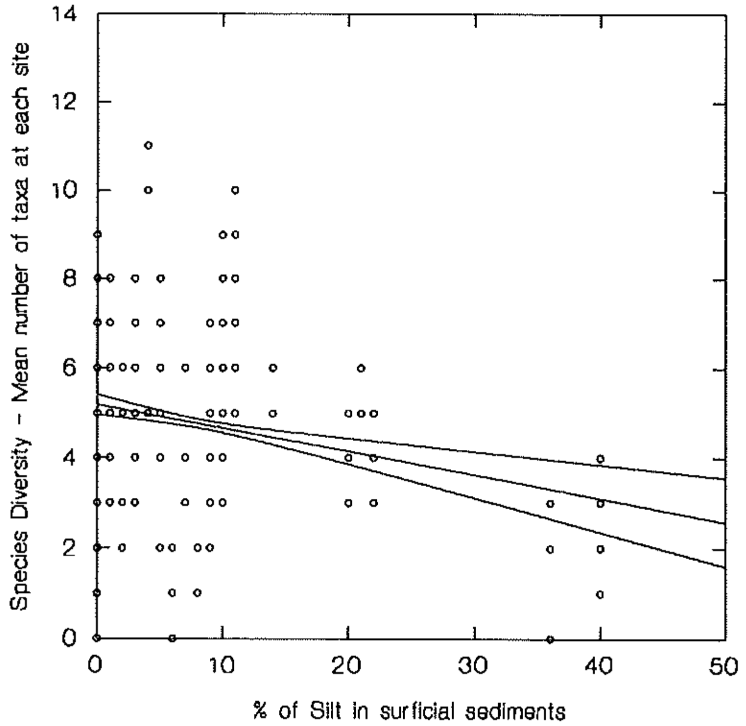
The relationship between species diversity of the subtidal macrofauna samples, the individual species and the recorded sediment parameters was investigated using Pearson correlations. Only the 38 most abundant of the 88 species recorded in the samples were used for the analysis. These species all occurred in more than 10% of the samples taken and the abundances were log10 (x+1) transformed. The correlation matrix of these species and the sediment parameters are presented in Appendix 6.

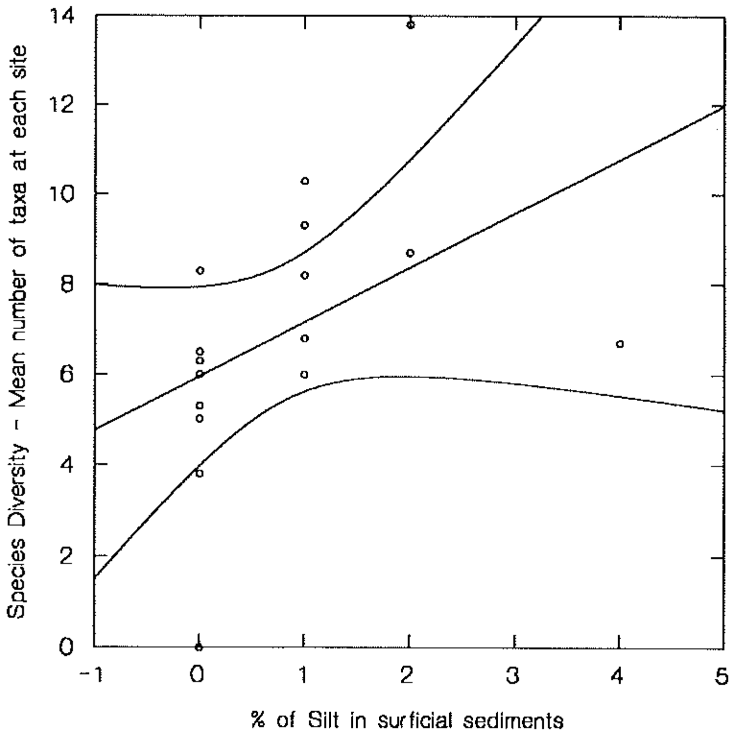
Species diversity at the subtidal macrofauna sites showed a weak positive correlation with the percentage silt content of the surficial sediments (pearson R = 0.378) and negatively correlated with depth (-0.269). The relationship between species diversity and silt content is graphically shown in Figure 3.2. The relationship is the opposite to that shown for the intertidal sites. Results of regression analysis between subtidal species diversity and silt and with depth were both significant (P = 0.000 and P = 0.008 respectively, full results are presented in Appendix 6).

The relationship between species diversity and silt for the subtidal samples is explained by the strong scouring action of currents and shifting sand in the channels. This not only reduces the amount of silt and TOC in the sediments but also limits the number species which can survive in that habitat as mentioned for Site 46 above. Where the currents are slower or there are stable objects such as large shells on the bottom capable of trapping silt there will also be a corresponding increase in the number of fauna. This relationship is not linear and if the currents were slow enough to allow very high siltation rates species diversity would once again decline as it does in the intertidal.

Some of the species which showed significant correlations with the physical variables also produced significant results using regression analysis. The cockle, nut shell and *Heteromastus filiformis* all showed significant negative relationships with depth. The preference of the sunset shell, cushion star and *Aonides oxycephala* for sediments without silt was reflected in their significant negative relationship with the graphic mean of sediment particle size. The polychaete worm, *Aglaophamus macroura* showed a positive relationship with finer sediments and graphic mean of sediment particle size.



(a)



(b)

Figure 3.2 The relationship between species diversity and % of silt found in surficial sediments for the descriptive macrofauna sites sampled in different areas of Tauranga Harbour over the summer period in 1990/91. (a) the intertidal sites, (b) the subtidal sites.

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3.2.5 Multivariate analysis of subtidal site and species associations

PCA analysis was used to reduce the dimensionality of the species abundance data set and identify trends of species communities and the relationships between sites. Cluster analysis was also used on the data as a means of observing the grouping of species and sites.

Only those species which occur in more than 10% of the samples were used in the multivariate analyses. This included 38 of the 88 species recorded from the subtidal sites. The species abundances were log10 (x+1) transformed. The full set of results for the multivariate analyses are presented in Appendix 6.

The PCA analysis (covariance) on the subtidal species abundances produced a first principal component which explained 32.0% of the total variance. The pipi, cockle, *Owenia fusiformis* and *Aonides oxycephala* (polychaete worms) account together for 92% of the variance explained by Principal Component 1.

The second Principal Component explained 19.6% of the total variance and the three polychaetes, *Owenia fusiformis, Oriopsis sp.* and *Heteromastus filiformis* together account for 74.8% of this variance. The third Principal Component explained 10.4% of the variance.

The results of the PCA are presented in Figure 3.3 which shows the sites in relation to decreasing sediment particle size and depth. Along the Principal Component 1 axis the sites separate out with coarse grain sediment sites to the left and fine grained sites more to the right.

Principal Component 2 axis relates to water depth with shallow sites tending to score positively and the deeper sites negatively.

The cluster analysis produces a very similar grouping of the subtidal macrofauna sites. Figure 3.4 shows a dendrogram of the cluster analysis results. An indication of the water depth and sediment grain size is marked on the plot to help with interpretation of factors that appear to be important in grouping the sites as determined from the PCA.

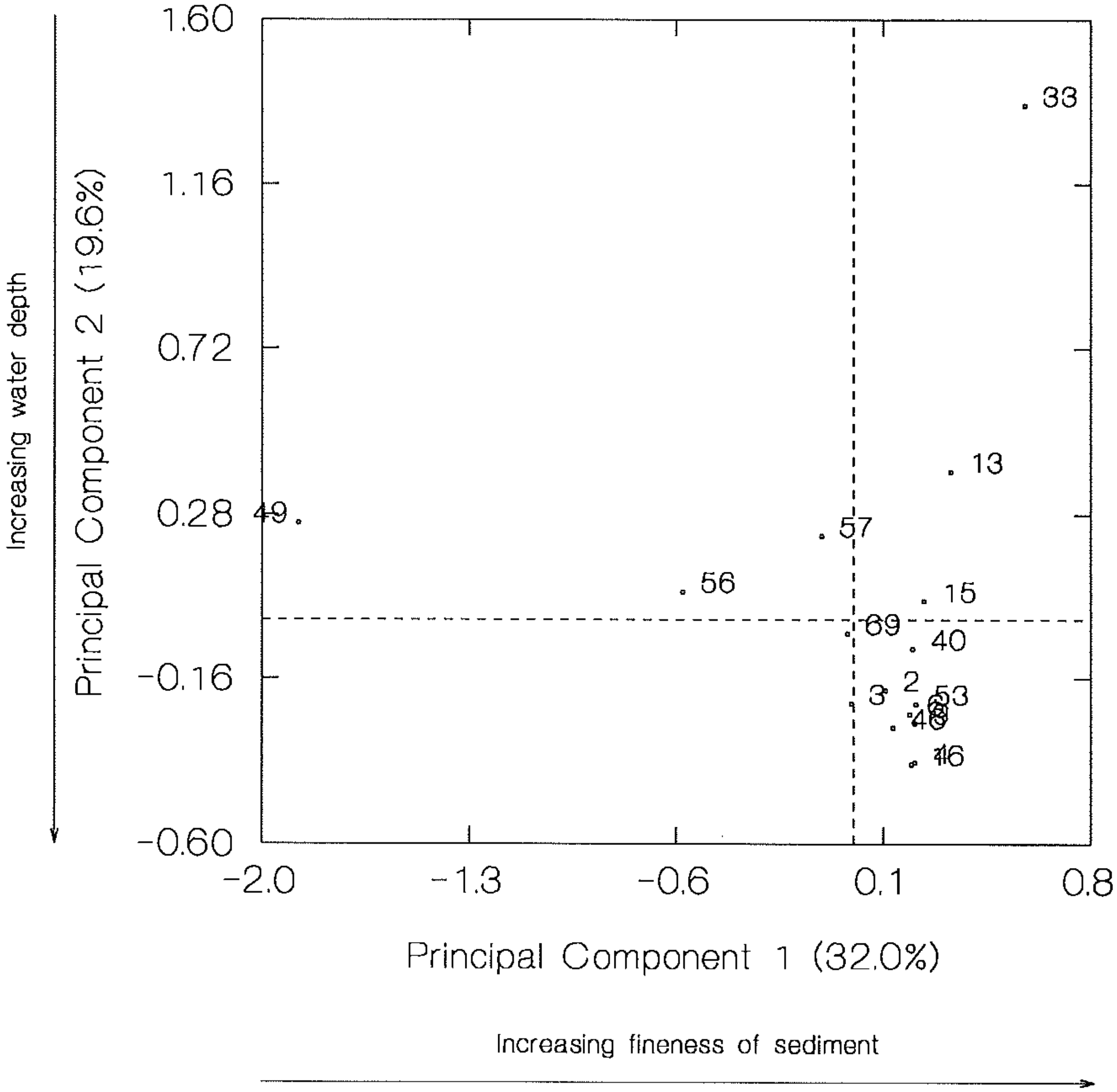

Figure 3.3 Principal Component Analysis (covariance on log10 x+1 transformed data) on site means. Comparison of species communities between sites for the 16 subtidal descriptive sites sampled throughout Tauranga Harbour as part of the Tauranga Harbour Regional Plan Project.

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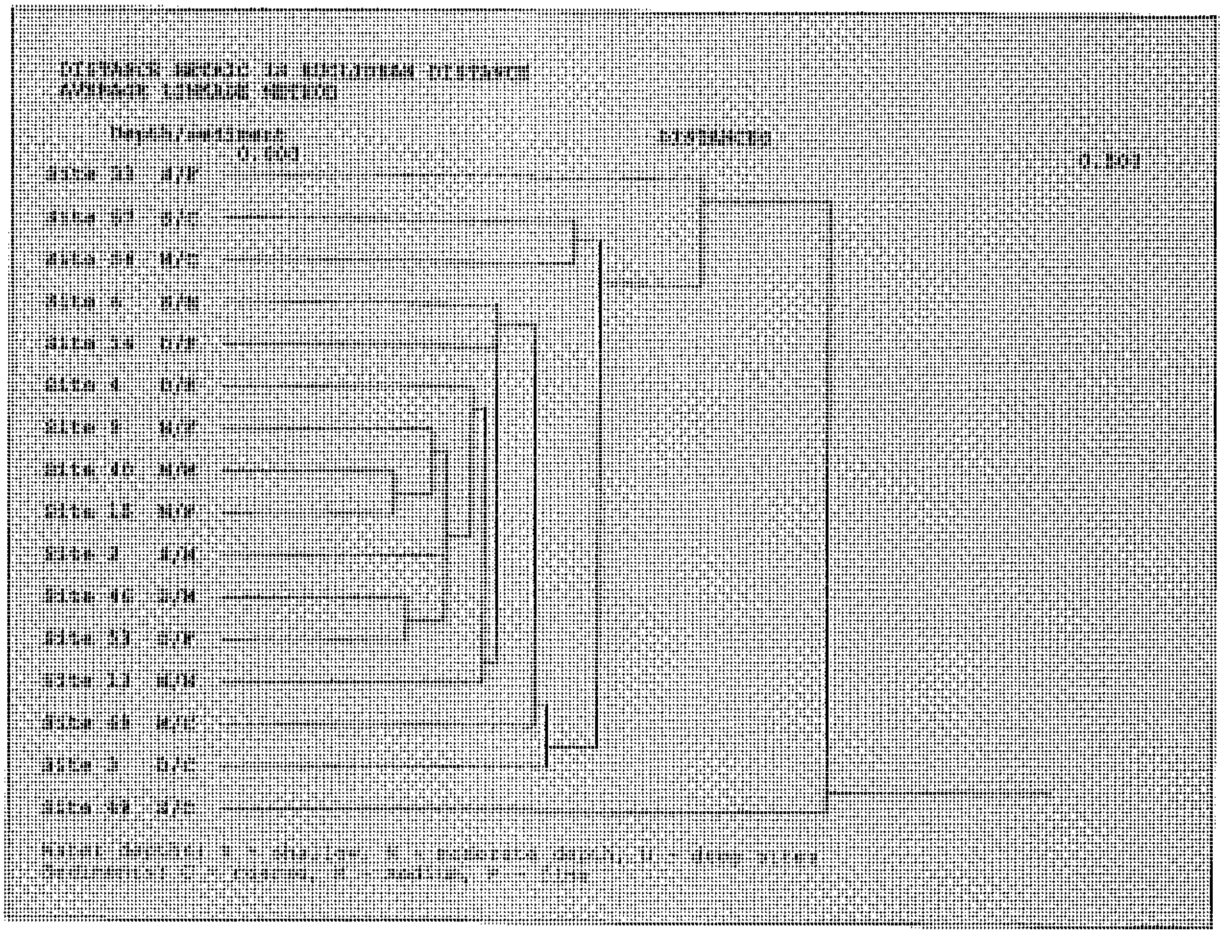


Figure 3.4 Cluster analysis of subtidal macrofauna sampling sites from Tauranga Harbour using site means of species abundance (log10 (x+1) transformed) data.

3.2.6 Comparison with previous studies

The quantitative study of soft-bottom subtidal macrofauna in Pilot Bay (Harrison and Grierson 1982) was restricted to the shallow waters of the bay. The commonest species were the polychaetes *Aglaophamus macroura, Pectinaria australis,* and Sabellidae sp. with very low numbers of cockles, nut shells, the mud whelk and hermit crabs present. Most of these species were also found by this study to be the dominant species in similar habitat elsewhere in the harbour. The presence of *Pectinaria australis,* cushion starfish and the olive shell tend to indicate that the substrate was well-sorted fine sand. This type of habitat occurs extensively throughout the harbour.

In the port area of the harbour where channels have been dredged to a greater depth Healy *et al* (1988) found that the subtidal macrofauna could be partitioned into shallow, intermediate and deep communities. Dominant species in the shallow community included the wedge shell, nut shell, cockle and *Aglaophamus macroura* which is similar to results discussed above and appears to be typical.

The deep community found in the port area by Healy *et al* (1988) was characterised by the presence of the pink sea star, *Amphiura rosea, Pectinaria australis* and the heart urchin, *Echinocardium australe* which are commonly found in fine or muddy offshore sediments (Morton and Miller 1968). This deep community indicates that the currents are not as strong in the deepened port basin with greater sediment stability and incorporation of fine material. The deep community of Healy *et al* (1988) had a higher species diversity compared to their intermediate and shallow communities.

Results of this current study show that the port area may be to some extent unique because of the highly diverse community with affinities to communities commonly found in deeper waters with silty substrates. The deeper sites included in the Tauranga Harbour Regional Plan Project study all showed greater degrees of scouring and substrate instability with clean sediments. Due to this it was found that diversity reduced with depth for the sites studied (see Section 3.2.5). More often species diversity would increase with depth due to the higher stability of the substrates allowing less mobile or sessile species to exist.

Roper's (1990) study of the soft-bottom subtidal macrofauna in the vicinity of Tauranga District Council's waste water treatment plant outfall in the Otumoetai Channel also revealed communities similar to those found in equivalent habitat elsewhere for this study. One difference was the presence of the small sea cucumber *Kolostoneura novaezelandiae* which may be the same as *Trochodota dendyi*, a similar species found in this study. The former species is usually found in rocky habitat.

Comparison of Roper's (1990) results can be made with this study for the number of individuals per 0.1 m^2 found at Site 53 in the vicinity of the outfall A mean of approximately 72 individuals was recorded which is below the range of 160 - 369 individuals per m^2 found by Roper. Other subtidal sites (33 and 13) which had similar sediments showed mean values of 324 and 144 respectively for the number of individual organisms which is similar to the range found by Roper.

The conclusions of Roper's (1990) study suggested that there was no biological impact of subtidal benthic macrofauna communities due to organic enrichment or siltation and that most of the observed variations were natural and related mainly to natural sediment variations. The findings of this study add support to those conclusions by showing that the outfall site has species composition and densities found at similar habitat sites elsewhere within Tauranga Harbour. The lack of impact is most likely a result of the strong tidal currents dispersing the waste water discharge plume and scouring fine material from the sediments as suggested by Roper (1990).

3.3 INTERTIDAL MACROFAUNA

3.3.1 Introduction

Due to the large size of Tauranga Harbour most biological investigations have in the past been confined to small areas of immediate concern or at a limited number of locations. A comprehensive qualitative study of the harbour was undertaken by Bioresearches (1976a, 1976b) for the Bay of Plenty Catchment Commission. This report provides a good overview of the habitat types and typical communities commonly found in Tauranga Harbour and Volume 2 of the report provides useful broad-scale maps. The mapping of the macrofaunal communities and shellfish beds is not duplicated or improved in this study because the intensity of sampling required on a harbour wide basis was well beyond available resources to complete such a task.

Limited quantitative studies of intertidal soft-shore macrofauna communities have been undertaken by Bioresearches in Rereatukahia Inlet, Wairoa Estuary, Waikareao Estuary, Waimapu Estuary and Welcome Bay (1974a, 1975a, 1975b) and Harrison and Grierson (1982) in Pilot Bay. Further quantitative studies which have concentrated on collecting edible shellfish data include Bioresearches (1974b, 1977a, 1977b, 1977d, 1984a, 1987, 1988a, 1988d) and Roan (1989).

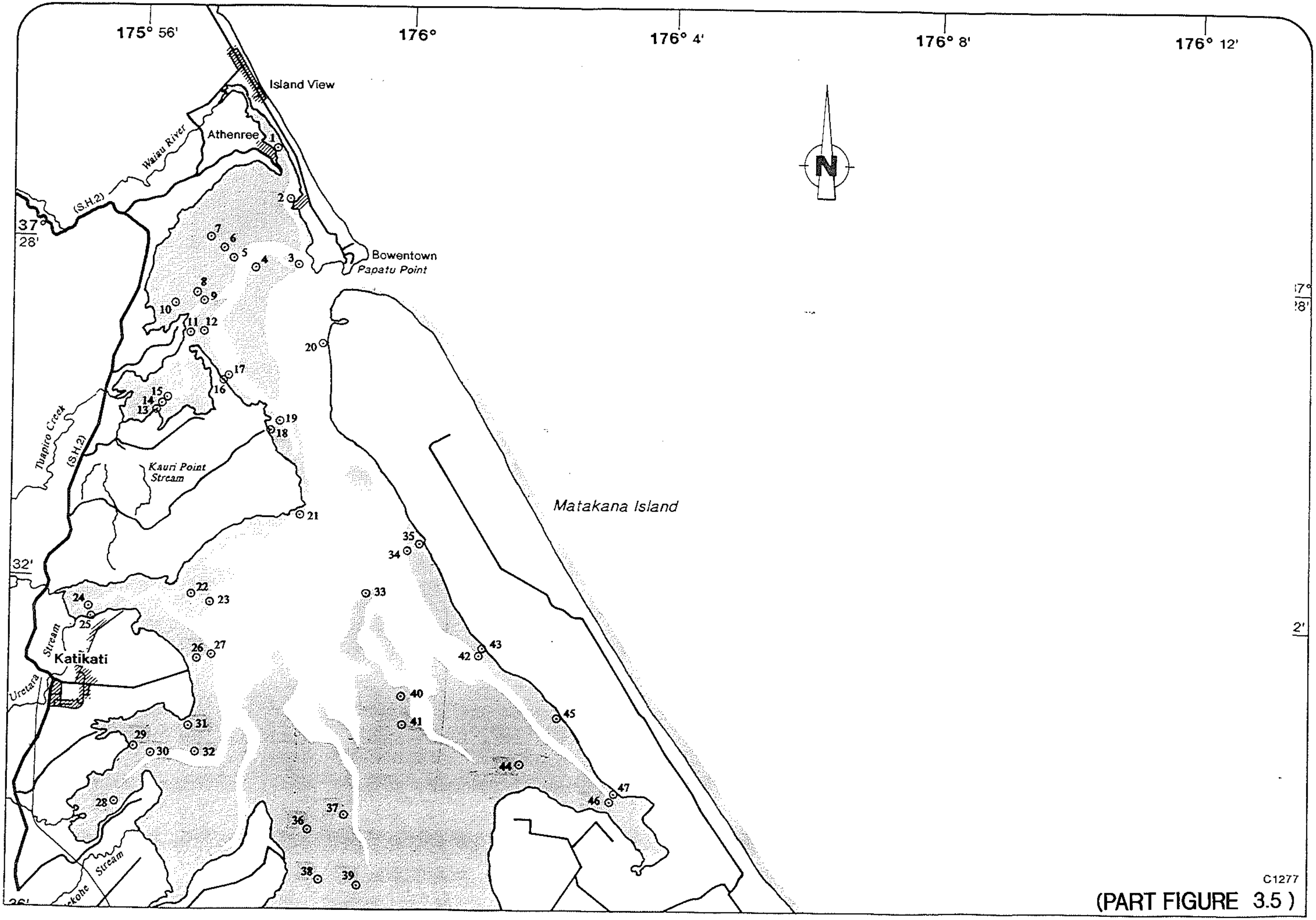
Variations in methods between many of the studies has limited the usefulness of data because it can not be directly compared. This effectively reduces the information cover for the harbour with comparison of the different regions not possible.

3.3.2 Methods

Before sampling commenced on a harbour-wide basis a more detailed investigation of the tidal zonation of species and diversity down the shore was made in Welcome Bay. Results of this pilot survey showed that in the steep upper shore berm which is present throughout much of the harbour, species diversity and biomass is very low. Across the very extensive midtide flats there was little consistent variation in species abundances or diversity. At the lowtide level on the shore obvious patterns of changing species abundance compared to the midtide flats were evident.

Because of the very small amount of consistent change in species abundance across the wide midshore section of the tidal flats, in most locations sampling sites were placed at only one midtide and lowtide level on the shore.

Intertidal macrofauna was sampled at 160 sites throughout Tauranga Harbour. The location of these sites is shown in Figure 3.5. Where possible macrofauna sampling sites were matched to sediment sampling sites to provide a range of physical parameters. These parameters were later used to investigate biotic/abiotic relationships between individual species and communities in the harbour. The methods and results of sediment studies are presented in detail in Environment B.O.P's Environmental Report 94/10.



(PART FIGURE 3.5)

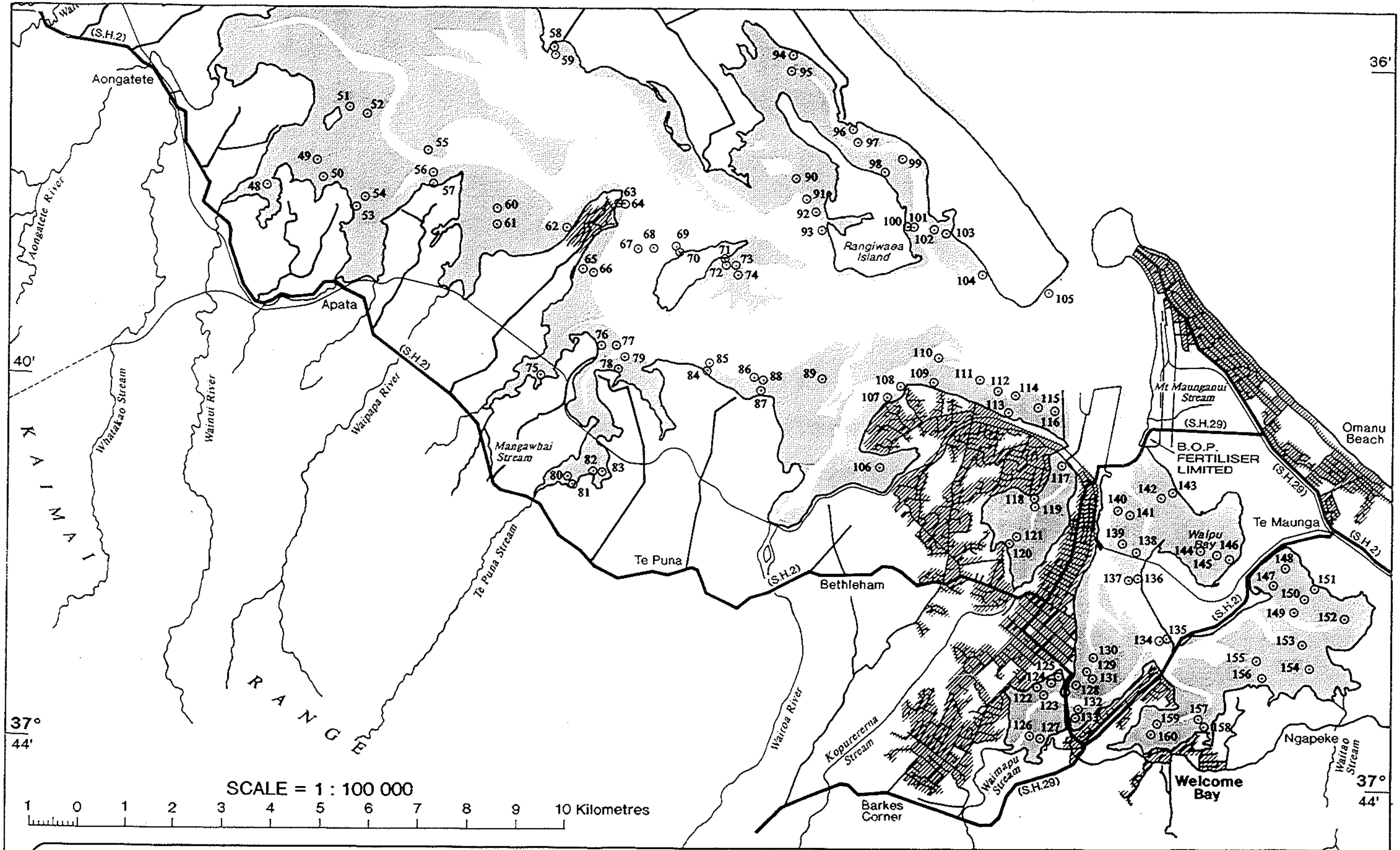


FIGURE 3.5 **LOCATION OF QUANTITATIVE BENTHIC INTERTIDAL MACROFAUNA SAMPLING SITES, INVESTIGATED IN THE SUMMER PERIOD OF 1990/91 AS PART OF THE TAURANGA HARBOUR REGIONAL PLAN PROJECT.**

At each intertidal macrofauna/sediment site, four replicate core samples of the sediments were randomly taken using a 13 cm diameter stainless steel corer. The cores were taken to a sediment depth of 15 cm and immediately enclosed in plastic bags with individual labels. Sediment core samples were then sieved back in the Laboratory using 2 mm mesh sieves. The sorted animals were then preserved in 5% formalin in seawater and counts later made of all species down to the lowest taxonomic level using a stereo microscope.

All the cockle and wedge shells collected in the samples were also measured across their greatest shell width. The results of this data are presented in Section 3.4.

3.3.3 Common intertidal macrofauna and communities

In total 83 species and 10,910 individual animals were recorded in the 640 samples collected from the intertidal macrofauna sites. The most numerous taxonomic group was the bivalves which accounted for 46.3% of the total number of animals. The next most numerous group was the polychaete worms at 19.3%, then the gastropods at 17.6%, coelenterates at 11.8%, and crustacea with 4.2%. These groupings and their composition of the total are presented in Figure 3.1. Figure 3.1 also shows results for the same groupings from the subtidal sites. The bivalves, gastropods and coelenterates were all more numerous in the intertidal zone in comparison to subtidal sites.

The most abundant of all the species encountered was the wedge shell with 15.1% of the total number of all animals recorded. The cockle was present at almost the same level of abundance with 14.9%. Cockles have been recorded as a dominant intertidal community species from a number of estuarine studies throughout New Zealand (Knox and Kilner 1973, Knox *et al* 1977).

Table 3.3 lists all the species in order of abundance for those which comprised 1% or more of the total.

The main macrofauna communities in the intertidal zone of Tauranga Harbour are well represented by the classifications and mapping undertaken by Bioresearches (1976a) for the Bay of Plenty Catchment Commission. In the muddier areas of the harbour, *Amphibola avellana* communities predominate. Throughout the majority of the open harbour the sediments are clean with cockle/wedge shell and sea grass-associated communities. The sea grass community is very similar in faunal composition to the description provided by Morton and Miller (1973) for northern New Zealand harbours.

Table 3.3 **The numerically dominant macrofauna species recorded in the inter-tidal surveys using 2 mm mesh sieves with the percentage composition of the total number of individuals from the 640 (13 cm diameter) core samples collected.**

	taxonomic group*	% composition of total
Tellina liliana	b	15.1
Austrovenus stutchburyi	b	14.9
Anthopleura aureoradiata	a	11.7
Nucula hartvigiana	b	11.6
Scoloplos sp.	p	6.7
Zeacumantus lutulentus	g	6.6
Zeacumantus subcarinatus	g	3.5
Cominella gladiformis	g	2.8
Sclecolepides benhami	p	2.4
Perinereis nuntia var. vallata	p	2.3
Paphies australis	b	2.2
Heteromastus filiformis	p	1.9
Felaniella zelandica	b	1.9
Diloma subrostrata	g	1.8
Micrelenchus huttoni	g	1.8
Aquilaspio aucklandica	p	1.4
Aonides oxycephala	p	1.0
Macroclymenella stewartensis	p	1.0
other remaining species (65)		19.4

*b - bivalves, a - anemones, p - polychaetes, g - gastropods.

Maximum and overall harbour wide values for densities of the most abundant macrofauna recorded from the intertidal sampling sites in Tauranga Harbour are presented in Table 8.4.

The densities of many of the dominant community species appear to be typical of other harbours and estuaries in New Zealand. Maximum density (m^2) of the cockles in Tauranga Harbour at 2,185 is similar to maximum density of 2,560 recorded by Knox and kilner (1973) in the Avon-Heathcote Estuary and Murray (1978) in the Maketu Estuary. Cockles can reach far higher densities, having been recorded in Shakespeare Bay at a maximum density of 7,400 (Knox and Bolton). Lower densities have also been recorded from the reasonably pristine Parapara Inlet (Knox *et al* 1977).

Table 3.4 **Abundance of common intertidal macrofauna species recorded in 13 cm diameter core samples (n=640) using 2 mm mesh sieves, sampled throughout Tauranga Harbour and presented as numbers per square metre.**

	Overall mean	Maximum
Bivalves		
Nucula hartvigiana	149	3,918
Paphies australis	28	2,486
Austrovenus stutchburyi	191	2,185
Felaniella zelandica	24	1,507
Tellina liliana	194	904
Crustacea		
Callianassa filholi	5	527
Macrophthalmus hirtipes	13	301
Halicarcinus whitei	10	301
Hemigrapsus crenulatus	4	226
Gastropods		
Comminella glandiformis	36	2,561
Zeacumantus subcarinatus	46	1,808
Micrelenchus huttoni	23	1,055
Zeacumantus lutulentus	85	979
Diloma subrostrata	23	678
Polychaetes		
Scolecolepides sp.	87	2,034
Aonides oxycephala	13	829
Perinereis nuntia	30	678
Heteromastus filiformis	24	678
Scolecolepides benhami	30	527
Macroclymenella stewartensis	12	377
Coelenterates (Anemone)		
Anthopleura aureoradiata	150	5,048

The wedge shell has a maximum density similar to those recorded in Maketu Estuary (Murray 1978), Avon-Heathcote Estuary (Knox and Kilner 1973) and Shakespeare Bay (Knox and Bolton). Even the overall mean density for Tauranga Harbour is higher than the maximum densities recorded from the Whangateau Harbour (Larcombe 1968) and almost as high as the maximum density of 230 recorded in Parapara Inlet (Knox *et al* 1977). Another dominant species in the Tauranga Harbour intertidal zone, with very high maximum densities compared to other studies, is the nut shell. The majority of habitat sampled in Tauranga Harbour appears to favour this species.

Appendix 7 contains the descriptive statistics for all the species recorded at the intertidal macrofauna sampling sites throughout Tauranga Harbour. The descriptive statistics are presented by habitat type for those species which showed significant variation between habitat. The appendix also contains the matrix of Pearson correlation coefficients and probabilities between species abundances.

Simple examination of the species abundance associations by correlation revealed that amongst those species with the highest correlations, two were due to habitat provided by one of the species. The cockle and common shore anemone had a high correlation as the cockle provides a stable hard substrate for the anemone. In a similar fashion the pipi also provides a hard substrate for the green shield chiton (*Chiton glaucus*) to feed and live on. Most other species with high correlations appear to have similar niche requirements. There were no highly significant negative correlations that suggest competitive interactions between species. There was also no significant correlation between total numbers of bivalves and polychaete worms at each of the sites. This suggests that there is little interaction of any sort with the changing dominance of these groups between sites.

3.3.4 Influence of sea grass beds and tidal height on species diversity and composition

Possible differences in species abundances and overall species diversity between the tidal heights sampled in this study and the presence or absence of sea grass bed was investigated using univariate and multivariate analysis of the data.

Results of a PCA (covariance) performed on transformed (log10 (x+1)) site means resulted in the first Principal Component explaining 26.8% of the total variance and Principal Component 2 explaining 13.6%. In the first principal component (in respective order) the cockle, common shore anemone (*Anthopleura aureoradiata*), nut shell, wedge shell and the horn shell (*Zeacumantus subcarinantus*) accounted for 89.3% of the component loading. For the second Principal Component the nut shell, the polychaete (*Scolecolepides sp.*), the common shore anemone, the horn shell (*Zeacumantus lutulentus*), the wedge shell and cockle together account for 88.4% of the loading for this component. The third Principal Component explained 9.7% of the total variance. All results are presented in Appendix 8.

Figure 3.6 shows the plot of the factor scores from the PCA with each sites represented by a symbol to show which habitat grouping it belonged to. There is some separation of the sites shown on this basis with the low tide sea grass sites being most distinct. The other habitat groupings show a higher degree of overlap which indicates that other factors may better explain the variance in the data, especially for Principal Component 1.

Macrofauna species form the intertidal sampling sites which showed variation in their mean abundance values between the mid/lowtide and sea grass/bare sand sites were tested for significance. Even the use of log10 (x+1) transformations had not normalised the species abundance data so non-parametric ANOVA's were used to test for differences in abundance. The results for those species which showed significant differences between the habitat groupings are presented in Table 3.5 below.

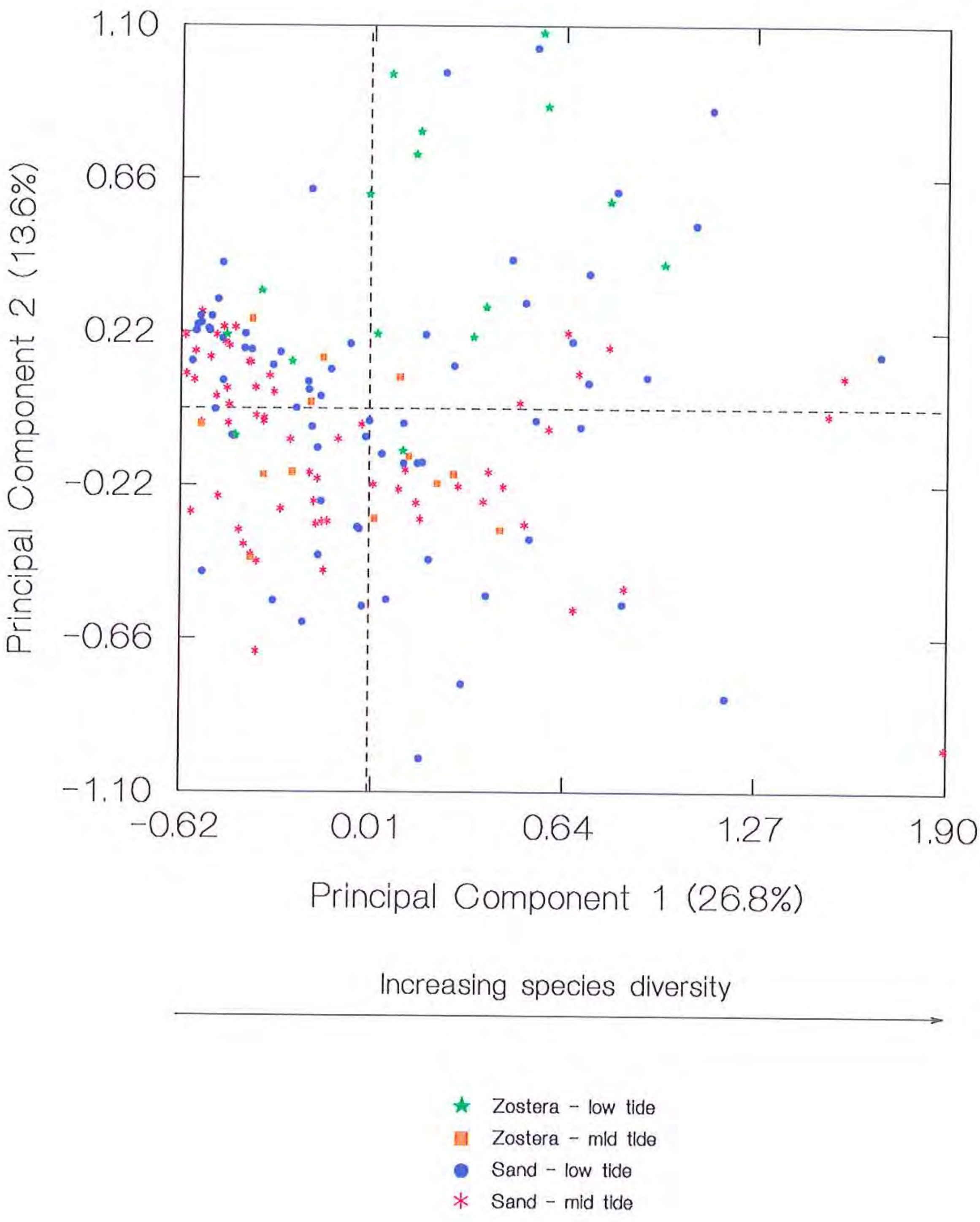


Figure 3.6 Principal Component Analysis (covariance on log10 x+1 transformed data) Comparison of species communities between sites for the 160 descriptive sites sampled throughout Tauranga Harbour over the 1990/91 summer period. An indication of habitat type is shown.

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Table 3.5 Probability values of non-parametric (Kruskal-Wallis) ANOVA's comparing differences in species diversity and species abundance between the habitats sampled in Tauranga Harbour. Only macrofauna species which showed a significant difference are presented.

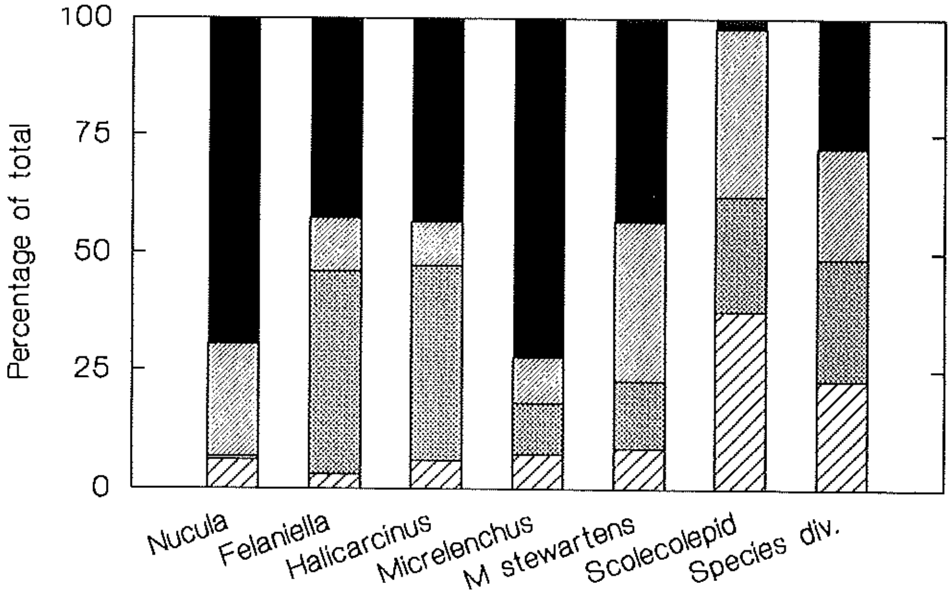
	Tide height	sea grass
Species diversity	0.264	0.002**
Nucula hartvigiana	0.000***	0.000***
Felaniella zelandica	0.019*	0.000***
Halicarcinus whitei	0.489	0.000***
Zeacumantus lutulentus	0.015*	0.105
Micrelenchus huttoni	0.000***	0.000***
Macroclymenella stewartens	0.000***	0.069
Perinereis nuntia	0.000***	0.033*
Scolecolepides benhami	0.022*	0.046*
Scolecolepides sp.	0.015*	0.001***

The nut shell and the small herbivorous opal shell (*Micrelenchus huttoni*) both had very significant tide height and sea grass cover results.

Figure 3.7 shows the differences in abundance between the habitat groupings for most of the species appearing in Table 3.5. The nut shell and small opal shell show higher abundance both with respect to sea grass beds and tide height while the polychaete worm (*Scolecolepides sp.*) shows the opposite with a reduced abundance in the low tide sea grass beds. The bivalve (*Felaniella zelandica*) and the pill box crab (*Halicarcinus whitei*) show a marked difference in abundance due to the presence of sea grass but had little or no change due to tidal height.

Increased species diversity, abundance and biomass of benthic communities within sea grass beds in comparison to barren substrates has been established by a number of studies world wide (eg., Edgar 1990, Homziak *et al* 1982, Bell and Westoby 1986, lewis 1984, Stoner and Lewis 1985). Sea grass beds increase species diversity by a number of mechanisms which include; (i) a greater variety of food sources, (ii) increased structural complexity and number of microhabitats, (iii) sediment deposition and stabilization, (iv) increased production of organic plant matter, (v) reduction of hydrodynamic forces within the beds.

While there was a significantly greater number of species within Tauranga Harbour sea grass beds, there was only a slightl increase in numbers relative to bare substrates. Mean species diversity in the bare substrate was 5.330 while sea grass beds recorded 6.198, a difference of less than one species but as a percentage an increase of 14%. The difference would most likely have been much greater if such a study was undertaken with fine meshed sieves (ie 0.5 mm) due to the abundance of smaller benthic species in the sea grass habitat.



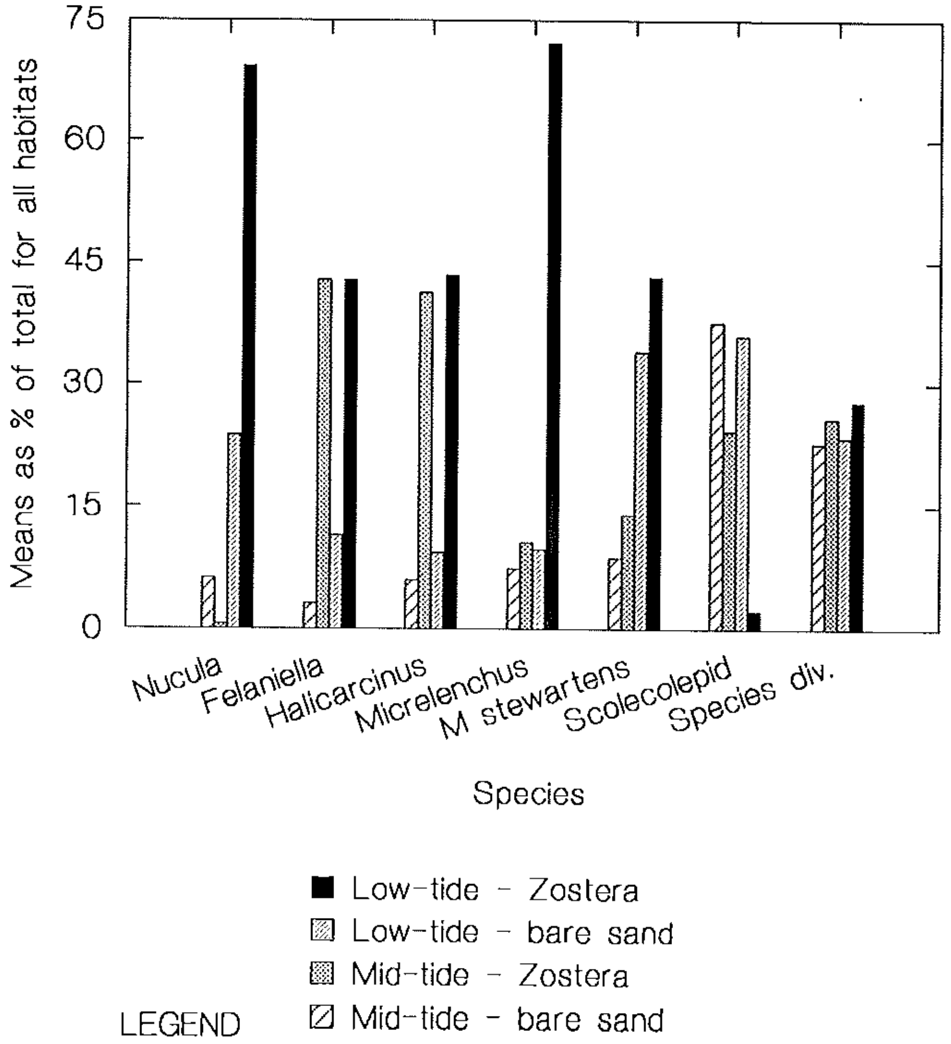


Figure 3.7 Mean abundance of macrofauna species showing the variation between each of the four habitats sampled throughout Tauranga Harbour over the summer period in 1990/91 as part of the Tauranga Harbour Regional Plan Project. Means are expressed as a percentage of the total for all four habitat zones.

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3.3.5 Influence of sediments on species diversity and communities

Sediments at the intertidal macrofauna sampling sites tended to be relatively clean sand with low silt, Total Organic Carbon (TOC) and nutrient content (see Environmental Report 94/10). It was only within the sheltered confines of the various sub-estuaries of Tauranga Harbour that silt content reached significant levels. Mean harbour-wide values were as follows; sand - 87.5%, silt 8.6%, gravel 3.7%, TOC 0.12 g/100g. The full set of sediment parameters and descriptive statistics is presented in Appendix 10.

Pearson correlations between species diversity, the individual species abundances and the descriptive sediment parameters resulted in a number of the variables showing significant values. All those species which showed significant results are presented in Appendix 10.

Species diversity of the samples showed the strongest correlation with silt content. The number of species found in each sample decreased as the percentage silt content of the surficial sediments increased. A regression analysis of species diversity and silt content produced a significant result ($P = 0.007$).

Figure 3.2(a) shows the negative relationship between species diversity and silt content of the surficial sediments. The Splom plot in Figure 3.8 shows some of the other sediments parameters plus six of the macrofauna species which also showed significant correlation and regression results (see Appendix 10).

Common macrofauna species which showed a significant negative correlation with silt content included, the cockle, nut shell, wedge shell, small opal shell, the horn shell and the carnivorous snail, *Comminella glandiformis*. The crab, *Macrophthalmus hirtipes* which prefers a slightly muddy habitat and the polychaete worm, *Heteromastus filiformis* both showed a positive correlation with silt content.

The sediment parameters and species diversity were correlated with the first Principal Component scores from the PCA of the macrofauna species abundances from the intertidal sampling sites. None of the physical sediment parameters showed significant correlations, but species diversity was strongly correlated (results in Appendix 10). Figure 3.9 shows the relationship between species diversity and Principal Component 1.

The PCA results suggest that the main factor explaining the variation observed in the species communities sampled in this study cannot be adequately explained by any single physical sediment parameter. The relationship between species diversity and silt content suggests that of all the sediment parameters, silt is likely to be the single most important variable contributing to the first Principal Component of the PCA.

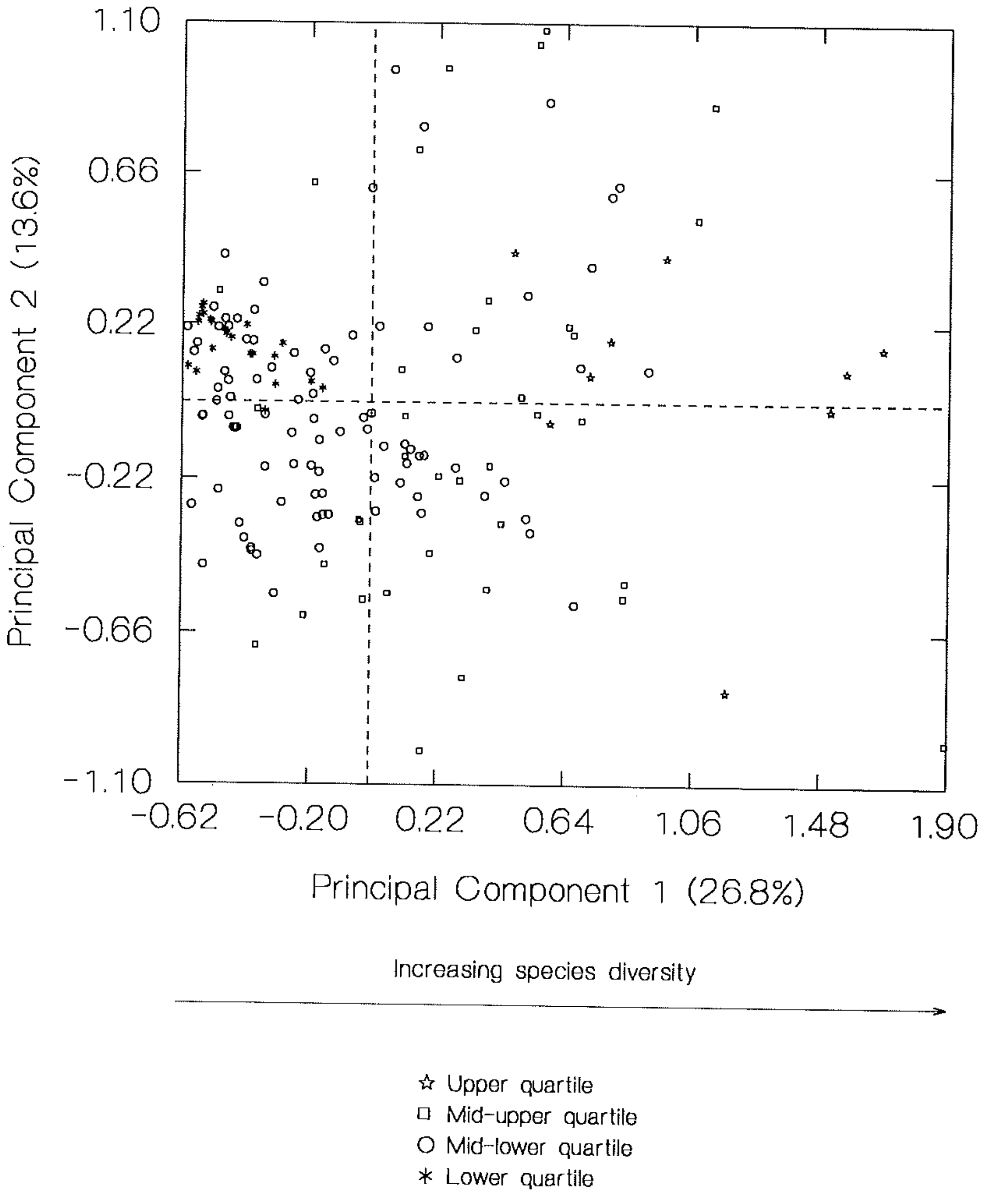

Figure 3.9 Principal Component Analysis (covariance on log10 x+1 transformed data) Comparison of species communities between sites for the 160 descriptive sites sampled throughout Tauranga Harbour over the 1990/91 summer period. The quartile range into which mean species diversity at each site falls is indicated by the symbols with the total range being 0 - 12.75 species.

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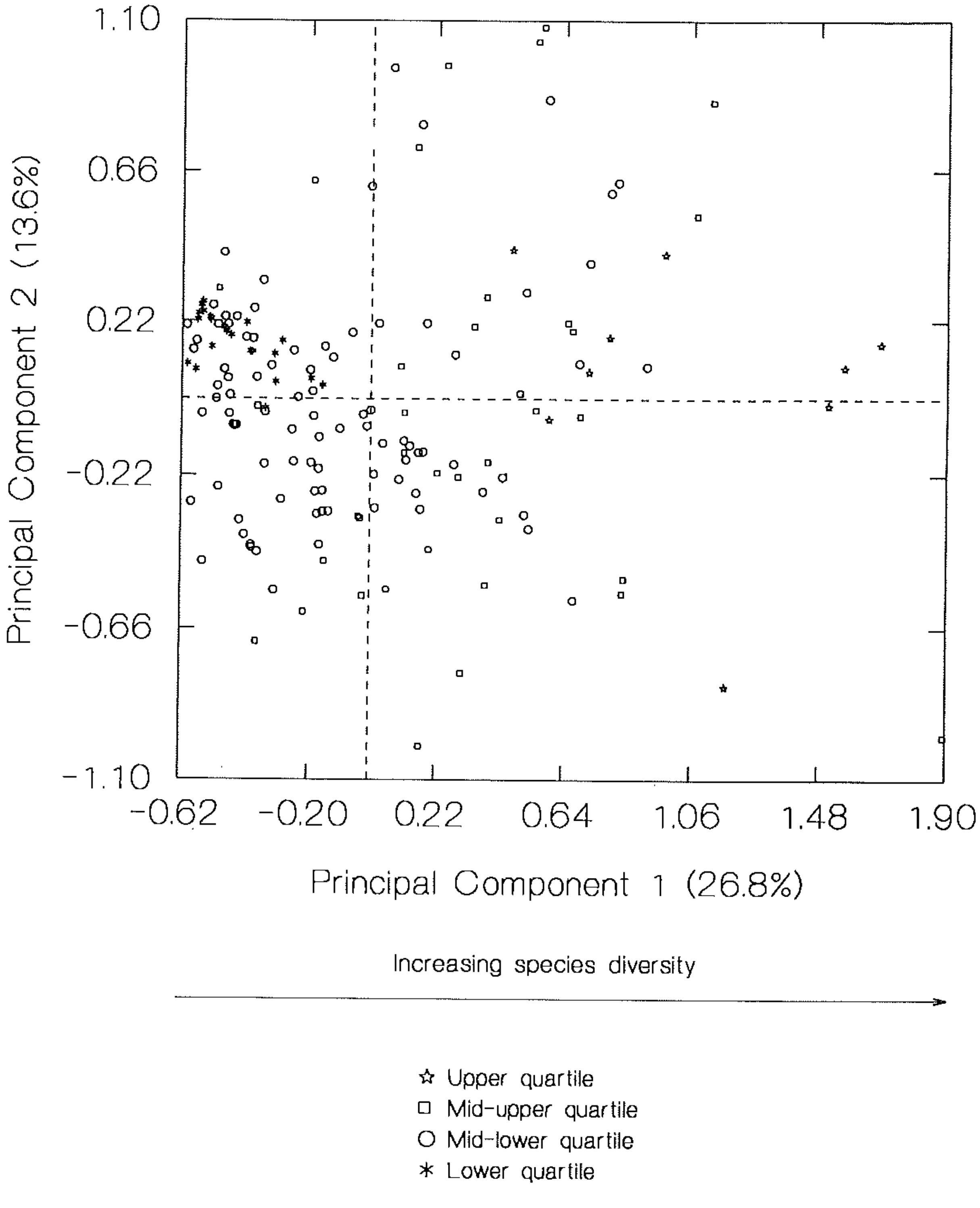

Figure 3.9 Principal Component Analysis (covariance on log10 x+1 transformed data) Comparison of species communities between sites for the 160 descriptive sites sampled throughout Tauranga Harbour over the 1990/91 summer period. The quartile range into which mean species diversity at each site falls is indicated by the symbols with the total range being 0 - 12.75 species.

File: R:/pc/systat/coms/rmn/cee/spdipca.cmd

The correlations between the macrofauna and sediment parameters also shows that the importance of parameters will vary from species to species. The presence of gravel material is important for the isopod, *Exosphaeroma planulum* and the green shield chiton, *Chiton glaucus*. The crab, *Macrophthalmus hirtipes* and the mud snail, *Amphibola avellana* both show a strong preference for sites with high TOC.

3.4 SHELLFISH STOCKS

Length-frequency data for cockles, wedge shells, and pipis collected from all the intertidal macrofauna sampling sites throughout Tauranga Harbour is presented in Appendix 11. These sites were not selected for the purpose of ensuring that all the edible shellfish beds within Tauranga Harbour were sampled. It should also be noted that the intertidal macrofauna sites are located at mid and mean lowtide levels while the largest cockles are usually slightly lower on the shore. The largest pipis are often found in the shallow subtidal.

Shellfish length-frequency data for the cockles and wedge shells was grouped into fifteen small geographic areas of Tauranga Harbour and length-frequency histograms plotted. Pipis were not treated in the same manner due to the low numbers collected in most of the samples.

Figure 3.10 shows the resulting length-frequency histograms for cockles based on 5 mm length intervals. Amongst all these sites there are some clear differences. All the upper harbour regions and smaller sub-estuaries tended to have a modal population size peak at around 15 mm length. The upper reaches of the Town Basin, Waimapu Estuary and Welcome Bay - Rangataua Bay, and the Waikareao Estuary (all in regions with lower water quality) have the lowest overall size.

Tanners Point - Pios Beach, Motuhoa Island, Hunters Creek, and the Wairoa River delta - Otumoetai foreshore have the populations with the largest sized shellfish. These regions are all in close proximity to the entrances of Tauranga Harbour. Proximity to the entrances may provide the shellfish at these sites with better overall feeding conditions with respect to food availability and water quality.

Overall cockle sizes in Tauranga Harbour tend to be small with most beds not reaching what is considered to be an edible size at around 30 mm or more. There are a number of areas in Tauranga Harbour not covered by this survey which are both nearer the spring lowtide level and close to the harbour entrances which support good densities of large cockles (35-50 mm). The size of Tauranga Harbour and habitat conditions throughout make it difficult to make simple comparisons to other studies within New Zealand.

Changes to the cockle populations may also have occurred over long periods of time within the harbour. At the entrance to Tuapiro Estuary in the northern Tauranga Harbour cockle shells had been dug up next to the boat ramp which

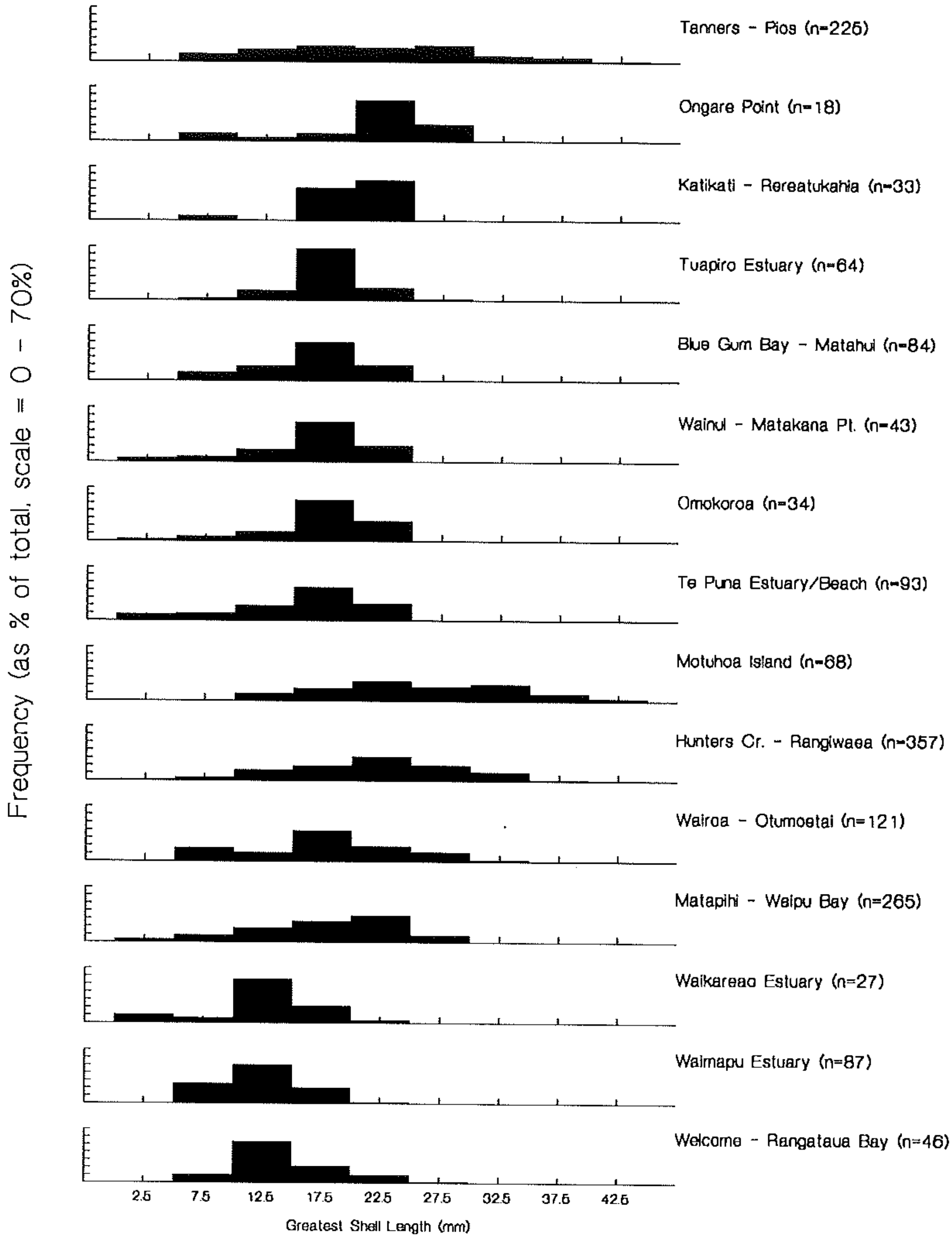

Figure 3.10 Length frequency histograms showing the variation in size classes of cockle (*Austrovenus stutchburyi*) populations recorded from different areas of Tauranga Harbour over the summer in 1990/91.

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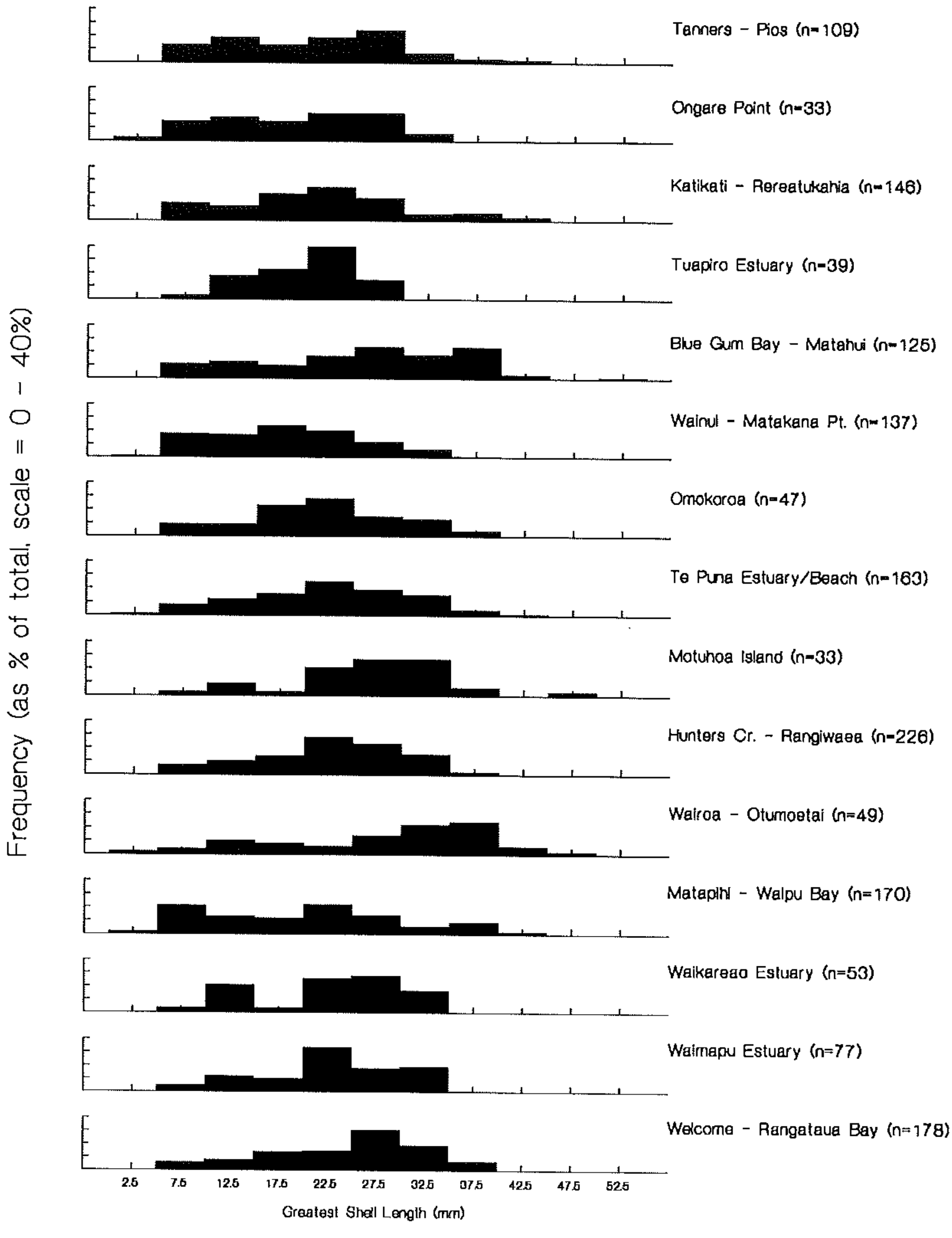

Figure 3.11 Length frequency histograms showing the variation in size classes of wedge shell (*Tellina liliana*) populations recorded from different areas of Tauranga Harbour over the summer in 1990/91.

File: R:/pc/systat/coms/rmn/cee/tellina.cmd measured up to 55 mm across. The age of these shells, or whether they had grown and died *in situ*, is not known but the present population of cockles in the vicinity of the boat ramp only reaches just over half this size. Reasons for this decline in size, if real, may include higher suspended solids levels in the water, a change in the quality of food available and the possibility of lower water quality with respect to herbicides and pesticides. The former aspects would have occurred in the early history of the harbour with forest clearance etc.

Comparison of shellfish length-frequency data from 1974 (Bioresearches 1974a) for Rereatukahia Inlet, Wairoa Estuary, Waikareao Estuary, Waimapu Estuary and Welcome Bay was possible for all but the Wairoa Estuary site. Bioresearches cockle length-frequency data for the Wairoa Estuary is obtained from a site half way up the inlet while data from this study was gained at the entrance. Consequently the smaller cockle size found in Bioresearches (1974a) study will be due to habitat changes and quality. For all the other sites, comparison of the most applicable data shows that over the sixteen year period there has been virtually no change in the size of the cockles.

Differences in the length-frequency histograms of wedge shell populations for the same regions of the harbour (Figure 3.11) are not as great as those shown by the cockle populations. There is a similar overall trend to cockle populations with the largest shellfish being recorded in the same areas. The one obvious difference is that in the upper northern harbour basin from Blue Gum Bay to Matahui the wedge shells are amongst the largest found any where in the harbour.

Although no length-frequency plots were produced for the pipis there was a trend for the largest shellfish to be located near to the harbour entrance. There are substantial beds of pipis further up the harbour in the Northern, Southern and Town basins and in all cases the shellfish are much smaller.

3.5 RECLAMATION AND OTHER CHANGES WITHIN THE INTERTIDAL ZONE

Easily observable changes over time to the intertidal zone of Tauranga Harbour can be attributed to two main causes. These are the reclamation and draining of maritime marsh around the harbour's shoreline and the impact of increased silt runoff from forest clearance and the change in land usage.

The impacts of increased silt runoff is most noticeable within the sheltered sub-estuaries of Tauranga Harbour. In the more exposed main harbour basins the wind fetch and resultant wave energy appears to be sufficient to prevent extensive siltation. In 1982 the collapse of the Ruahihi Canal resulted in large quantities of silt being deposited on the sandflats in the Wairoa Estuary and surrounding areas of Tauranga Harbour. Layers of silt several centimeters in depth smothered and killed marine life both in the intertidal and subtidal (Bioresearches 1982). During this study, no evidence of this siltation could be found in the more open areas of the harbour.

Within many of the small sub-estuaries rapid changes since 1943 are evident as a result of siltation. In Katikati Estuary in 1943, sea grass beds covered an extensive part of the lower estuary. At this point in time the sea grass beds have been excluded from all but the exposed entrance. In Katikati Estuary and many others around the harbour, the former sandy sediments can still be found at varying depths below often sharply-defined layers of mud.

In Figure 3.12 the changes that have taken place in the Wainui Estuary since 1943 are shown. The changes include the loss of maritime marsh and mangrove areas by reclamation, drainage, fencing and grazing etc. High siltation rates have also encouraged the spread of mangroves as the intertidal areas have shallowed and as the sediments became far muddier. The dramatic increase in mangroves within the Wainui Estuary has also occurred in many other parts of the harbour.

As part of the Tauranga Harbour Regional Plan Project the areas of mangrove throughout the harbour have been mapped and will be digitised to provide a baseline from which future changes can be assessed. The same also applies to mapping of areas of reclamation and draining or other activities which have resulted in the significant degradation or loss of the maritime marsh and intertidal habitat.

Interim estimates of reclaimed areas (as defined above), mangroves, and maritime marsh throughout Tauranga Harbour were made using aerial photographs and a planimeter. The results are presented in Table 3.6 and provide some degree of partitioning for the various regions of the harbour. There are no aerial photographs of the whole Tauranga Harbour taken before 1943. At this point in time many major reclamations had already taken place, so it is not possible to provide exact figures on the amount of maritime marsh or mangroves lost due to reclamations etc.

The estimates of reclaimed maritime marsh and intertidal zone suggest that possibly between half and two thirds of the maritime marsh habitat in Tauranga Harbour has been reclaimed, drained or severely impacted in some way. The reclamations are mainly in the upper reaches of the harbour where streams and rivers enter. There is almost no reclamation on Matakana Island and the majority of reclaimed area is within the southern half of the harbour.

Even since the last estimate of mangroves in Tauranga was made (Crisp *et al* 1990) based on 1976 aerial photographs, changes may have occurred. Estimates for mangrove cover at 1976 was 542.9 hectares compared to 596.7 in 1991. If both of these figures are reasonably accurate then there has been approximately a 10% increase over this fifteen year period. As previously mentioned the increase in mangroves is confined mainly to the small sheltered sub-estuaries. The large expanse of mangroves in the upper reaches of the harbour just off Tirohanga Point, Matakana Island has remained virtually unchanged since 1976.

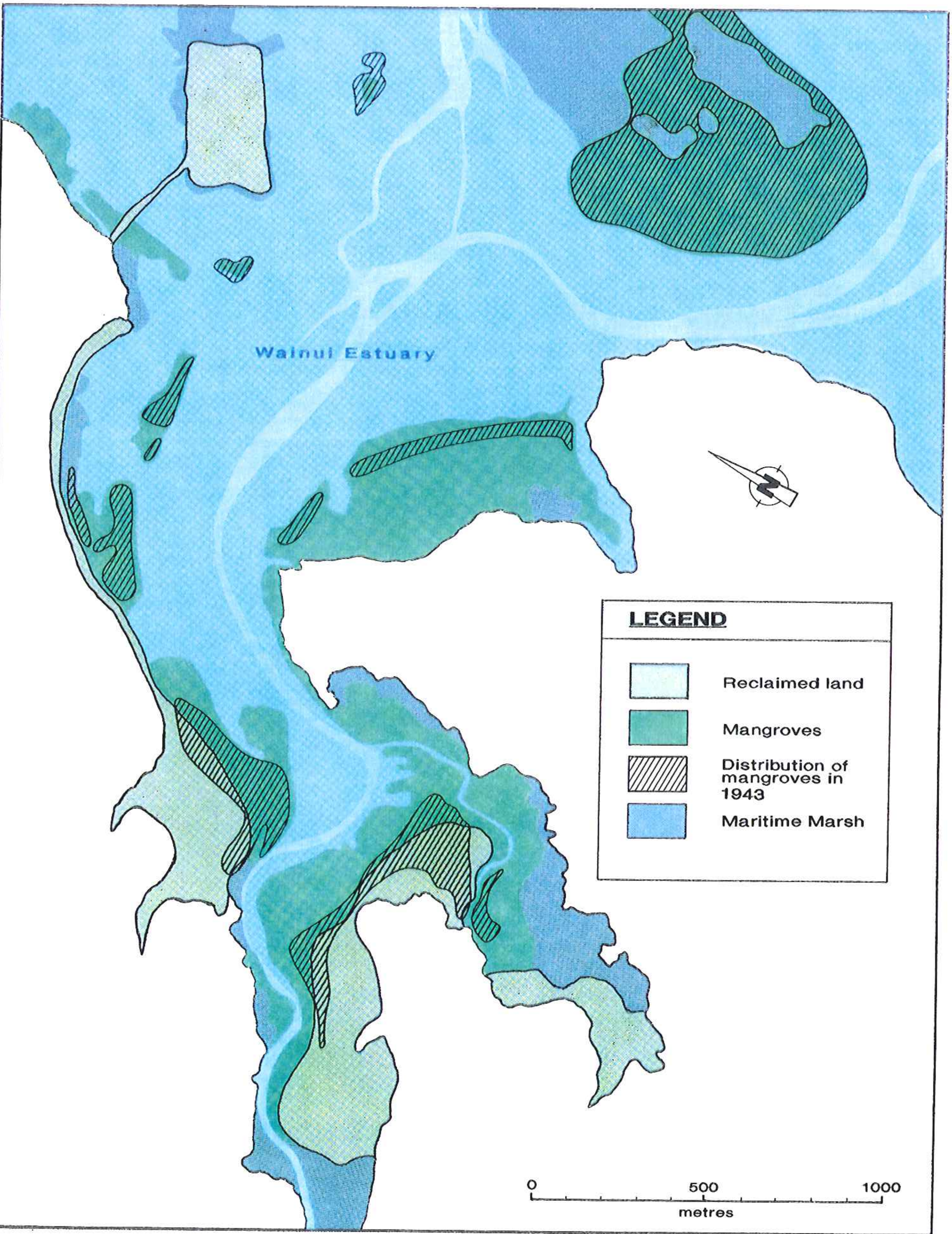

FIGURE 3.12 **AREAS OF RECLAMATION AND CHANGES IN THE DISTRIBUTION OF MANGROVES IN WAINUI ESTUARY AS ASSESSED FROM AERIAL PHOTOGRAPHY TAKEN IN 1943 AND 1991**

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Table 3.6: The area of reclaimed land, mangroves, and maritime marsh in Tauranga Harbour at 1992 as assessed from 1943 aerial photography. Results for each category are expressed in hectares and as a percentage of the three categories summed. Each area is the harbour margin and intertidal zone between the prominent geographic landmarks specified in the table.

Harbour margin including offshore Islands from:	Total of all areas (H)	Reclaimed Land		Mangroves		Maritime Marsh	
		Hectares	% of total	Hectares	% of total	Hectares	% of total
Athenree-Yellow Point	74.6	30.8	41.3	21.4	28.7	22.4	30.0
Yellow Point-Tanners Point	187.7	121.9	64.9	45.6	24.3	20.2	10.8
Tanners Point-Kauri Point	45.9	16.0	34.9	19.2	41.8	10.7	23.3
Kauri Point-Pitua Road Point	77.7	16.2	20.9	45.5	58.5	16.0	20.6
Pitua Road Point-Puketutu Point including Tutaetaka Island	21.6	12.6	38.7	10.4	31.9	9.6	29.4
Puketutu Point-Matahui Point	55.9	16.4	29.3	19.8	35.4	19.7	35.3
Matahui Point-Morton Road Point	339.8	191.3	56.3	86.4	25.4	62.1	18.3
Morton Road Point-Ngakautuakina Point	226.3	52.0	22.9	135.0	59.5	39.3	17.6
Ngakautuakina Point-Omokoroa Point	117.3	52.1	44.4	52.1	44.4	13.1	11.2
Omokoroa Point-Waipa Road Point	160.9	81.3	50.5	57.1	35.5	22.5	14.0
Waipa Road point-Tilby Point	378.1	333.4	88.2	4.6	1.2	40.1	10.6
Tilby Point-Railway Bridge	214.2	187.7	87.3	5.5	2.6	21.0	10.1
Railway Bridge-Maungatapu Bridge	60.2	26.3	43.7	1.2	2.0	32.7	54.3
Maungatapu Bridge-Karikari Point	76.3	11.9	15.6	15.4	20.2	49.0	64.2
Karikari Point-Oruamatua Point	59.2	38.6	65.2	5.8	9.8	14.8	25.0
Oruamatua Point-Maheka Point Bridge	2.4	2.4	100.0	0.0	0.0	0.0	0.0
Maheka Point Bridge-Whareroa point	50.5	35.1	73.0	0.0	0.0	13.0	27.0
Whareroa Point-Mount Maunganui North (At NZMS 260 U14 904 925)	47.1	47.1	100.0	0.0	0.0	0.0	0.0
Panepane Point-Flax Point including Motungaio & Rangiwaea Islands	76.7	5.4	7.0	18.5	24.1	52.8	68.8
Flax Point-Katikati Entrance	105.5	0.0	0.0	53.2	50.4	52.3	49.6
Total Area for South Basin (South of Matahui Point-Flax Point)	1912.2	1064.7	55.6	434.8	22.8	412.7	21.6
Total Area for North Basin (North of Matahui Point-Flax Point)	474.5	214.0	45.1	161.9	22.8	98.6	21.6
Total Area for Taurauanga Harbour	2386.7	1278.7	53.5	596.7	25.1	511.3	21.4

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3.6 FISHERIES RESOURCES OF TAURANGA HARBOUR

3.6.1 Recreational Fisheries

There is very limited and unsatisfactory quantitative information available on the recreational shellfish and fin fish fisheries of Tauranga Harbour. Two general surveys have been conducted on the recreational use of the harbour. The earliest was conducted by the Tauranga County Council (1985) and focused more on beach/reserve use. A later survey by Beca Carter Holling and Ferner (1986) took a more quantitative approach and identified all harbour uses within defined areas. The most popular recreational use of the harbour areas covered was the collection of shellfish and the netting of fish. The species commonly collected from the harbour by hand gathering or fishing include cockles, pipis, scallops, mussels, snapper, trevally, grey mullet and flounder.

Recreational catch data for fin fish in Tauranga Harbour is limited and available only for snapper. Results from a MAFFish snapper tagging programme in 1983 indicated that 68 tonnes of snapper were caught by amateur fishermen in Tauranga Harbour within that year. The 68 tonnes represented 17% of the total amateur snapper catch within the Bay of Plenty and was 2.5 times the commercial catch from the harbour for the same year. More recent estimates by MAFFish, based on a boat ramp survey in 1990/91, have put the amateur snapper catch at 2.98 tonnes with 7.82 tonnes for the total of all species caught by amateur fishermen. This is considerably different from the 1983 estimate, which is likely to be more accurate as the 1990/91 estimate applies only to that part of the fishery based on boat capture.

A number of size, quantity and method restrictions apply to all amateurs gathering restricted species of fin fish, rock lobster, and shellfish etc as set out in the fisheries regulations. The allowable daily amateur quotas may be reduced in the future as catches for species such as snapper are high and may have contributed to the decline of stocks within the Bay of Plenty.

The effects of the recreational pressures on shellfish and finfish stocks in Tauranga Harbour and overall ecological impacts cannot be determined without good fisheries data. For some of the recreational fisheries impacts and fishing pressures may be more obvious.

Dredging for scallops is a very destructive method which kills many other species such as horse mussels and sponges living on the bottom. It also disturbs or destroys small algal assemblages growing on horse mussels and other shells which form the recruitment habitat of scallops.

During the subtidal surveys conducted as part of the Tauranga Harbour Regional Plan Project it was noted that mussel beds which used to exist in the entrance to the northern harbour are now severely depleted as a result of fishing pressure. The beds, if left intact, stabilise the bottom and form more complex communities with higher species diversity and possibly higher productivity.

3.6.2 Commercial Fisheries

The Bay of Plenty region is the most productive zone of the Auckland Fisheries Management Area and historically the inshore fisheries were very important. Snapper was one of the most important species with catches peaking in 1978 and over-fishing evident by 1982. Catch levels have remained at depressed but possibly sustainable yields since that time. The development of the pelagic skipjack tuna fishery, with off season use of the purse seiners to fish the Bay of Plenty trevally, kahawai and mackerel stocks, is now regionally more important.

A significant proportion (approximately 10%) of the region's snapper and trevally catch comes from Tauranga Harbour. The main commercial fishing method used and allowed in the harbour is drag netting. There are a number of fishing method restrictions (Figure 3.13) which apply to the Bay of Plenty and Tauranga Harbour as follows:

a, Pair trawling and Danish seining methods are restricted in BOP waters;

b, Trawling is prohibited within two nautical miles of shore;

c, commercial Drag netting is prohibited in Tauranga Harbour from 1 June - 31 August and from 14 December - 31 January;

d, commercial Drag netting is prohibited from the areas shown in Figure 8.40;

e, all commercial fishing is prohibited in the most southern area of Tauranga Harbour as shown in Figure 8.40;

f, commercial shellfish gathering is prohibited in Tauranga Harbour.

These restrictions on commercial fishing methods and seasons were put in place primarily to help conserve the inshore fisheries and avoid conflict with recreational anglers.

The commercial catch of fin fish from Tauranga Harbour is represented in this report as the catch reported for drag netting in fisheries statistical area 9. Virtually no drag netting is done outside of Tauranga Harbour for this fisheries statistical area. Some species such as flounder are not reported here as there is no way of determining where catches were made inside of area 9 apart from the very small by-catch from drag netting. Six to eight boats catch most of the fin fish landed in Tauranga Harbour. There are two boats that currently fish full time in the southern harbour and two in the northern harbour.

Table 3.7 below shows the commercial catch of selected fin fish species for the period 1984-1986 and May 1990-March 1993.

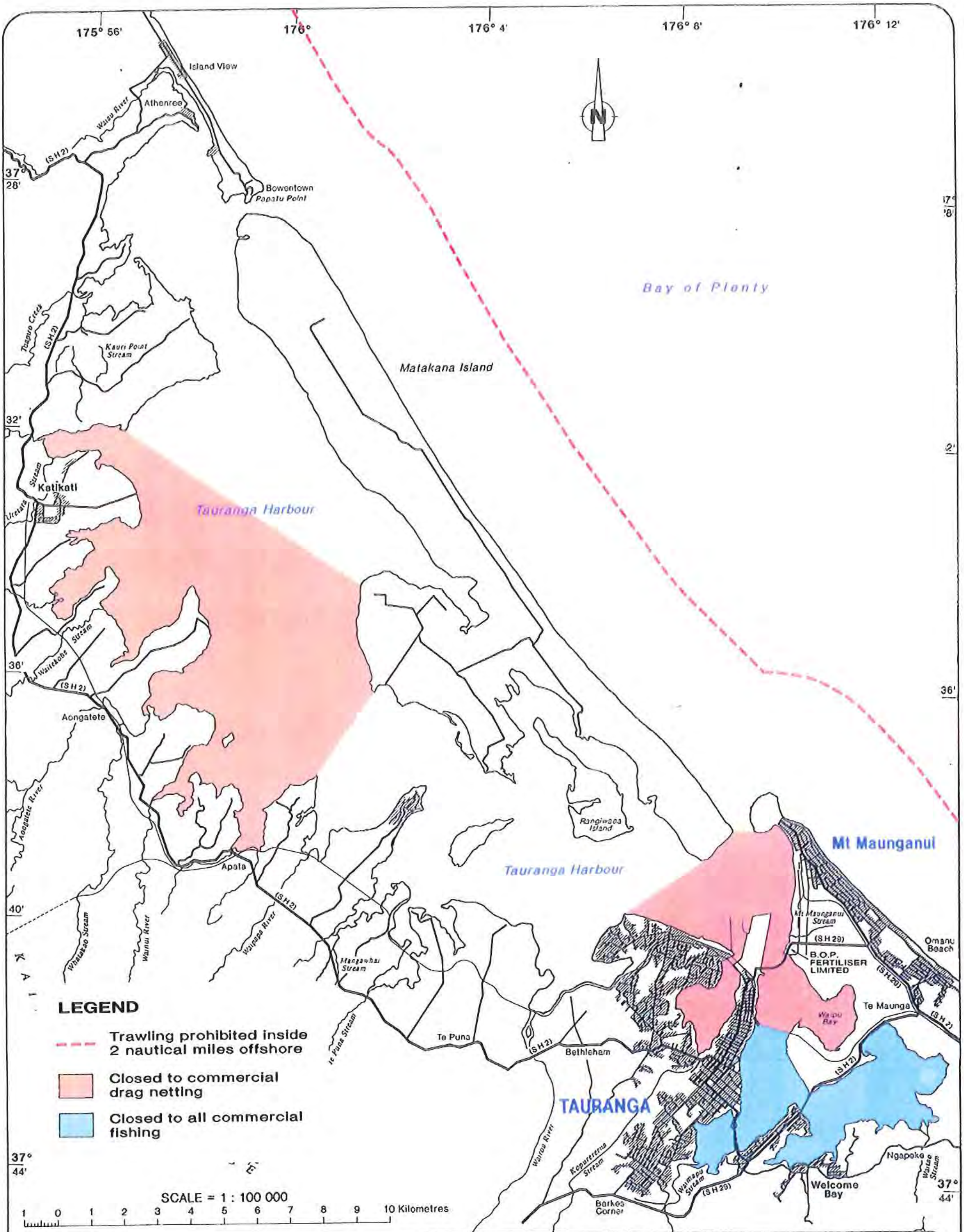

Figure 3.13 COMMERCIAL FISHING RESTRICTIONS APPLYING TO TAURANGA HARBOUR

Table 3.7 Landings of fin fish (tonnes per year) from Tauranga Harbour based on catch returns from drag netting in fisheries statistical area 9.

Year	Snapper	Trevally	Kingfish	Kahawai	Parore
1984	27.1	61.1	-	-	-
1985	5.8	70.0	-	-	-
1986	9.7	34.3	-	-	-
1990	8.0	26.4	3.9	1.2	0.2
1991	15.3	51.7	3.6	1.0	1.0
1992*	7.2	85.0	4.0	1.9	0.1

* catch statistic for years 1990 - 1992 are for the period May - April, and the 1992 figures are adjusted to compensate for the months of April and May 1993 not yet being available.

Trevally, as shown in Table 3.7 above, are the target species of the drag nett fishery with snapper and kingfish also forming a significant portion of the catch. Snapper stocks are over-exploited and at such low levels that the fishery is essentially dependant on only three year classes (3-5 year old fish). Due to the small number of year classes forming the snapper fishery, year to year variation in recruitment success shows up strongly in catches and accounts for a large part of the variation apparent in landings from the harbour.

The commercial fishing restrictions in Tauranga Harbour were mainly established for the conservation of snapper. A large part of the prohibited zones for drag netting are set in areas of the harbour where fishing by this method would not be suitable. Snapper are only present in the harbour in large numbers from November/December to April which leaves the most effective restriction on drag netting as the six weeks during December and January. This is also the most likely period in which conflict could arise with recreational fishers.

The substantial quantity of kingfish commercially landed within Tauranga Harbour has brought opposition from recreational fishers for a number of years because of its importance as a sports fishery. This type of sports fishery can be an important component of local tourism with high regional values that may out-weigh its commercial worth.

Parore, although only landed in small quantities, were included in Table 8.10 because of their importance in the harbour ecosystem. Parore feed predominantly on algae and show a preference for species such as sea lettuce. The quantity of parore removed by drag netting alone is significant and when catches by set netting (both commercial and recreational) and other methods are added to this it is possible that parore stocks are low in comparison to their potential. Depression of the parore stocks will reduce their effectiveness as an important biological control agent helping to limit blooms of sea lettuce.

Set-netting within Tauranga Harbour is popular amongst recreational fishers but no quantitative information on the species targeted and quantities caught are available. In comparison to all other fishing methods, set nets are the most destructive form of fishing. The method is less selective, long duration sets may result in large numbers of fish being dead when caught or not surviving if released, and lost nets (one observed during this project in the northern harbour) continue to catch and kill fish. The majority of parore removed from Tauranga Harbour are likely to caught using this method.

CHAPTER FOUR
FRESHWATER ECOLOGY

4.1 INTRODUCTION

Information on the ecology of rivers and streams feeding the Tauranga Harbour is limited to a small number of scattered reports. The following outlines what is known of the fish and macroinvertebrate communities.

4.2 FRESHWATER FISH

Specific information on the freshwater fish communities of the Tauranga Harbour catchment is sparse. Table 4.1 lists the 15 species which have been reported.

Table 4.1: **Freshwater fish species reported in the Tauranga Harbour catchment (information obtained from distribution maps presented in McDowall 1990).**

Species	**Common name**
Native	
Geotria australis	Lamprey
Anguilla deiffenbachii	Longfinned eel
Anguilla australis	Shortfinned eel
Retropinna retropinna	Common smelt
Galaxias argenteus	Giant kokopu
Galaxias postvectis	Shortjawed kokopu
Galaxias brevipinnis	Koaro
Galaxias maculatus	Inanga
Gobiomorphus gobioides	Giant bully
Gobiomorphus cotidianus	Common bully
Gobiomorphus basalis	Crans bully
Rhombosolea retiaria	Black flounder
Introduced	
Salmo trutta	Brown trout
Oncorhynchus mykiss	Rainbow trout
Gambusia affinis	Mosquito fish

Most work has been directed toward the status of the trout fishery. With the exception of the Tuapiro Stream and the Wainui River, most of Tauranga's lowland rivers and streams contain both rainbow and brown trout (Richardson et al. 1986). Richardson et al. reported that the Wairoa system is the most popular trout fishery in the former Tauranga Acclimatisation District. A recent fisheries survey by Kusabs and Reiland (1992) found only rainbow trout and longfinned eels in the upper Wairoa River system. Aside from eels no other native fish were recorded leading the authors to conclude that the various hydro-electric structures present in the headwater streams are obstructing natural migration.

Information on inanga (whitebait) spawning sites on the Wairoa River is given by Mitchell (1990).

4.3 MACROINVERTEBRATES

Bioresearches Limited have produced a number of reports on the ecology of the Opuiaki River to satisfy the requirements of a water right held by the Tauranga Joint Generation Committee. These reports generally suggest that, at the two sites sampled, invertebrate densities are moderate to low while diversity is high (up to 32 taxa). In July 1985 the fauna was generally dominated by Ephemeroptera (mayflies), Trichoptera (caddisflies) and Plecoptera (stoneflies) (Bioresearches 1985). Overall, this is a community indicative of very high water quality.

Two Tauranga catchment stream sites have been studied as part of Environment BOP's NERMN Freshwater Ecology programme (BOPRC 1992c). In 1992 the Tuapiro Stream (BOPRC site 110038) had the highest mean macroinvertebrate abundance of the 17 Bay of Plenty sites surveyed (663 per 0.1 m^2) while diversity was moderate (14 taxa). Chironomidae (midge larvae) dominated the fauna (65%) while two molluscs (*Potamopyrgus antipodarum* and *Latia neritoides*) and two caddisflies (*Aoteapsyche* spp. and *Oxyethira albiceps*) made up minor components. This community is indicative of moderate to poor water quality reflecting pastoral development in the catchment.

In 1992 the macroinvertebrate fauna of the Ngamuwahine River (BOPRC site 110035) was moderately abundant (289 per 0.1 m^2) and quite diverse (22 taxa). Tolerant taxa (Chironomidae, *Latia neritoides* and *Aoteapsyche* spp.) dominated the assemblage though a number of very sensitive taxa (*Austroclima jollyae, Coloburiscus humeralis, Rallidens mcfarlanei* and *Zealandoperla* spp.) were also present. This mix of tolerant and sensitive taxa is indicative of moderate to high water quality.

4.3.1 Macroinvertebrates - Northern catchment streams

A preliminary survey of the ecology and water quality of four Northern catchment streams was carried out by Environment BOP in the summer of 1993. This was initiated due to the need for information on the effects of agricultural discharges on the ecology of these small, relatively sensitive systems. Two sites were sampled on each stream, the upper sites, considered to be unimpacted (bush catchment), and the lower sites impacted (developed catchment). Site details are given in Table 4.2.

Table 4.2: **Site details for Northern Tauranga Harbour streams. Note: distance refers to the length of stream between sites.**

Stream	BOPRC Site No.	NZMS260 Reference	Distance (km)	Comments
Waiaua	BOP710039	T13:676118		Pine/pasture catchment
Waiaua	BOP710040	T13:699129	4.5	Pine/pasture catchment
Uretara	BOP710036	T14:626995		Indigenous forest catchment
Uretara	BOP710020	T13:670008	6.5	Pastoral catchment, piggeries
Te Rereatukahia	BOP710038	T14:630968		Indigenous forest catchment
Te Rereatukahia	BOP710025	T14:672987	6.0	Pastoral catchment
Tuapiro	BOP710041	T13:643069		Indigenous forest catchment
Tuapiro	BOP160126	T13:678061	6.0	Pastoral catchment

4.3.2 Sample collection

Sampling was carried out between 2 February and 5 February 1993. To allow valid comparisons between sites ecological sampling was targeted at riffle areas which were moderately shallow (0.2-0.4m) and cobbly (substrate 64-256mm) and with a flow velocity of 0.6-1.0 m/s. Where these conditions were not attainable the following were considered adequate: depth <0.7m, velocity 0.2-1.0 m/s, gravel substrate (2-64 mm). Riffle areas are generally considered to be species rich and their communities provide a good baseline upon which to assess water quality trends (Winterbourn 1985).

Five replicate macroinvertebrate samples were collected from each site using a surber sampler (see Biggs 1983). This had an enclosed area of 0.1 m^2 and a collecting net of 250μm mesh. The sampler was positioned at random within the riffle area and the overlying substrate scrubbed thoroughly with a small brush. Following this the underlying substrate was stirred vigorously for a period of one minute to a depth of approximately 0.1m. Adherence to this time was an essential element of the sampling strategy. Samples were washed into labelled containers and preserved in 10% formalin for later identification and enumeration.

Immediately prior to the collection of each macroinvertebrate replicate, a number of physical characteristics were recorded. Water depth and velocity were measured using the velocity head rod described by Ciborowski (1991). An estimate of surficial sediment composition was made using a modification of the size class categories proposed by Minshall (1984). This involved a visual assessment of the percentage cover of the following:

Silt	<0.063 mm
Sand	0.063-2mm
Small gravel	2-16mm
Large gravel	16-64mm
Small cobbles	64-128mm
Large cobbles	128-256mm
Boulders	256mm+
Bedrock	

Percentage periphyton cover was also visually assessed using the following classes; mats, filamentous (green and brown) and films (green and brown). Additionally, five undisturbed cobbles were collected from each site and frozen for later analysis of periphyton chlorophyll-a.

Water quality samples were collected over four consecutive days around the time of the ecological sampling. These were analysed for various nutrient measures, dissolved oxygen, temperature, BOD^5, conductivity, pH, suspended solids and turbidity.

4.3.3 Sample and data analysis

Macroinvertebrates were sorted in white trays and transferred to 70% ethanol in vials prior to identification and enumeration. Organisms were identified and counted using a stereomicroscope. All organisms were identified to the lowest practicable taxonomic level using a number of references (McFarlane 1951, Winterbourn 1973, Chapman and Lewis 1976, Cowley 1978, Towns and Peters 1979, Towns 1983, Winterbourn and Gregson 1989). Chironomidae, Oligochaeta, Platyhelminthes and Acarina were considered as single taxonomic units.

Macroinvertebrate Community Indices (MCI's) are presented for each site. The MCI is a biotic index which was developed by Stark (1985), originally to assess organic pollution in stony streams of the Taranaki region. It has since been tested and applied New Zealand wide (e.g. Quinn and Hickey 1990a). In its simplest form the index is calculated using presence/absence invertebrate distributional data. Individual taxa are assigned a score (1 to 10) which relates to their pollution tolerance. Sensitive taxa score high values, pollution tolerant taxa low values. For a given site the MCI is derived as follows;

$$MCI = \frac{\text{site score}}{\text{no. of scoring taxa}} \quad X20$$

Site scores are obtained by summing the MCI scores of those taxa present. The resultant MCI is multiplied by 20 (a scaling factor) to simplify expression of the data. In practise the MCI may range between 50 (indicating gross organic pollution) and 150 (pristine).

A further biotic index, that of EPT number, is also presented. EPT refers to the number of Ephemeroptera, Trichoptera and Plecoptera taxa present at a given site. Taxa in these groups are generally intolerant of water quality degradation. Lenat (1988) found that the EPT index was a useful indicator of water quality in North American streams and the index has also been correlated with enrichment in New Zealand rivers (Quinn and Hickey 1990a).

To simplify statistical analysis of the substrate data, size assessments were transformed into a single substrate index (SI, mm) by summing the mid-point values of the size classes weighted by their proportional cover (Quinn and Hickey 1990b).

Chlorophyll-a was extracted from the collected cobbles by the direct ethanol extraction method of Cattaneo and Roberge (1991). Concentrations were determined using spectrophotometric methodology. Each cobble was measured along 3 axes and the surface area estimated using the areal equation and correction factor given by Biggs and Close (1989). Chlorophyll-a is expressed here as the concentration per m^2 of substrate.

Relationships between the environmental variables (water quality and physical) and the biotic variables (macroinvertebrate abundance, taxa number, EPT number, MCI index and periphyton chlorophyll-a concentration) were investigated using scatterplot matrices and Spearman rank correlation coefficients. Where necessary differences between variables at the upper and lower sites were tested using non-parametric ANOVA with the Tukey adjustment for multiple inference.

4.3.4 Results

Periphyton chlorophyll-a concentrations are presented in Figure 4.1. Concentrations were moderate to low and, with the exception of the Tuapiro Stream, periphyton was more abundant at the upper sites than at the lower sites.

In all 44 macroinvertebrate taxa were recorded - a full species list, including the MCI scores assigned to individual taxa is given in Table 4.3. The raw data is presented in Appendix 12. Mean values and additional descriptive statistics for the macroinvertebrate variables (abundance, the number of taxa, MCI index and EPT index) are presented in Appendix 13 and Figure 4.2. Total abundance, the total number of taxa and the overall MCI and EPT index values for each site (determined from the pooled replicates) are presented in Table 4.4.

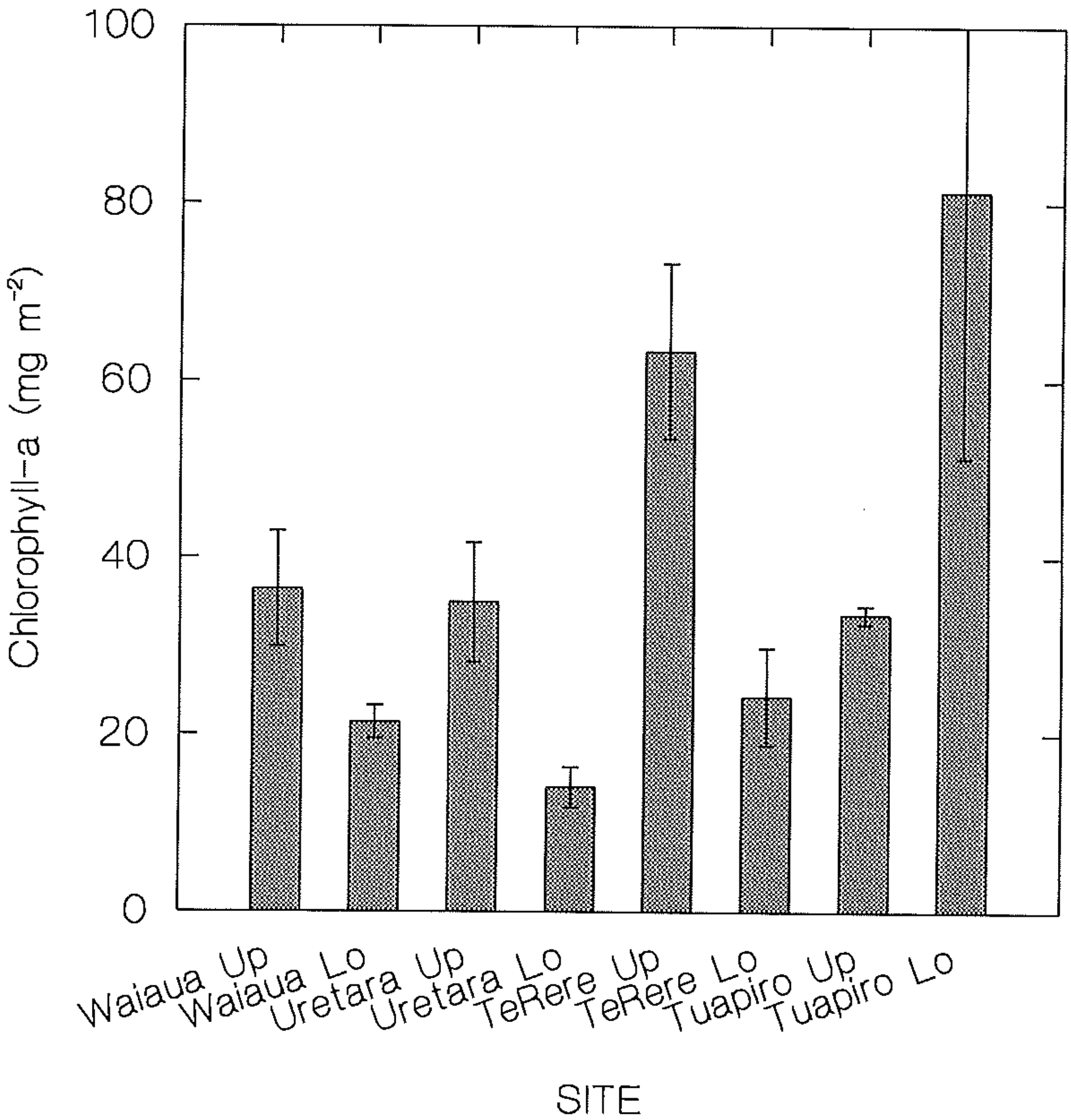

Figure 4.1 Northern Tauranga Harbour streams. Comparison of the mean periphyton chlorophyll-a concentrations (+/-SE).

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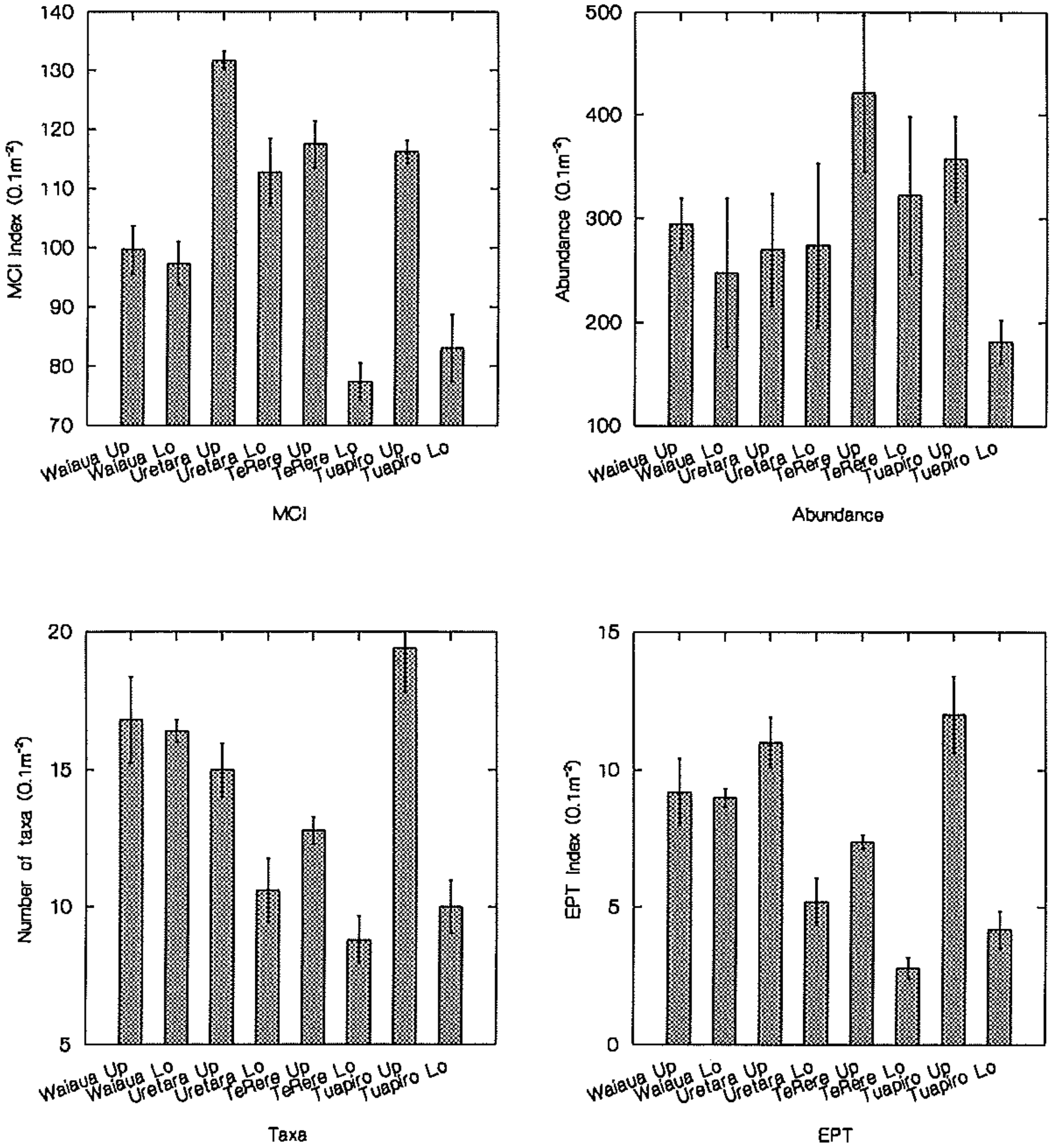

Figure 4.2 Northern Tauranga Harbour streams. Comparison of the mean macroinvertebrate variables (+/- SE).

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Table 4.3 Northern Tauranga Harbour streams. Species list and assigned MCI scores. Note: high MCI scores indicate sensitive taxa, low scores tolerant taxa.

	MCI
Ephemeroptera (Mayflies)	
Coloburiscus humeralis	9
Mauiulus luma	5
Austroclima sepia	9
Zephlebia versicolor	7
Zephlebia spp.	7
Neozephlebia scita	7
Nesameletus spp.	9
Deleatidium spp.	8
Rallidens mcfarlanei	9
Trichoptera (Caddisflies)	
Aoteapsyche colonica	4
Hydrobiosis umbripennis	5
Hydrobiosis parumbripennis	5
Hydrobiosis spp.	5
Neurochorema spp.	6
Costachorema xanthoptera	7
Costachorema callista	7
Costachorema spp.	7
Oxyethira albiceps	2
Beraeoptera roria	8
Pycnocentrodes spp.	5
Olinga feredayi	9
Helicopsyche spp.	10
Tiphobiosis spp.	6
Polyplectropus puerilis	8
Pycnocentrella eruensis	9
Triplectides spp.	5
Plecoptera (Stoneflies)	
Stenoperla prasina	10
Zelandoperla fenestrata	10
Diptera (Two-winged flies)	
Aphrophila neozelandica	5
Austrosimulium spp.	3
Chironomidae	2*
Muscidae	3
Neocurupira spp.	7
Limonia spp.	6
Molophilus spp.	9
Coleoptera (Beetles)	
Elmidae	6
Berosus spp.	5
Dytiscus spp.	5
Ptilodactylidae	8

Megaloptera (Dobson-flies)

Archicauliodes diversus	7

Crustacea

Paratya curvirostris	5

Oligochaeta (segmented worms) 1

Gastropoda (Snails)

Potamopyrgus antipodarum	4
Latia neritoides	3

* The Chironomidae have been given a score of 2 (after Quinn and Hickey 1990a).

Table 4.4: Macroinvertebrate variables calculated using the pooled data from each site.

Site	MCI	EPT	Taxa	Total
Waiaua upper	110	15	25	1473
Waiaua lower	106	16	25	1247
Uretara upper	132	19	24	1351
Uretara lower	114	8	17	1370
TeRere upper	112	13	23	2108
TeRere lower	77	4	12	1613
Tuapiro upper	121	20	30	1789
Tuapiro lower	96	8	20	908

Waiaua Stream - Upper site

This site was characterised by a high number of invertebrate taxa, high EPT index and a moderate mean MCI index (100). Chironomidae were most abundant (64%) followed by *Aoteapsyche* spp. (9%) and *Oxyethira albiceps* (6%). Other taxa included molluscs (*Potamopyrgus antipodarum, Latia neritoides*) and dipterans (*Austrosimulium* spp., *Aphrophila neozelandica*). A number of sensitive taxa were present in low numbers (*Coloburiscus humeralis, Zephlebia* spp., *Nesameletus* spp., *Zelandoperla fenestrata*).

Waiaua Stream - Lower site

The invertebrate community was similar to that found at the upper site. Chironomidae were most abundant (57%) followed by *Aoteapsyche* spp. (14%) though *Oxyethira* was absent. The values for the number of taxa, MCI index, EPT Index and abundance were not significantly different from the upper site (Table 4.5). Taxa unique to this site included a number of sensitive mayfly species (*Deleatidium* spp., *Rallidens mcfarlanei, Nesameletus* spp., *Neozephlebia scita*).

Uretara Stream - Upper site

This site had the highest MCI index of the survey a high number of taxa and a high EPT index. The invertebrate community was dominated by two sensitive caddisfly species (*Beraeoptera roria* - 31%, *Olinga feredayi* - 11%), *Pycnocentrodes* spp. (22%) and Chironomidae (20%). Minor taxa included *Deleatidium* spp., *Zelandoperla fenestrata, Helicopsyche* spp., Elmidae and *Potamopyrgus antipodarum.*

Uretara Stream - Lower site

The invertebrate community of this site was markedly different to that of the upper site. The mean values for the EPT index and the MCI index declined significantly. *Pycnocentrodes* spp. were most abundant (84%) followed by a freshwater shrimp (*Paratya curvirostris* - 4.4%) and *Potamopyrgus antipodarum* (3.3%). Other taxa included *Latia neritoides, Beraeoptera roria* and Chironomidae. Compared to the upper site there was a marked decrease in the abundance of sensitive taxa (mayflies, stoneflies) and in increase in the more tolerant molluscs (Figures 4.3 and 4.4).

Te Rereatukahia Stream - Upper site

This was a diverse community (23 taxa, EPT index 13) with a moderate MCI index (112). Chironomidae dominated (44%) followed by a clean water caddis, *Beraeoptera roria* (33%), and a very sensitive stonefly (*Zelandoperla fenestrata* - 12%). Minor taxa included a number of caddisflies (*Pycnocentrodes* spp., *Tiphobiosis* spp., *Olinga feredayi, Costachorema* spp.) and mayflies (*Coloburiscus humeralis, Rallidens mcfarlanei*). Of interest was the presence of net-wing midge larvae (*Neocurupira* spp.).

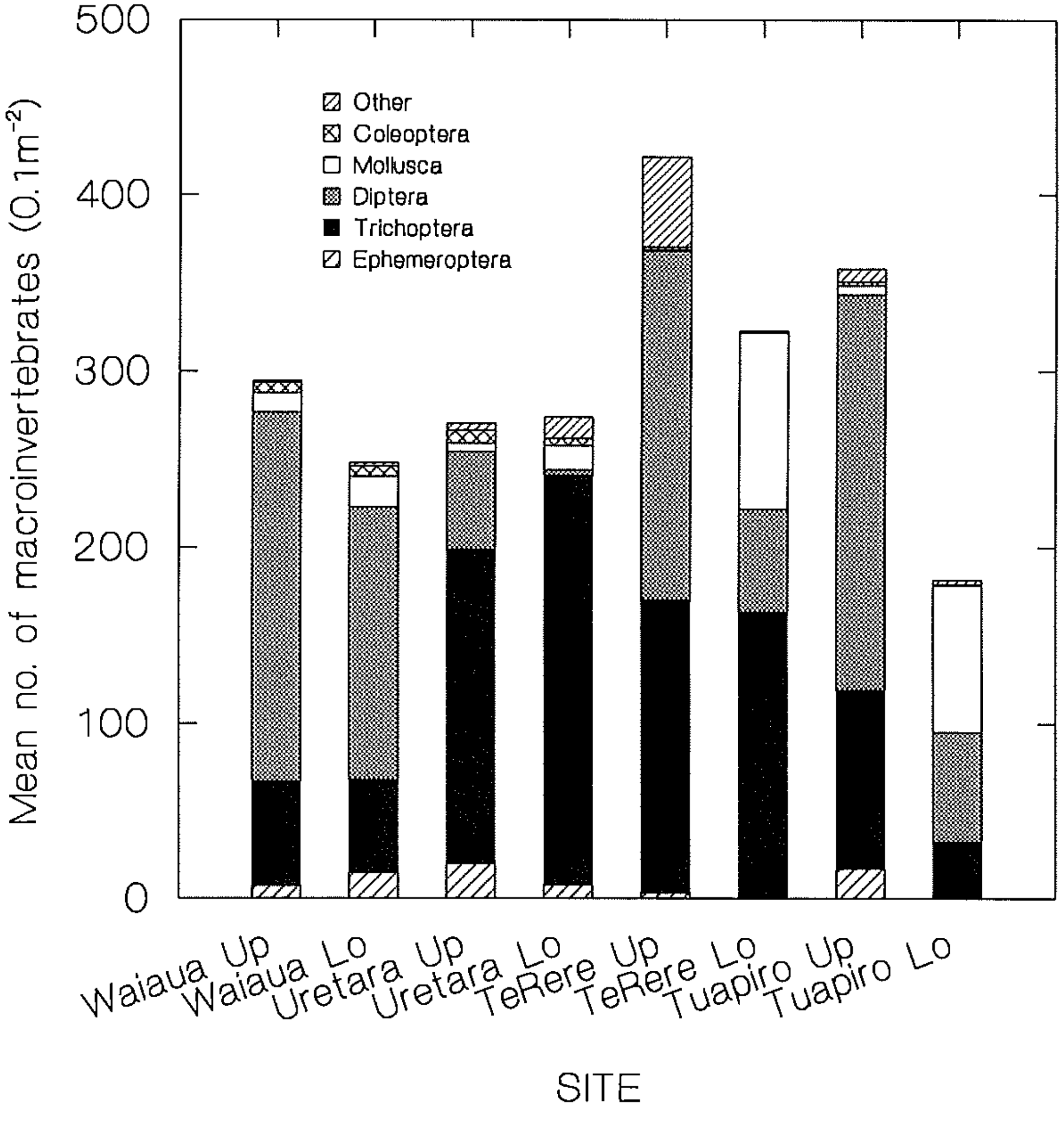

Figure 4.3 Northern Tauranga Harbour streams. Comparison of macroinvertebrate community composition and mean abundance at the upper and lower sites.

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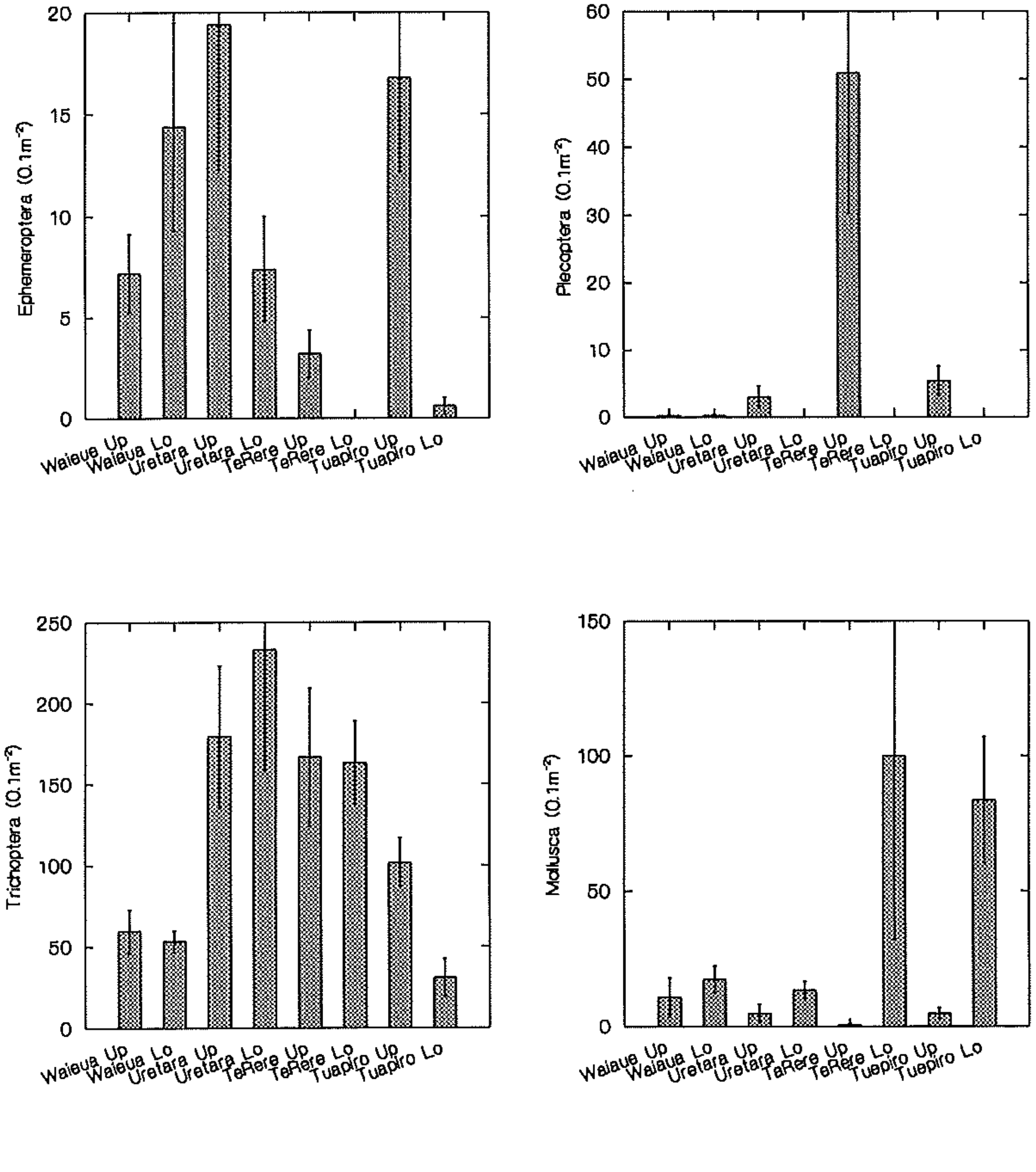

Figure 4.4 Northern Tauranga Harbour streams. Comparison of the mean abundance of some macroinvertebrate groups (+/- SE).

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Te Rereatukahia Stream - Lower site

This site had the lowest number of taxa, lowest EPT index and the lowest MCI index of the survey. The means for the EPT and MCI indices were significantly lower than those at the upper site. The invertebrate community was dominated by a cased caddis, *Pycnocentrodes* spp. (47%), followed by *Potamopyrgus antipodarum* (25%) and Chironomidae (16%). Minor taxa included *Latia neritoides, Aoteapsyche* spp., *Aphrophila neozelandica* and *Oxyethira albiceps*. Notably there was a complete loss of sensitive taxa (particularly the stoneflies but also the mayflies) and a sharp increase in the abundance of molluscs compared to the upper site (Figures 4.3 and 4.4).

Tuapiro Stream - Upper site

A diverse invertebrate community was present at this site (30 taxa, EPT index 20) and the moderate MCI index indicated relatively high water quality. Chironomidae were most abundant (58%) followed by two caddisflies (*Oxyethira albiceps* and *Pycnocentrodes* spp.). A number of sensitive taxa were present in low abundance (*Coloburiscus humeralis, Austroclima sepia, Beraeoptera roria, Helicopsyche* spp. and *Zelandoperla fenestrata*). Other minor taxa included two molluscs (*Potamopyrgus antipodarum* and *Latia neritoides*).

Tuapiro Stream - Lower site

Compared to the upper site, the lower Tuapiro had significantly less invertebrate taxa, and significantly lower EPT and MCI index values (Table 4.5). The community was dominated by tolerant taxa (MCI scores of 2-3) all of which were present at the upper site. These included *Latia neritoides* (34%), Chironomidae (30%), *Potamopyrgus antipodarum* (12%) and *Oxyethira albiceps* (8%). A number of sensitive taxa found at the upper site were absent from the lower site (*Zelandoperla fenestrata, Beraeoptera roria, Helicopsyche* spp., *Austroclima sepia*). As with the Te Rereatukahia Stream there was a sharp decline in stonefly and mayfly abundance and a large increase in the abundance of molluscs compared to the upper site (Figures 4.3 and 4.4).

Table 4.5: **Non-parametric ANOVA results with the Tukey adjustment for multiple inference for the macroinvertebrate variables at the upper and lower sites. Summary statistics given in Appendix 13. NS = not significant, * = $P<0.05$, ** = $P<0.01$, *** = $P<0.001$.**

Stream	MCI	EPT	Taxa	Total
Waiaua	NS	NS	NS	NS
Uretara	*	**	NS	NS
TeRereatukahia	***	**	NS	NS
Tuapiro	***	***	**	NS

Environmental and biotic variables

The relationships between the water quality variables (mean values given in Appendix 14) and the biotic parameters are presented graphically in Figure 4.5 and 4.6. Spearman rank correlation coefficients, calculated using data from all the sites, are presented in Appendix 15. Significant correlations are presented in Table 4.6. Notable among these results are the relationships between the MCI index and total Kjeldahl nitrogen, and the number of taxa and EPT index with dissolved oxygen and temperature (Figures 4.7 and 4.8).

Table 4.6:

Spearman rank correlations between the environmental and biotic variables. Note: Significant results given in bold type; NS = not significant, * = p<0.05, ** = p<0.01.

VARIABLE	MCI	EPT	Taxa	Total
BOD5	-0.180 NS	-0.192 NS	-0.287 NS	**-0.850 ** **
Conductivity	-0.571 NS	-0.357 NS	-0.095 NS	-0.381 NS
Temperature	-0.524 NS	**-0.690 * **	**-0.810 * **	-0.429 NS
Dissolved Oxygen	0.667 NS	**0.786 * **	**0.714 * **	-0.381 NS
Dissolved Reactive Phosphorus	-0.071 NS	0.595 NS	**0.714 * **	-0.119 NS
Ammonium	-0.667 NS	-0.548 NS	-0.405 NS	**-0.619 * **
Total Kjeldahl Nitrogen	**-0.833 * **	-0.619 NS	-0.476 NS	-0.357 NS

The raw data for the physical variables measured during sampling (water depth, velocity and the substrate index) is contained in Appendix 16. The results of one-way ANOVA tests for these variables between the upper and lower sites are presented in Table 4.7. These results suggest that there was generally little difference in the physical environment within each pair of sites.

Table 4.7: Non-parametric ANOVA results for the physical variables at the upper and lower sites. NS = not significant, * = *P*<0.05.

Stream	Depth	Velocity	Substrate Index
Waiaua	NS	NS	NS
Uretara	NS	NS	NS
TeRereatukahia	NS	NS	NS
Tuapiro	NS	*	*

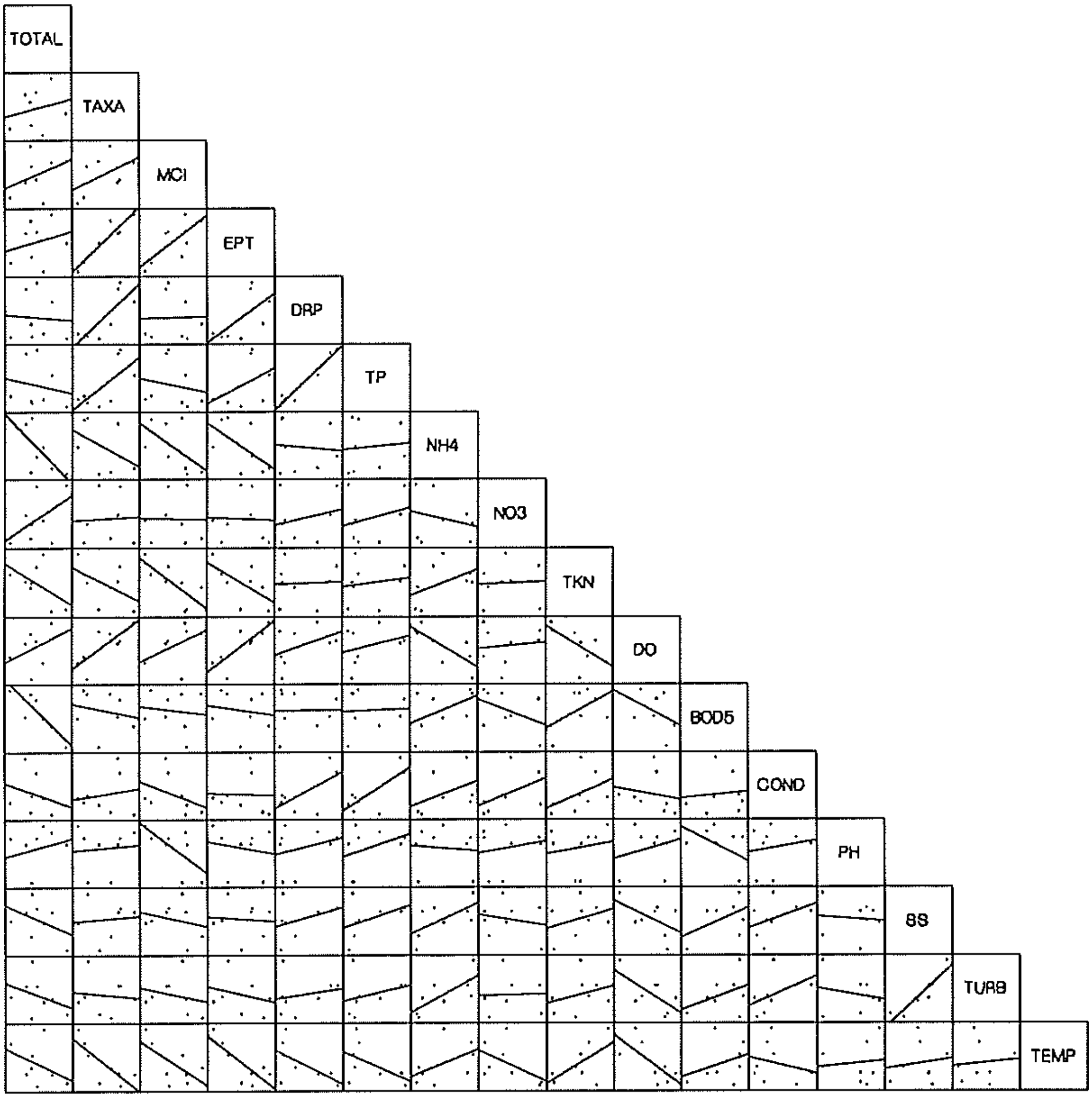

Figure 4.5 Northern Tauranga Harbour streams. Scatterplot matrix of the water quality and macroinvertebrate variables.
Note: Regression lines fitted regardless of significance.
For key to variables see Appendix 14.

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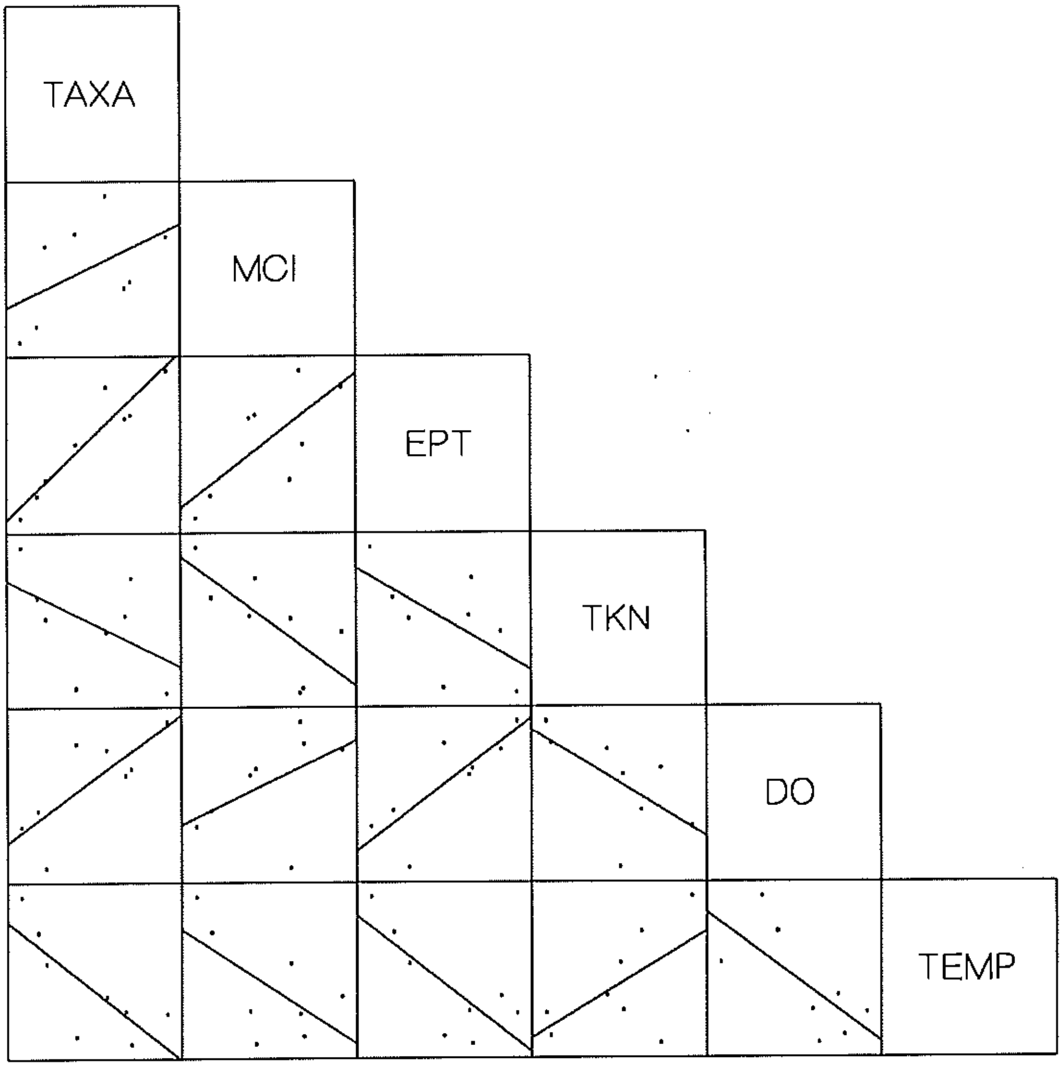

Figure 4.6 Northern Tauranga Harbour streams. Scatterplot matrix of some water quality and macroinvertebrate variables.
Note: Regression lines fitted regardless of significance.
For key to variables see Appendix 14.

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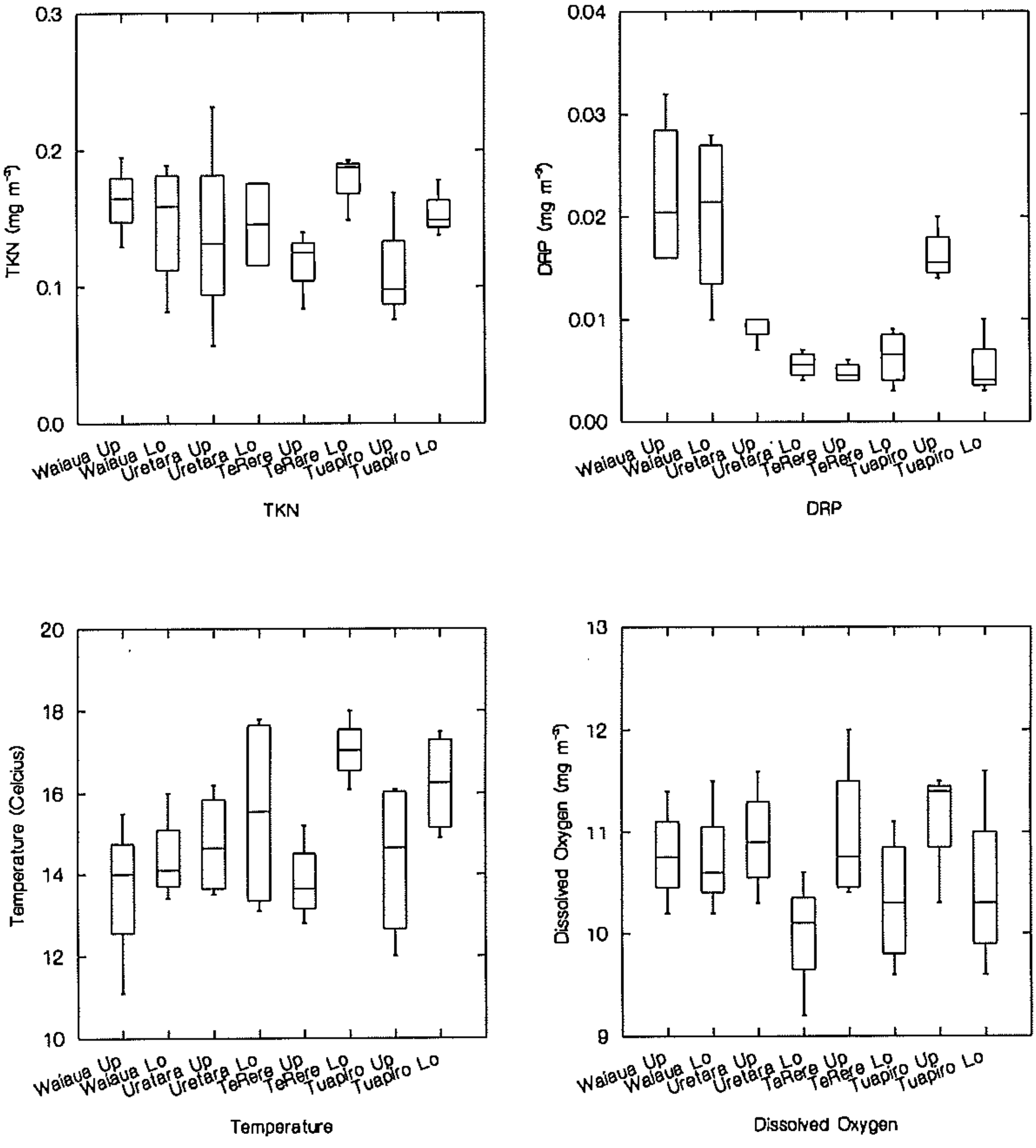

Figure 4.7 Northern Tauranga Harbour streams. Boxplots of some water quality variables. See Appendix 17 for a boxplot explanation.

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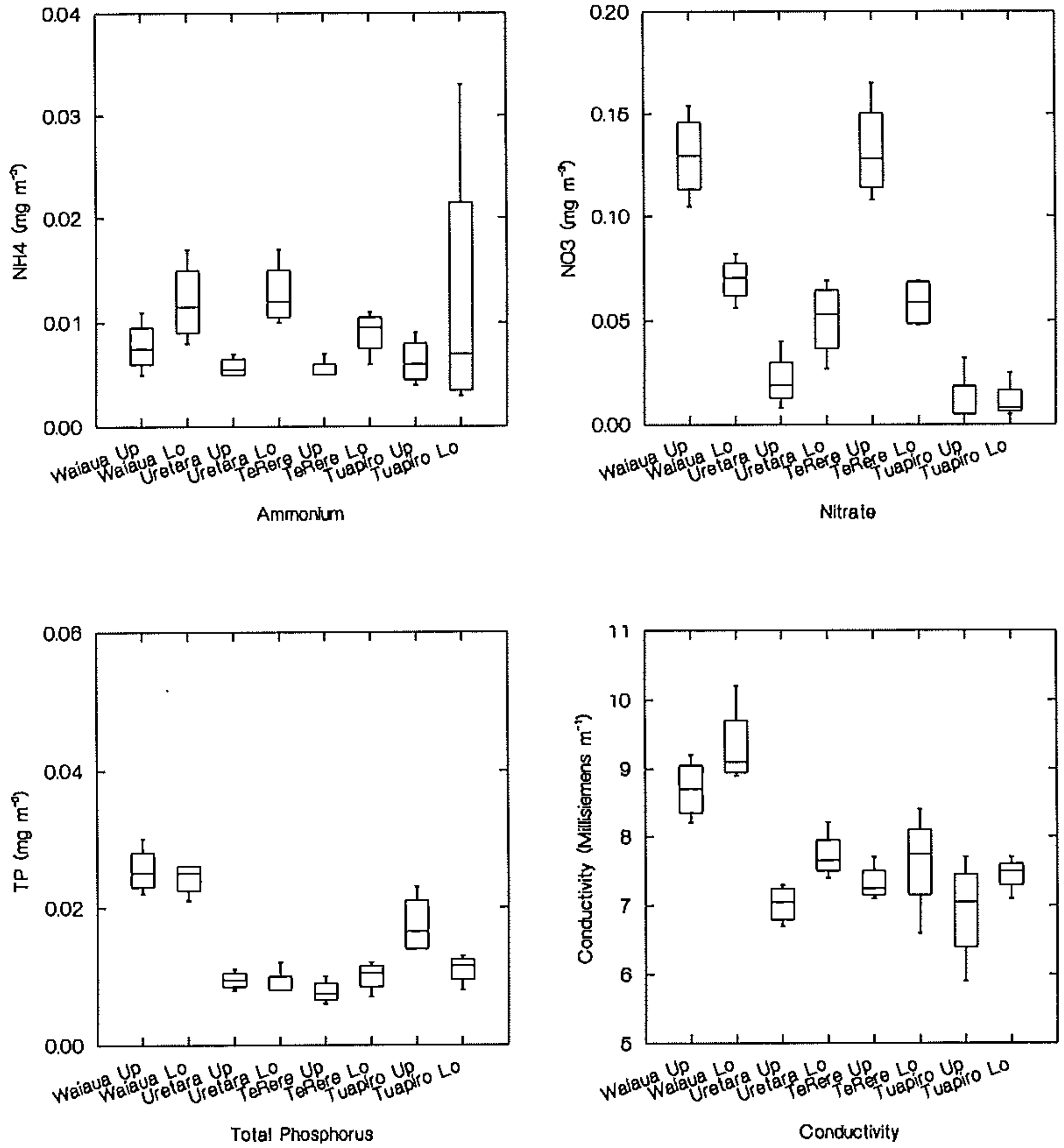

Figure 4.8 Northern Tauranga Harbour streams. Boxplots of some water quality variables. See Appendix 17 for a boxplot explanation.

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4.3.5 Discussion

With the exception of the Waiaua Stream, there were marked differences in the macroinvertebrate communities within each pair of sites. Generally, the response to catchment modification was a decline in the abundance of sensitive mayfly and stonefly taxa and an increase in the more tolerant molluscs. These changes were reflected in declines in three measures of community "health"; the MCI index, the number of taxa and the EPT index. Of the environmental variables, total Kjeldahl nitrogen, dissolved oxygen and temperature appeared to contribute most strongly to these impacts. In general, the downstream transition from indigenous forest to pasture resulted in an increase in the concentration of total Kjeldahl nitrogen (an indicator of organic enrichment), a decrease in dissolved oxygen concentrations and an increase in stream temperature.

In a study of 88 New Zealand rivers, macroinvertebrate communities were found to respond to a number of environmental factors. Generally values for the EPT and MCI indexes declined with increasing catchment development to improved pasture, increasing water temperature, nutrient concentrations and periphyton biomass (Quinn and Hickey 1990a). Similar impacts have been recorded by Environment BOP in the Whakatane and Waimana rivers (BOPRC 1992c). Sites in indigenous forest catchments were found to have a lower number of taxa, lower abundance and higher MCI index values than sites influenced by improved pasture. These impacts are likely to be due to the combined effects of loss of riparian cover, increased suspended sediment loads and higher periphyton biomass (Lenat 1984; Quinn et al. 1992).

Periphyton chlorophyll-a biomass in the four Tauranga streams was moderate to low (range 8 to 200 mg m^{-2}) and not indicative of any algal proliferation. Biggs (1990) studied the periphyton communities of a large number of New Zealand rivers and recorded chlorophyll-a biomass in the range of 0 to 374 mg m^{-2}. Periphyton biomass would be expected to increase in response to conversion of the catchment to improved pasture because of increases in nutrient concentrations, water temperature and light levels. With the exception of the Tuapiro periphyton biomass did not increase at the lower stream sites.

The impact of catchment modification on the water quality and ecology of the study streams could be mitigated to some extent by providing riparian protection zones. Quinn et al. (1992) documented an increase in summer stream temperature and temperature variability in small stream reaches without riparian protection. Taxa favoured by cool water and low periphyton abundance decreased in density compared to riparian protected streams while those favoured by an abundance of periphyton increased. In addition the QMCI (a quantitative version of the MCI index) was generally higher at the riparian protected sites.

CHAPTER FIVE

SUMMARY

5.1 ALGAL FLORA OF TAURANGA HARBOUR

The survey of sea grass and algal flora throughout Tauranga Harbour provided information on the relative abundance of species in the intertidal zone. Sea grass was most abundant and had an overall average cover of 22.5%. The next most abundant species were sea lettuce (*Ulva spp*), neptunes necklace (*Hormosira banksii*) and *Gracilaria secundata*. An unusual feature of the harbour's flora was the extensive high density beds of unattached *Hormosira* and the high abundance of pink coralline turf amongst the sea grass beds.

Sea grass is sensitive to disturbance and within New Zealand many harbours and estuaries have declining abundances. Experience overseas has shown that pollution can contribute to sea grass loss in a number of ways. Results from this study indicate that sea grass distribution is related to silt loading of surficial sediments. Distribution is limited to areas where the silt content is generally below 13%. Other related factors such as turbidity are also likely to influence sea grass distribution and health.

Investigations of sea grass biomass showed little significant variation throughout Tauranga Harbour. The sea grass beds near Grace Road in the Town Reach basin were in the poorest condition on the basis of biomass. The reasons for this may be due to several factors such as increased turbidity, and abundant sea lettuce accumulating on top of the beds.

Comparison of historical distributions has shown a loss of sea grass beds from the enclosed sub-estuaries of Tauranga Harbour such as Katikati Estuary. Sediments in Katikati Estuary are too muddy to allow the growth of sea grass. The sea grass beds form an integral part of the ecology and productivity of Tauranga Harbour and it is pleasing that the overall loss of beds to date appears to be low. An estimated 1-7% removal of sea grass from some areas of Tauranga Harbour by black swans grazing may also contribute to localised stress or decline of the beds.

Sea lettuce was the most abundant algal species in Tauranga Harbour and causes a number of recreational, commercial, and ecological impacts. In addition to the distribution and abundance investigations conducted as part of this study there are a number of on-going or specialised research projects designed to provide data required for the assessment of management options.

Results from this study indicated that at the time the investigations were made, there were significant positive correlations between abundance and concentration of Dissolved Reactive Phosphorous and Nitrate-Nitrogen in surrounding waters. These elements are the most important macro-nutrients which could limit plant growth. There was also a tendency for sea lettuce abundance to be higher in areas with higher water clarity. The abundance of sea lettuce was significantly higher in the areas surrounding Tauranga City at the time of the survey.

On-going studies have indicated that sea lettuce is also capable of blooming to nuisance proportions in the northern basin of Tauranga Harbour which receives very little land run-off or stream inputs of nutrients. This indicates that a range of climatic and environmental factors may also be involved in fluctuations in sea lettuce abundance. Information from a number of sources including the general public has indicated that nuisance blooms of sea lettuce have occurred in both the northern and southern harbours throughout this century. Unfortunately there is no quantitative data from which to make comparisons of abundance.

The information already gained from baseline studies of sea lettuce in Tauranga Harbour as part of the BOPRC NERMN indicates that nitrogen and phosphorous are present in the plant tissue at levels which would normally restrict growth for much of the year, especially in the northern harbour. Despite the low availability of nutrients sea lettuce has recently increased its biomass the in northern harbour by dramatic proportions. The large sea lettuce drifts which accumulate during proliferation events alter sediments, and kill off large areas of the intertidal benthos.

5.2 MACROFAUNA OF TAURANGA HARBOUR

Investigations of the subtidal soft-bottom macrofauna of Tauranga Harbour revealed a progressive sequence of communities related to current velocity and sediments within the harbour channels. Benthic communities near the entrances to the harbour are similar to *Tawera-Corbula-Glycymeris* bivalve associations occurring in coarse gravels elsewhere in northern New Zealand. As the sediments then grade through to shallower harbour waters and medium-fine sands the communities show a corresponding change to turret shell (*Maoricolpus roseus*), green lip mussel, scallop, pipi, and *Patiriella-Fellaster-Amalda* associations. The mussel beds are small patchy remnants of what were more extensive beds in the past.

Species diversity in subtidal areas of Tauranga Harbour is limited by high sediment mobility. Results from the brief survey conducted as part of this study indicate that diversity tends to decrease with increasing water depth. This trend is the opposite to many studies but results from higher current velocities in the deeper entrance channels to Tauranga Harbour. In the narrowest zone of the harbour entrances the channels are armoured with stable rock which supports a very rich and diverse community dominated by sessile organisms.

The survey of intertidal macrofauna identified 83 species. The most numerous taxonomic group were the bivalves followed by polychaete worms, gastropods coelenterates and crustacea. The two most abundant species were the wedge shell (*Tellina liliana*) and cockle (*Austrovenus stutchburyi*) each comprising approximately 15% of the animals collected. The cockle-wedge shell and sea grass macrofaunal communities that dominate the Tauranga Harbour intertidal have species abundances and compositions that are typical for northern New Zealand harbours.

The presence of sea grass beds resulted in significantly higher species diversities. The difference is likely to have been even greater if the mesh size used for sampling was smaller. Species diversity was also higher at the low tide level and declined with increasing silt content within the surficial sediments.

The overall size of cockles in Tauranga Harbour was small with many beds not attaining edible size. A trend of larger sized shellfish near the harbour entrances with progressively smaller sized shellfish occurring in the upper harbour reaches was also noted. A similar trend also existed for pipis. Comparison of cockle lengths with an earlier data set showed no apparent change over the last sixteen years.

5.3 FRESHWATER ECOLOGY

From the limited investigations presented here it is apparent that the water quality and ecology of small streams in the Northern Tauranga Harbour catchment is affected by agricultural development. The downstream transition from indigenous forest to pasture resulted in an increase in organic enrichment, a decrease in dissolved oxygen concentrations and an increase in stream temperature. The response of the invertebrate communities to these changes was a decline in the abundance of sensitive species and an increase in those that are more tolerant. It is suggested that these impacts could be mitigated to some extent by providing riparian protection zones.

Relatively little work has been done on the freshwater fishery values of the Tauranga Harbour catchment. The Wairoa system is the most popular trout fishery. Recent fisheries surveys have found only rainbow trout and longfinned eels in the upper Wairoa River system. The general lack of native fish in this area has been attributed to obstruction of migration by structures associated with hydro-electric generation.

5.4 MANAGEMENT ISSUES

In early 1989 newspaper articles reported predictions of the possible death of Tauranga Harbour within 3 - 4 years. The harbour has out-lived these predictions. This study indicates that in a number of ways, the overall ecological health of some harbour habitats may be declining.

1) Sea lettuce

The predictions of death for Tauranga Harbour were focusing only on the problems arising from the increase of sea lettuce. The most commonly perceived problems with sea lettuce to date have been the nuisance/recreational impacts affecting the public. At the same time severe but localised ecological impacts have been occurring in association with drifting rafts of sea lettuce. Accumulation of sea lettuce can suffocate large tracts of less mobile benthic organisms.

Although this study identified some parameters influencing sea lettuce abundance in Tauranga Harbour, several years of baseline data will be required to identify factors which could be used for management purposes.

2) Sea Grass

Sea grass beds are important to the harbour ecosystem because of the important role they play in stabilizing the substrates, increasing species diversity, and increasing the overall productivity of the intertidal flats. The beds are very sensitive to disturbance or pollution and take a very long time to recolonise bare substrate. Some loss of sea grass within the harbour has already occurred but a lack of historical data means that quantitative assessment is not possible. Future reassessment will be needed to ensure that this valuable habitat is being adequately protected.

3) Siltation

Siltation, resulting from increased soil erosion and land runoff in association with changing land use and forest clearance since human settlement, has a number of negative impacts on the ecology of Tauranga Harbour. Silt derived from catchments and carried via streams to the sheltered sub-estuaries of Tauranga Harbour tends to settle out over the intertidal flats. In turn this study presents evidence that sediments are becoming muddier with associated reductions in species diversity and biomass.

The build-up of sediments also results in a more rapid shallowing and subsequent invasion by mangroves. Mangroves do not provide a productive habitat in comparison to open substrate or sea grass beds or provide nursery habitat for juvenile fish as has been suggested in the past. Although mangroves do form a natural part of the harbour habitat their increased abundance as shown in this study does not add to the ecological health of the harbour. Their increasing abundance will reduce the area in which flounder etc can feed and ultimately accelerate trapping of silt and infilling of the sub-estuaries if siltation can not be managed and possibly reduced.

Increased silt loadings and turbidity of harbour waters also has a number of other flow-on ecological effects. The reduced water clarity will reduce benthic primary production, especially subtidally, and may have contributed to the loss of sea grass beds overseas. The higher suspended silt concentrations will also stress and slow down the rate of growth in filter feeding animals while less tolerant species will be lost.

4) Reclamation

Extensive degradation and reduction of the maritime marsh habitat around the margins of Tauranga Harbour has occurred as a result of reclamations, drainage, and grazing. Assessment of these areas indicates approximately 1,200 hectares, formerly consisting of bare intertidal flat, mangroves, and maritime marsh has been lost from the harbour ecosystem mainly for agricultural purposes. This area is approximately equal to the remaining mangrove and maritime marsh habitat combined representing a 50% loss.

Maritime marsh serves a number of important functions related to the harbour ecosystem. It also provides habitat for feeding and breeding of many birds including threatened and rare species such as the banded rail and North Island fern bird. Due to the extensive loss of maritime marsh that has already taken place, protection of the remaining habitat is desirable.

5) Marine Fisheries

The functions of Environment B.O.P do not apply to the direct control of fisheries. However the primary function of Environment B.O.P is to promote the sustainable management of the region's natural resources and while not having direct control, Environment B.O.P must ensure that the fisheries habitat is protected from non-fishing activities. Additionally Environment B.O.P is required to consider the effects of all activities on the environment, and recognises the need to adopt an advocacy role in promoting the sustainable management of the regional fisheries.

Environment B.O.P has been very active in all fisheries issues within the Bay of Plenty being mindful of its obligations under the Resource Management Act to consider the overall social, economic and cultural wellbeing of the community. Environment B.O.P made a number of submissions on the Auckland Fisheries Management Plan aimed at enhancing fish stocks and marine habitat within the Bay of Plenty. Submissions which directly relate to Tauranga Harbour included a ban on all set-netting (unless attended), long lining and commercial drag netting in the enclosed waters of the Bay of Plenty.

In addition to the above submissions relating to fisheries within Tauranga Harbour, it would be beneficial to the harbour ecosystem for a number of other minor fisheries restrictions to apply. These would include a ban on scallop dredging and the taking of parore.

In 1986 a petition (with approximately 3000 signatures) sought a marine reserve in northern Tauranga Harbour. If established such a reserve should include areas near the entrance where mussel beds could re-establish and be protected. Yellow Point, also near the entrance supports a very rich and diverse hard substrate community worthy of protection which could easily form the focal point of an attractive reserve.

6) Fresh water ecology

Results of the investigations into the ecology of the northern Tauranga Harbour catchment streams has shown impacts from agricultural development and clearance of forest from stream banks. The use of riparian strips along these streams could greatly improve the in-stream habitat of both the fish and invertebrate fauna.

The presence of hydroelectric and other obstructions on streams and rivers also restricts the number of migratory fish species that can utilise some of the upper catchment areas as has been reported in fisheries surveys of the upper Wairoa River.

APPENDICES

APPENDIX 1

The percentage cover of algal species and eel grass recorded from algal transects throughout Tauranga Harbour over the summer period in 1990/91 as part of the Tauranga Harbour Regional Plan Project.

data stored in qpro/rmn/cee/thmppa.wq1

Appendix .1 Raw data for the % cover of all algal species in 0.25 m sq quadrats recorded along transects throughout Tauranga Harbour over the summer period in 1990/91 as part of the Tauranga Harbour Regional Plan Project. Codes for algal species are at the end of the appendix.

Trans. #	Dist. (m)	Area	ALGAL SPECIES 1	2	3	4	5	6	7	8	9	10	11
2	0	1	0	3	0	0	0	0	0	0	9	0	0
2	0	1	0	1	0	0	0	0	0	0	2	0	0
2	0	1	0	1	0	0	0	0	0	0	0	0	0
2	0	1	0	1	0	0	0	0	0	0	5	0	0
2	0	1	0	2	0	0	0	0	0	0	4	0	0
2	0	1	0	3	0	0	0	0	0	0	8	0	0
3	0	1	0	0	0	0	0	0	2	0.5	0	0	0
3	0	1	0	0	0	0	0	0	3	0	0	0	0
3	0	1	0	0	0	0	0	0	5	0.5	0	0	0
3	0	1	0	0	0	0	0	0	0	0	0	0	0
3	0	1	0	0	0	0	0	0	1	0	0	0	0
3	0	1	0	0	0	0	0	0	2	0.5	0	0	0
3	-100	1	0	0	0	39	3	0	56	2	0	0	0
3	-100	1	0	0	0	48	0	0	32	3	0	0	0
3	-100	1	0	0	0	8	4	0	27	1	0	0	0
3	-100	1	0	0	0	12	2	0	11	0.5	0	0	0
3	-100	1	0	0	0	38	5	0	54	3	0	0	0
3	-100	1	0	0	0	43	2	0	43	2	0	0	0
3	-200	1	0	0	0	0	0	0	100	0	0	0	0
3	-200	1	0	0	0	65	0	0	31	3	0	0	0
3	-200	1	0	0	0	43	1	0	26	2	0	0	0
3	-200	1	0	0	0	61	0.5	0	34	2	0	0	0
3	-200	1	0	0	0	36	0	0	52	0.5	0	0	0
3	-200	1	0	0	0	50	1	0	44	2	0	0	0
3	-300	1	0	0	0	20	0	0	0	0	0	0	0
3	-300	1	0	0	0	32	0.5	0	5	0	0	0	0
3	-300	1	0	0	0	14	0	0	2	2	0	0	0
3	-300	1	0	0	0	16	0	0	8	0	0	0	0
3	-300	1	0	0	0	43	0.5	0	1	0	0	0	0
3	-300	1	0	0	0	5	0	0	3	0	0	0	0
3	-400	1	0	0	0	51	0	0	1	0	0	0	0
3	-400	1	0	0	0	6	0	0	2	0	0	0	0
3	-400	1	0	0	0	11	0	0	0	0	0	0	0
3	400	1	0	0	0	16	0	0	3	0.5	0	0	0
3	-400	1	0	0	0	7	0	0	1	0	0	0	0
3	-400	1	0	0	0	23	0	0	2	0	0	0	0
4	-10	1	0	0	0	0	3	0	0.5	4	0	0	0
4	-10	1	0	0.5	0	0	0.5	0	1	1	0	0	0
4	-10	1	0.5	0	0	0	2	0	2	0.5	0	0	0
4	-10	1	0	0.5	0	0	4	0	0	2	0	0	0
4	-10	1	0.5	0	0	0	2	0	0.5	3	0	0	0
4	-10	1	0	3	0	0	1	0	1	1	0	0	0
4	-50	1	0	0	0	73	0	0	7	0	0	0	0
4	-50	1	5	0	0	64	0	0	8	0	0	0	0
4	-50	1	2	3	0	31	0	0	18	0	0	0	0
4	-50	1	0	4	0	70	0	0	3	0	0	0	0
4	-50	1	0	0	0	68	0	0	4	1	0	0	0
4	-50	1	0	0	0	61	0	0	2	0	0	0	0
4	-150	1	8	0	0	63	0.5	0	6	0	0	0	0
4	-150	1	0	0	0	42	0.5	0	3	0	0	0	0
4	-150	1	0	0	0	39	0.5	0	5	0	0	0	0
4	-150	1	5	0	0	12	0.5	0	1	0	0	0	0
4	-150	1	5	0	0	54	0.5	0	11	0.5	0	0	0
4	-150	1	0	0	0	77	0.5	0	9	0.5	0	0	0
4	-250	1	0	0	0	24	0	0	6	0	0	0	0
4	-250	1	1	0	0	43	0	0	12	0	0	0	0
4	-250	1	4	0	0	38	0	0	20	0	0	0	0
4	-250	1	3	0	0	12	0	0	16	0	0	0	0
4	-250	1	5	0	0	39	0	0	8	0	0	0	0
4	-250	1	2	0	0	51	0	0	13	0	0	0	0
4	-400	1	0	0	0	13	0	0	42	0	0	0	0
4	400	1	2	0	0	29	0	0	8	0	0	0	0
4	-400	1	0	0	0	60	0	0	31	0	0	0	0
4	-400	1	1	0	0	24	0	0	26	0	0	0	0
4	-400	1	0	0	0	16	0	0	28	0	0	0	0
4	-400	1	0	0	0	39	0	0	14	0	0	0	0
5	-100	1	20	0	0	0	0	0	2	0	0	0	0
5	-100	1	6	0.5	0	0	0	0	0.5	0	0	0	0
5	-100	1	2	0	0	0	0	0	5	0	0	0	0
5	-100	1	18	0	0	0	0	0	0.5	0	0	0	0
5	-100	1	12	6	0	0	0	0	2	0	0	0	0
5	-100	1	10	0	0	0	0	0	1	0	0	0	0
5	-150	1	2	0	0	46	0	0	2	0	0	0	0
5	-150	1	1	0	0	32	0	0	1	0	0	0	0
5	-150	1	0.5	0	0	51	0	0	0.5	0	0	0	0
5	-150	1	3	0	0	47	0	0	0	0	0	0	0
5	-150	1	1	0.5	0	61	0	0	1	0	0	0	0
5	-150	1	0.5	0	0	53	0	0	1	0	0	0	0
5	-250	1	0.5	0	0	5	0	0	0.5	0	0	0	0
5	-250	1	0	0	0	12	0	0	0.5	0	0	0	0
5	-250	1	1	2	0	26	0	0	0	0	0	0	0
5	-250	1	0	0	0	17	0	0	2	0	0	0	0
5	-250	1	0.5	0	0	39	0	0	0	0	0	0	0
5	-250	1	0.5	0	0	7	0	0	0.5	0	0	0	0
5	-350	1	0	0	0	42	0	0	3	0	0	0	0
5	-350	1	2	0	0	58	0	0	2	0	0	0	0
5	-350	1	0	0	0	59	0	0	6	0	0	0	0
5	-350	1	3	0	0	32	0	0	3	0	0	0	0
5	-350	1	0.5	0	0	47	0	0	2	0	0	0	0
5	-350	1	4	0	0	44	0	0	1	0	0	0	0
6	50	1	0.5	0	0	0	0	0	0	0	0	0	0
6	50	1	0	0	0	0	0	0	0	0	0	0	0
6	50	1	0.5	0	0	0	0	0	0	0.5	0	0	0
6	50	1	0.5	0	0	0	0	0	0	0	0	0	0
6	50	1	0	0	0	0	0	0	0	0	0	0	0
6	50	1	0	0	0	0	0	0	0	0	0	0	0
6	100	1	0	0	0	60	0	0	0	1	0	0	0
6	100	1	0	7	0	47	0	0	0	0.5	0	0	0
6	100	1	0	6	0	43	0	0	0	0.5	0	0	0
6	100	1	0	1	0	48	0	0	0	0	0	0	0
6	100	1	0	0.5	0	36	0	0	2	0	0	0	0
6	100	1	0	3	0	33	0	0	0	1	0	0	0
6	200	1	0	0	0	30	0	0	0	0	0	0	0
6	200	1	0	0	0	42	0	0	0	0	0	0	0
6	200	1	0	0.5	0	35	0	0	0	0.5	0	0	0
6	200	1	0	0	0	46	0	0	0	0	0	0	0
6	200	1	0	0.5	0	21	0	0	0	0.5	0	0	0
6	200	1	0	0	0	27	0	0	0	0.5	0	0	0
6	305	1	0	0	0	0	0	0	0	2	0	0	0
6	305	1	0.5	3	0	0	0	0	0	1	0	0	0
6	305	1	0	2	0	0	0	0	0	3	0	0	0
6	305	1	0.5	1	0	0	0	0	0	1	0	0	0
6	305	1	1	4	0	0	0	0	0	2	0	0	0
6	305	1	0.5	0.5	0	0	0	0	0	2	0	0	0
7	50	1	0	0	0	42	0	0	0	0	0	0	0

Trans. #	Dist. (m)	Area	ALGAL SPECIES 1	2	3	4	5	6	7	8	9	10	11
30	0	2	0	0	0	0	0	0	0	0	0	0	0
30	0	2	0	0	0	0	0	0	0	0	0	0	0
30	0	2	0	0	0	0	0	0	0	0	0	0	0
30	0	2	0	0	0	0	0	0	0	0	0	0	0
30	-50	2	0	0	0	0	0	0	0	0	0	0	0
30	-50	2	0	0	0	0	0	0	0	0	0	0	0
30	-50	2	0.5	0	0	0	0	0	0	0	0	0	0
30	-50	2	0	0	0	0	0	0	0	0	0	0	0
30	-50	2	0	0	0	0	0	0	0	0	0	0	0
30	-50	2	0	0	0	0	0	0	0	0	0	0	0
32	50	2	0	0	0	0	0	0	0	0	0	0	0
32	50	2	2	0	0	0	0	0	0	0	0	0	0
32	50	2	0	0	0	0	0	0	0	0	0	0	0
32	50	2	0	0	0	0	0	0	0	0	0	0	0
32	50	2	0.5	0	0	0	0	0	0	0	0	0	0
32	50	2	0	0	0	0	0	0	0	0	0	0	0
32	100	2	0	0	0	0	0	0	0	0	0	0	0
32	100	2	1	0	0	0	0	0	0	0	0	0	0
32	100	2	0	0	0	0	0	0	0	0	0	0	0
32	100	2	0.5	0	0	0	0	0	0	0	0	0	0
32	100	2	0.5	0	0	0	0	0	0	0	0	0	0
32	100	2	0.5	0	0	0	0	0	0	0	0	0	0
32	150	2	0	0	0	0	0	0	0	0	0	0	0
32	150	2	0.5	0	0	0	0	0	0	0	0	0	0
32	150	2	0	0	0	0	0	0	0	0	0	0	0
32	150	2	0	0	0	0	0	0	0	0	0	0	0
32	150	2	0.5	0	0	0	0	0	0	0	0	0	0
32	150	2	0.5	0	0	0	0	0	0	0	0	0	0
32	200	2	0	0	0	0	0	0	0	0	0	0	0
32	200	2	0.5	0	0	0	0	0	0	0	0	0	0
32	200	2	0	0	0	0	0	0	0	0	0	0	0
32	200	2	0	0	0	0	0	0	0	0	0	0	0
32	200	2	0	0	0	0	0	0	0	0	0	0	0
32	200	2	0	0	0	0	0	0	0	0	0	0	0
33	50	2	0	0	0	0	0	0	0	0	0	0	0
33	50	2	0.5	0	0	0	0	0	0	0	0	0	0
33	50	2	0	0	0	0	0	0	0	0	0	0	0
33	50	2	0	0	0	0	0	0	0	0	0	0	0
33	50	2	0.5	0	0	0	0	0	0	0	0	0	0
33	50	2	0	0	0	0	0	0	0	0	0	0	0
33	100	2	0	0	0	0	0	0	0	0	0	0	0
33	100	2	0	0	0	0	0	0	0	0	0	0	0
33	100	2	0	0.5	0	0	0	0	0	0	0	0	0
33	100	2	0	0	0	0	0	0	0	0	0	0	0
33	100	2	0.5	0	0	0	0	0	0	0	0	0	0
33	100	2	0	0	0	0	0	0.5	0	0	0	0	0
33	150	2	0.5	0	0	0	0	0	0	0	0	0	0
33	150	2	0	0	0	0	0	0	0	0	0	0	0
33	150	2	0.5	0	0	0	0	0	0	0	0	0	0
33	150	2	0	0	0	0	0	0	0	0	0	0	0
33	150	2	0	0.5	0	0	0	0	0	0	0	0	0
33	150	2	0	0	0	0	0	0	0	0	0	0	0
33	250	2	0	0	0	0	0	0	0	0	0	0	0
33	250	2	0.5	0	0	0	0	0	0	0	0	0	0
33	250	2	0	0.5	0	0	0	0	0	0	0	0	0
33	250	2	0	0	0	0	0	0	0	0	0	0	0
33	250	2	0	0	0	0	0	0	0	0	0	0	0
33	250	2	0	0.5	0	0	0	0	0	0	0	0	0
33	300	2	0	0	0	0	0	0	0	0	0	0	0
33	300	2	0	3	0	0	0	0	0	0	0	0	0.5
33	300	2	0	0	0	0	0	0	0	0	0	0	0.5
33	300	2	0	0	0	0	0	0	0	0	0	0	1
33	300	2	0	5	0	0	0	0	0	0	0	0	0.5
33	300	2	0	0.5	0	0	0	0	0	0	0	0	0
34	100	2	0	0	0	72	0	0	0	0	0	0	0
34	100	2	0	0	0	83	0	0	0	0	0	0	0
34	100	2	0	0	0	76	0	0	0	0	0	0	0
34	100	2	0	0	0	91	0	0	0	0	0	0	0
54	100	2	0	0	0	78	0	0	0	0	0	0	0
34	100	2	0	0	0	59	0	0	0	0	0	0	0
34	200	2	0	0	0	67	0	0	0	0	0	0	0
34	200	2	0	0	0	83	0	0	0	0	0	0	0
34	200	2	0	0	0	61	0	0	0	0	0	0	0
34	200	2	0	0	0	75	0	0	0	0	0	0	0
34	200	2	0	0	0	67	0	0	0	0	0	0	0
34	200	2	0	0	0	66	0	0	0	0	0	0	0
34	300	2	0	2	0	0	0	0	0	0	0	0	0
34	300	2	0	3	0	0	0	0	0	0	0	0	0
34	300	2	0	0.5	0	0	0	0	0	0	0	0	0
34	300	2	0	0	0	0	0	0	0	0.5	0	0	0
34	300	2	0	0.5	0	0	0	0	0	0	0	0	0
34	300	2	0	2	0	0	0	0	0	0.5	0	0	0
34	400	2	0	0	0	95	0	0	0	0	0	0	0
34	400	2	0	0	0	92	0	0	0	0	0	0	0
34	400	2	0	0	0	87	0	0	0	0	0	0	0
34	400	2	0	0	0	96	0	0	0	0	0	0	0
34	400	2	0	2	0	65	0	0	0	0	0	0	0
34	400	2	0	0	0	88	0	0	0	0	0	0	0
34	500	2	0	0	0	78	0	0	0	0	0	0	0
34	500	2	0	0	0	69	0	3	0	0	0	0	0
34	500	2	0	3	0	64	0	0	0	0	0	0	0
34	500	2	0	0	0	80	0	2	0	0	0	0	0
34	500	2	0	2	0	73	0	0	0	0	0	0	0
34	500	2	0	0	0	94	0	2	0	0	0	0	0
35	50	2	0	0	0	0	0	0	0	0	0	0	0
35	50	2	0	0	0	0	0	0	0	0	0	0	0
35	50	2	0	0	0	0	0	0	0	0	0	0	0
35	50	2	0	0	0	0	0	0	0	0	0	0	0
35	50	2	0	0	0	0	0	0	0	0	0	0	0
35	50	2	0	0	0	0	0	0	0	0	0	0	0
35	100	2	0	0	0	45	0	0	0	0	0	0	0
35	100	2	0	0	0	76	0	0	0	0	0	0	0
35	100	2	0	0	0	81	0	0	0	0	0	0	0
35	100	2	0	0	0	72	0	0	0	0	0	0	0
35	100	2	0	0	0	5	0	0	0	0	0	0	0
35	100	2	0	0	0	88	0	0	0	0	0	0	0
36	50	2	0	0	0	0	0	0	0	0	0	0	0
36	50	2	0	0	0	0	0	0	0	0	0	0	0
36	50	2	0	0	0	0	0	0	0	0	0	0	0
36	50	2	0	0	0	0	0	0	0	0	0	0	0
36	50	2	0	0	0	0	0	0	0	0	0	0	0
36	50	2	0	0	0	0	0	0	0	0	0	0	0
36	100	2	0	0	0	0	0	0	0	0	0	0	0
36	100	2	0.5	0	0	0	0	0	0	0	0	0	0
36	100	2	0	0	0	0	0	0	0	0	0	0	0

Trans. #	Dist. (m)	Area	ALGAL SPECIES 1	2	3	4	5	6	7	8	9	10	11
63	100	2	0	1	0	0	0	0	0	0	0	0	0
63	100	2	0	0	0	0	0	0	0	0	0	0	0
63	150	2	0	5	0	1	0	0	0	0	0	0	0
63	150	2	0	6	0	1	0	0	0	0	0	0	0
63	150	2	0	0	0	15	0	0	0	0	0	0	0
63	150	2	0	0	0	39	0	0	0	0	0	0	0
63	150	2	0	0	0	10	0	0	0	0	0	0	0
63	150	2	0	0	0	11	0	0	0	0	0	0	0
63	190	2	0	0	0	80	0	0	0	0	0	0	0
63	190	2	0	15	0	80	0	0	0	0	0	0	0
63	190	2	0	0	0	78	0	0	0	0	0	0	0
63	190	2	0	0.5	0	72	0	0	0	0	0	0	0
63	190	2	0	5	0	72	0	0	0	0	0	0	0
63	190	2	0	0	0	91	0	0	0	0	0	0	0
64	50	2	0	2	0	0	0	0	0	0	0	0	0
64	50	2	0	0	0	0	0	0	0	0	0	0	0
64	50	2	0	0	0	0	0	0	0	0	0	0	0
64	50	2	0	3	0	0	0	0	0	0	0	0	0
64	50	2	0	0	0	0	0	0	0	0	0	0	0
64	50	2	0	0	0	0	0	0	0	0	0	0	0
64	100	2	0	0	0	0	0	0	0	0	0	0	0
64	100	2	0	0	0	0	0	0	0	0	0	0	0
64	100	2	0	0	0	0	0	0	0	0	0	0	0
64	100	2	0	0	0	0	0	0	0	0	0	0	0
64	100	2	0	0	0	0	0	0	0	0	0	0	0
64	100	2	0	0	0	0	0	0	0	0	0	0	0
64	150	2	0	0	0	0	0	0	0	0	0	0	0
64	150	2	0	0	0	0	0	0	0	0	0	0	0
64	150	2	0	0	0	15	0	0	0	0	0	0	0
64	150	2	0	4	0	0	0	0	0	0	0	0	0
64	150	2	0	0	0	8	0	0	0	0	0	0	0
64	150	2	0	0	0	0	0	0	0	0	0	0	0
64	200	2	0	3	0	59	0	0	0	0	0	0	0
64	200	2	0	0	0	73	0	0	0	0	0	0	0
64	200	2	0	12	0	45	4	0	0	0	0	0	0
64	200	2	0	2	0	82	0	0	0	0	0	0	0
64	200	2	0	14	0	90	7	0	0	0	0	0	0
64	200	2	0	9	0	53	3	0	0	0	0	0	0
65	20	2	0	0	0	82	11	0	0	0	0	0	0
65	20	2	0	1	0	19	0	0	0	0	0	0	0
65	20	2	0	0	0	54	0.5	0	0	0	0	0	0
65	20	2	0	0	0	14	0	0	0	0	0	0	0
65	20	2	0	0	0	51	4	0	0	0	0	0	0
65	20	2	0	0	0	72	8	0	0	0	0	0	0
65	50	2	0	0.5	0	89	7	0	0	0	0	0	0
65	50	2	0	0.5	0	72	13	0	0	0	0	0	0
65	50	2	0	0	0	95	14	0	0	0	0	0	0
65	50	2	0	2	0	0.5	0	0	0	0	0	0	0
65	50	2	0	0	0	31	6	0	0	0	0	0	0
65	50	2	0	2	0	44	2	0	0	0	0	0	0
65	100	2	0	16	0	48	26	0	0	0	0	0	0
65	100	2	0	9	0	57	34	0	0	0	0	0	0
65	100	2	0	11	0	80	41	0	0	0	0	0	0
65	100	2	0	20	0	46	36	0	0	0	0	0	0
65	100	2	0	12	0	75	30	0	0	0	0	0	0
65	100	2	0	19	0	85	28	0	0	0	0	0	0
65	150	2	0	22	0	90	5	0	0	0	0	0	0
65	150	2	0	0	0	94	0	0	0	0	0	0	0
65	150	2	0	11	0	88	7	0	0	0	0	0	0
65	150	2	0	0	0	91	3	0	0	0	0	0	0
65	150	2	0	7	0	98	8	0	0	0	0	0	0
65	150	2	0	14	0	82	2	0	0	0	0	0	0
66	20	2	0	0	0	0	0	0	0	0	0	0	0
66	20	2	0	8	0	0	0	0	0	0	0	0	0
66	20	2	0	0	0	0	0	0	0	0	0	0	0
66	20	2	0	12	0	0	0	0	0	0	0	0	0
66	20	2	0	7	0	0	0	0	0	0	0	0	0
66	20	2	0	0	0	0	0	0	0	0	0	0	0
66	50	2	0	8	0	62	29	0	0	0	0	0	0
66	50	2	0	3	0	83	16	0	0	0	0	0	0
66	50	2	0	11	0	57	22	0	0	0	0	0	0
66	50	2	0	0	0	48	26	0	0	0	0	0	0
66	50	2	0	0	0	60	24	0	0	0	0	0	0
66	50	2	0	1	0	71	15	0	0	0	0	0	0
66	100	2	0	4	0	38	80	0	0	0	0	0	0
66	100	2	0	11	0	53	27	0	0	0	0	0	0
66	100	2	0	5	0	72	33	0	0	0	0	0	0
66	100	2	0	22	0	52	46	0	0	0	0	0	0
66	100	2	0	13	0	39	28	0	0	0	0	0	0
66	100	2	0	21	0	18	5	0	0	0	0	0	0
66	150	2	0	0.5	0	75	78	0	0	0	0	0	0
66	150	2	0	1	0	61	50	0	0	0	0	0	0
66	150	2	0	0	0	73	62	0	0	0	0	0	0
66	150	2	0	4	0	64	57	0	0	0	0	0	0
66	150	2	0	3	0	84	49	0	0	0	0	0	0
66	150	2	0	5	0	69	60	0	0	0	0	0	0
66	200	2	0	0	0	95	15	0	0	0	0	0	0
66	200	2	0	0	0	97	14	0	0	0	0	0	0
66	200	2	0	0	0	96	20	0	0	0	0	0	0
66	200	2	0	0	0	91	24	0	0	0	0	0	0
66	200	2	0	14	0	78	12	0	0	0	0	0	0
66	200	2	0	3	0	95	14	0	0	0	0	0	0
67	5	3	0	0	0	0	0	0	0	0	0	0	0
67	5	3	0	0	0	0	0	0	0	0	0	0	0
67	5	3	0	0	0	0	0	0	0	0	0	0	0
67	5	3	0	0	0	0	0	0	0	0	0	0	0
67	5	3	0	0	0	0	0	0	0	0	0	0	0
67	5	3	0	0	0	0	0	0	0	0	0	0	0
67	50	3	0	60	0	0	0	0	0	0	0	0	0
67	50	3	0	10	0	0	0	0	0	0	0	0	0
67	50	3	0	1	0	0	0	0	0	0	0	0	0
67	50	3	0	81	0	0	0	0	0	0	0	0	0
67	50	3	0	100	0	0	0	0	0	0	0	0	0
67	50	3	0	90	0	0	0	0	0	0	0	0	0
67	80	3	0	1	0	0	0	0	0	0	0	0	0
67	80	3	0	5	0	0	0	0	0	0	0	0	0
67	80	3	0	89	0	0	0	0	0	0	0	0	0
67	80	3	0	1	0	0	0	0	0	0	0	0	0
67	80	3	0	10	0	0	0	0	0	0	0	0	0
67	80	3	0	30	0	0	0	0	0	0	0	0	0
67	100	3	0	0	0	0	0	0	0	0	0	0	0
67	100	3	0	0	0	0	0	0	0	0	0	0	0
67	100	3	0	0	0	0	0	0	0	0	0	0	0
67	100	3	0	0	0	0	0	0	0	0	0	0	0
67	100	3	0	0	0	0	0	0	0	0	0	0	0

Appendix 1 Raw data for the % cover of all algal species in 0.25 m sq quadrats recorded along transects throughout Tauranga Harbour over the summer period in 1990/91 as part of the Tauranga Harbour Regional Plan Project. Codes for algal species are at the end of the appendix.

Trans. #	Dist. (m)	Area	ALGAL SPECIES 1	2	3	4	5	6	7	8	9	10	11
7	50	1	0	0	0	29	0	0	0	0	0	0	0
7	50	1	0	0	0	53	0	0	0	0	0	0	0
7	50	1	0	0	0	45	0	0	0	0	0	0	0
7	50	1	0	0	0	50	0	0	0	0	0	0	0
7	50	1	0	0	0	38	0	0	0	0	0	0	0
7	150	1	0.5	0	0	0	0	0	0	2	0	0	0
7	150	1	0	0	0	0	0	0	0	0	0	0	0
7	150	1	1	0	0	0	0	0	0	2	0	0	0
7	150	1	0	0	0	0	0	0	0	1	0	0	0
7	150	1	0.5	0	0	0	0	0	0	0.5	0	0	0
7	150	1	0.5	0	0	0	0	0	0	0	0	0	0
7	250	1	0	0	0	0	0	0	0	0	0	0	0
7	250	1	0.5	0	0	0	0	0	0	0	0	0	0
7	250	1	0	0	0	0	0	0	0	0	0	0	0
7	250	1	0	0	0	0	0	0	0	0.5	0	0	0
7	250	1	0.5	0	0	0	0	0	0	0	0	0	0
7	250	1	0	0	0	0	0	0	0	0	0	0	0
7	350	1	1	0	0	0	0	0	0	0	0	0	0
7	350	1	0	2	0	0	0	0	0	2	0	0	0
7	350	1	0.5	0	0	0	0	0	0	0.5	0	0	0
7	350	1	2	0	0	0	0	0	0	0	0	0	0
7	350	1	0.5	0	0	0	0	0	0	0.5	0	0	0
7	350	1	0.5	0	0	0	0	0	0	1	0	0	0
7	450	1	0.5	0	0	0	0	0	0	3	0	0	0
7	450	1	1	0	0	0	0	0	0	1	0	0	0
7	450	1	1	0	0	0	0	0	0	0.5	0	0	0
7	450	1	3	0	0	0	0	0	0	0.5	0	0	0
7	450	1	3	0.5	0	0	0	0	0	0.5	0	0	0
7	450	1	4	0.5	0	0	0	0	0	0.5	0	0	0
8	100	1	0	0	0	0	0	0	0	0	0	0	0
8	100	1	0	0	0	0	0	0	0	0	0	0	0
8	100	1	0	0	0	0	0	0	0	0	0	0	0
8	100	1	0	0	0	0	0	0	0	0	0	0	0
8	100	1	0	0	0	0	0	0	0	0	0	0	0
8	100	1	0	0	0	0	0	0	0	0	0	0	0
8	200	1	0	0	0	0	0	0	0	0	0	0	0
8	200	1	0	0	0	0	0	0	0	0	0	0	0
8	200	1	0	0	0	0	0	0	0	0	0	0	0
8	200	1	0	0	0	0	0	0	0	0	0	0	0
8	200	1	0	0	0	0	0	0	0	0	0	0	0
8	200	1	0	0	0	0	0	0	0	0	0	0	0
8	350	1	0	0	0	62	0	0	0	0	0	0	0
8	350	1	0	0	0	70	0	0	0	0	0	0	0
8	350	1	0	0	0	55	0	0	0	0	0	0	0
8	350	1	0	0	0	74	0	0	0	0	0	0	0
8	350	1	0	0	0	68	0	0	0	0	0	0	0
8	350	1	0	0	0	58	0	0	0	0	0	0	0
8	500	1	3	0	0	0	0	0	0	0	0	0	0
8	500	1	2	0	0	0	0	0	0	0	0	0	0
8	500	1	1	0	0	0	0	0	0	0	0	0	0
8	500	1	0.5	0	0	0	0	0	0	0.5	0	0	0
8	500	1	0.5	0	0	0	0	0	0	0	0	0	0
8	500	1	0	0	0	0	0	0	0	0.5	0	0	0
8	650	1	5	0	0	0	0	0	0	0	0	0	0
8	650	1	7	0	0	0	0	0	0	1	0	0	0
8	650	1	4	0	0	0	0	0	0	0	0	0	0
8	650	1	3	0	0	0	0	0	0	0	0	0	0
8	650	1	4	0	0	0	0	0	0	0.5	0	0	0
8	650	1	2	0	0	0	0	0	0	0	0	0	0
9	0	1	0.5	5	0	0	0	0	0	0.5	0	0	0
9	0	1	2	0	0	0	0	0	0	0	0	0	0
9	0	1	1	2	0	0	0	0	0	0.5	0	0	0
9	0	1	0.5	1	0	0	0	0	0	1	0	0	0
9	0	1	3	1	0	0	0	0	0	0.5	0	0	0
9	0	1	1	0.5	0	0	0	0	0	0	0	0	0
9	-50	1	0.5	0	0	0	0	0	0.5	0	0	0	0
9	-50	1	0.5	0	0	0	0	0	0	0	0	0	0
9	-50	1	0	0.5	0	0	0	0	0.5	0	0	0	0
9	-50	1	0.5	0	0	0	0	0	0.5	0	0	0	0
9	-50	1	0	0.5	0	0	0	0	0	0	0	0	0
9	-50	1	0.5	0	0	0	0	0	0	0	0	0	0
9	-150	1	2	0	0	66	0	0	5	0	0	0	0
9	-150	1	0	0	0	51	0	0	6	0.5	0	0	0
9	-150	1	0.5	1	0	48	0	0	2	0.5	0	0	0
9	-150	1	3	0	0	27	2	0	0	0	0	0	0
9	-150	1	0	0	0	52	0	0	3	0.5	0	0	0
9	-150	1	0.5	0	0	61	0	0	0.5	0	0	0	0
9	-300	1	0	0	0	52	0	0	0.5	0.5	0	0	0
9	-300	1	0.5	0	0	45	0.5	0	0	0	0	0	0
9	-300	1	0	0	0	31	0.5	0	1	0.5	0	0	0
9	-300	1	2	0	0	43	0	0	2	0.5	0	0	0
9	-300	1	0	0	0	58	1	0	0	0.5	0	0	0
9	-300	1	0.5	0	0	27	0	0	0.5	0	0	0	0
10	20	1	0	0	0	82	0	0	0	0	0	0	0
10	20	1	0	5	0	0	0	0	0	0	0	0	0
10	20	1	0	0	0	76	0	0	0	0	0	0	0
10	20	1	0	0	0	93	0	0	4	0	0	0	0
10	20	1	0	0	0	79	0	0	0	0	0	0	0
10	20	1	0	0	0	83	0	0	0	0	0	0	0
10	40	1	0	0	0	25	0	0	0	0	0	0	0
10	40	1	0	0	0	32	0	0	0	0	0	0	0
10	40	1	0	0	0	18	0	0	0	0	0	0	0
10	40	1	0	0	0	15	0	0	0	0	0	0	0
10	40	1	0	0	0	22	0	0	0	0	0	0	0
10	40	1	0	0	0	30	0	0	0	0	0	0	0
10	60	1	0	0	0	5	0	0	0	0	0	0	0
10	60	1	0	0	0	14	0	0	0	0	0	0	0
10	60	1	0	0	0	23	0	0	0	0	0	0	0
10	60	1	0	0	0	36	0	0	0	0	0	0	0
10	60	1	0	3	0	18	0	0	0	0	0	0	0
10	60	1	0	0	0	16	0	0	0	0	0	0	0
10	80	1	0	0	0	84	0	0	0	0	0	0	0
10	80	1	0	0	0	75	0	0	0	0	0	0	0
10	80	1	0	4	0	56	0	0	0	0	0	0	0
10	80	1	0	0	0	12	0	0	0	0	0	0	0
10	80	1	0	0	0	21	0	0	0	0	0	0	0
10	80	1	0	2	0	34	0	0	0	0	0	0	0
10	110	1	0	0	0	16	0	0	0	0	0	0	0
10	110	1	0	0	0	31	0	0	0.5	0	0	0	0
10	110	1	0	0	0	40	0	0	0	0	0	0	0
10	110	1	0	1	0	28	0	0	0	0	0	0	0
10	110	1	0	0	0	71	0	0	0	0.5	0	0	0
10	110	1	0	0	0	52	0	0	0	0	0	0	0
11	50	1	0	0	0	74	0	0	0	0	0	0	0
11	50	1	0	6	0	77	0	0	0	0	0	0	0
36	100	2	0	0	0	0	0	0	0	0	0	0	0
36	100	2	0	0	0	0	0	0	0	0	0	0	0
36	100	2	0	0	0	0	0	0	0	0	0	0	0
36	150	2	0	0	0	0	0	0	0	0	0	0	0
36	150	2	1	0	0	0	0	0	0	0	0	0	0
36	150	2	0	0	0	0	0	0	0	0	0	0	0
36	150	2	0.5	0	0	0	0	0	0	0	0	0	0
36	150	2	0	0	0	0	0	0	0	0	0	0	0
36	150	2	0.5	0	0	0	0	0	0	0	0	0	0
36	200	2	0	0	0	63	0	0	0	0	0	0	0
36	200	2	0	0	0	0	0	0	0	0	0	0	0
36	200	2	0	0	0	72	0	0	0	0	0	0	0
36	200	2	0	0	0	16	0	0	0	0	0	0	0
36	200	2	0	0	0	0	0	0	0	0	0	0	0
36	200	2	0	0	0	0	0	0	0	0	0	0	0
37	0	2	0	0	0	0	0	0	0	0	0	0	0
37	0	2	0	0	0	0	0	0	0	0	0	0	0
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37	50	2	0	0	0	0	0	0	0	0	0	0	0
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37	150	2	0	0	0	0	0	0	0	0	0	0	0
37	150	2	0	0	0	0	0	0	0	0	0	0	0
37	150	2	0	0	0	0	0	0	0	0	0	0	0
37	150	2	0	0	0	0	0	0	0	0	0	0	0
37	150	2	0	0	0	0	0	0	0	0	0	0	0
37	150	2	0	0	0	0	0	0	0	0	0	0	0
37	250	2	0	0	0	0	0	0	0	0	0	0	0
37	250	2	0	0	0	0	0	0	0	0	0	0	0
37	250	2	0	0	0	0	0	0	0	0	0	0	0
37	250	2	0	0	0	0	0	0	0	0	0	0	0
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37	250	2	0	0	0	0	0	0	0	0	0	0	0
37	300	2	0	0	0	0	0	0	0	0	0	0	0
37	300	2	0	0	0	0	0	0	0	0	0	0	0
37	300	2	0	0	0	0	0	0	0	0	0	0	0
37	300	2	0	0	0	0	0	0	0	0	0	0	0
37	300	2	0	0	0	0	0	0	0	0	0	0	0
37	300	2	0	0	0	0	0	0	0	0	0	0	0
38	50	2	0	0	0	38	0	0	0	0	0	0	0
38	50	2	0	0	0	45	0	0	0	0	0	0	0
38	50	2	0	0	0	41	0	0	0	0	0	0	0
38	50	2	0	0	0	32	0	0	0	0	0	0	0
38	50	2	0	0	0	29	0	0	0	0	0	0	0
38	50	2	0	0	0	43	0	0	0	0	0	0	0
38	150	2	0	5	0	25	0	0	0	0	0	0	0
38	150	2	0	0	0	39	0	0	0	0	0	0	0
38	150	2	0	2	0	42	0	0	0	0	0	0	0
38	150	2	0	0	0	16	0	0	0	0	0	0	0
38	150	2	0	0	0	38	0	0	0	0	0	0	0
38	150	2	0	3	0	40	0	0	0	0	0	0	0
38	200	2	0	0	0	62	0	0	0	0	0	0	0
38	200	2	0	0	0	49	0	0	0	0	0	0	0
38	200	2	0	0	0	55	0	0	0	0	0	0	0
38	200	2	0	0	0	78	0	0	0	0	0	0	0
38	200	2	0	0	0	76	0	0	0	0	0	0	0
38	200	2	0	0	0	63	0	0	0	0	0	0	0
38	300	2	0	0	0	0	0	0	0	0	0	0	0
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39	0	2	0	0	0	0	0	0	0	0	0	0	0
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39	0	2	0	0	0	0	0	0	0	0	0	0	0
39	-50	2	0	1	0	99	0	0	0	0	0	0	0
39	-50	2	0	20	0	95	0	0	0	0	0	0	0
39	-50	2	0	1	0	85	0	0	0	0	0	0	0
39	-50	2	0	3	0	86	0	0	0	0	0	0	0
39	-50	2	0	0	0	90	0	0	0	0	0	0	0
39	-50	2	0	5	0	95	0	0	0	0	0	0	0
39	-140	2	0.5	0	0	0	0	0	0	0	0	0	0
39	-140	2	0.5	0	0	0	0	0	0	0	0	0	0
39	-140	2	0	0	0	0	0	0	0	0	0	0	0
39	-140	2	0.5	0	0	0	0	0	0	0	0	0	0
39	-140	2	0.5	0	0	0	0	0	0	0	0	0	0
39	-140	2	0.5	0	0	0	0	0	0	0	0	0	0
39	-245	2	0	3	0	0	0	0	0	2	0	0	0
39	-245	2	0	1	0	0	0	0	0	1	0	0	0
39	-245	2	0	2	0	0	0	0	0	0.5	0	0	0
39	-245	2	0	2	0	0	0	0	0	1	0	0	0
39	-245	2	0	3	0	0	0	0	0	0.5	0	0	0
39	-245	2	2	7	0	0	0	0	0	1	0	0	0
39	-300	2	1	0	0	0	0	0	0	0	0	0	0
39	-300	2	1	0	0	0	0	0	0	0	0	0	0
39	-300	2	2	0	0	0	0	0	0	0	0	0	0
39	-300	2	2	0	0	0	0	0	0	0	0	0	0
39	-300	2	2	0	0	0	0	0	0	0	0	0	0
39	-300	2	3	0	0	0	0	0	0	0	0	0	0
40	50	2	4	0	0	0	0	0	0	0	0	0	0
40	50	2	0.5	0	0	0	0	0	0	5	0	0	0
40	50	2	0	0	0	0	0	0	0	2	0	0	0
40	50	2	0.5	0	0	0	0	0	0	2	0	0	0
40	50	2	0.5	0	0	0	0	0	0	0.5	0	0	0
40	50	2	0	0	0	0	0	0	0	2	0	0	0
40	120	2	0	4	0	0	0	0	0	0	0	0	0
40	120	2	0	6	0	0	0	0	0	1	0	0	0
40	120	2	0	2	0	0	0	0	0	0.5	0	0	0
40	120	2	0	1	0	0	0	0	0	0.5	0	0	0
40	120	2	0	4	0	0	0	0	0	0	0	0	0
40	120	2	0	5	0	0	0	0	0	0.5	0	0	0
40	200	2	0	7	0	0	0	0	0	2	0	0	0
40	200	2	0	9	0	0	0	0	0	0.5	0	0	0
40	200	2	0	6	0	0	0	0	0	0.5	0	0	0
40	200	2	0	45	0	0	0	0	0	0.5	0	0	0
67	100	3	0	0	0	0	0	0	0	0	0	0	0
67	130	3	0	0	0	0	0	0	0	0	0	0	0
67	130	3	0	0	0	0	0	0	0	0	0	0	0
67	130	3	0	0	0	0	0	0	0	0	0	0	0
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67	130	3	0	0	0	0	0	0	0	0	0	0	0
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68	50	3	0	0	0	0	0	0	0	0	0	0	0
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68	150	3	0.5	0	0	0	0	0	0	0	0	0	0
68	150	3	1	0	0	0	0	0	0	0	0	0	0
68	150	3	0	0	0	0	0	0	0	0	0	0	0
68	150	3	0.5	0	0	0	0	0	0	0	0	0	0
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68	200	3	0	0	0	0	0	0	0	0	0	0	0
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68	200	3	0	0	0	0	0	0	0	0	0	0	0
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69	50	4	0	0	0	0	0	0	0	0	0	0	0
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69	400	4	0	0	0	0	0	0	0	0	0	0	0
69	400	4	0	0.5	0	0	0	0	0	0	0	0	0
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70	50	4	0	0	0	0	0	0	0	0	0	0	0
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70	200	4	0	1	0	0	0	0	0	0	0	0	0
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70	250	4	0	0	0	0	0	0	0	0	0	0	0
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70	300	4	0	0	0	0	0	0	0	0	0	0	0
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70	300	4	0	8	0	0	0	0	0	0	0	0	0
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71	70	4	0	18	0	50	0	0	0	1	0	0	0
71	70	4	0	45	0	45	0	0	0	0	0	0	0
71	70	4	0	5	0	61	0	0	0	0	0	0	0
71	70	4	0	36	0	53	0	0	0	0	0	0	0
71	70	4	0	9	0	74	0	0	0	0	0	0	0
71	70	4	0	43	0	32	0	0	0	0	0	0	0
71	120	4	0	86	0	37	0	0	0	1	0	0	0
71	120	4	0	84	0	29	0	0	0	3	0	0	0
71	120	4	0	95	0	48	0	0	0	2	0	0	0
71	120	4	0	39	0	57	0	0	0	4	0	0	0
71	120	4	0	53	0	54	0	0	0	6	0	0	0
71	120	4	0	28	0	63	0	0	0	3	0	0	0
71	190	4	1	5	0	0	0	0	0	0	0	0	0
71	190	4	2	2	0	0	0	0	0	0	0	0	0
71	190	4	0	1	0	0	0	0	0	0	0	0	0
71	190	4	3	4	0	0	0	0	0	0	0	0	0
71	190	4	1	7	0	0	0	0	0	0	0	0	0
71	190	4	1	1	0	0	0	0	0	0	0	0	0
72	30	4	0	82	0	0	0	0	0	0	0	0	0
72	30	4	0	87	0	0	0	0	0	0	0	0	0
72	30	4	0	94	0	0	0	0	0	0	0	0	0
72	30	4	0	76	0	0	0	0	0	0	0	0	0
72	30	4	0	81	0	0	0	0	0	0	0	0	0
72	30	4	0	95	0	0	0	0	0	0	0	0	0
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72	70	4	0	0	0	0	0	0	0	0	0	0	0
72	20	4	0	0	0	0	0	0	0	0	0	0	0
72	100	4	0	9	0	61	0	0	0	0	0	0	0
72	100	4	0	6	0	68	0	0	0	0	0	0	0
72	100	4	0	0	0	54	0	0	0	0	0	0	0
72	100	4	0	3	0	74	0	0	0	0	0	0	0
72	100	4	0	4	0	76	0	0	0	0	0	0	0
72	100	4	0	8	0	67	0	0	0	0	0	0	0

Appendix 1 Raw data for the % cover of all algal species in 0.25 m sq quadrats recorded along transects throughout Tauranga Harbour over the summer period in 1990/91 as part of the Tauranga Harbour Regional Plan Project. Codes for algal species are at the end of the appendix.

Trans. #	Dist. (m)	Area	ALGAL SPECIES 1	2	3	4	5	6	7	8	9	10	11
11	50	1	0	0	0	68	0	0	0	0	0	0	0
11	50	1	0	2	0	70	0	0	0	0	0	0	0
11	50	1	0	5	0	80	0	0	0	0	0	0	0
11	50	1	0	2	0	58	0	0	0.5	0	0	0	0
11	100	1	0	11	0	51	0	5	0	0	6	0	0
11	100	1	0	14	0	60	0	0	0	0	4	0	0
11	100	1	0	0	0	66	0	0	0	0	0	0	0
11	100	1	0	5	0	55	0	0	0	0	0	0	0
11	100	1	0	17	0	50	0	0	2	0	0	0	0
11	100	1	0	6	0	54	0	0	0	0	0	0	0
11	150	1	4	21	0	0	0	0	0	0	0	0	0
11	150	1	3	18	0	0	0	8	0.5	0	0	0	0
11	150	1	7	3	0	0	0	0	0	2	3	0	0
11	150	1	4	5	0	0	0	3	0	0	0	0	0
11	150	1	0	8	0	0	0	0	0.5	2	0	0	0
11	150	1	2	26	0	0	0	3	0	0	0	0	0
11	250	1	0	3	0	79	0	0	2	0	0	0	0
11	250	1	0	0.5	0	75	0	0	0	0	0	0	0
11	250	1	0	0	0	82	0	0	0	0	0	0	0
11	250	1	0	3	0	76	0	0.5	0	0	0	0	0
11	250	1	0	0	0	70	0	0	0	0	0	0	0
11	250	1	0	3	0	83	0	0	0	0	0	0	0
11	300	1	0	0	0	84	0	0	0	0	0	0	0
11	300	1	0	2	0	57	0	2	0	0	0	0	0
11	300	1	0	0	0	81	0	0	0	0	0	0	0
11	300	1	0	0	0	64	0	0	0	0	0	0	0
11	300	1	0	29	0	68	0	0	0	0	0	0	0
11	300	1	0	5	0	76	0	0	0	0	0	0	0
12	100	1	0	0	0	0	0	0	0	0	0	0	0
12	100	1	0	0	0	0	0	0	0	0	0	0	0
12	100	1	0	0	0	0	0	0	0	0	0	0	0
12	100	1	0	0	0	0	0	0	0	0	0	0	0
12	100	1	0	0	0	0	0	0	0	0	0	0	0
12	100	1	0	0	0	0	0	0	0	0	0	0	0
12	200	1	0	0	0	0	0	0	0	0	0	0	0
12	200	1	0	0	0	0	0	0	0	0	0	0	0
12	200	1	0	0	0	0	0	0	0	0	0	0	0
12	200	1	0	0	0	0	0	0	0	0	0	0	0
12	200	1	0	0	0	0	0	0	0	0	0	0	0
12	200	1	0	0	0	0	0	0	0	0	0	0	0
13	20	1	0	0	0	0	0	0	0	0	0	0	0
13	20	1	0	18	0	0	0	0.5	0	0	0	0	0
13	20	1	0	0	0	0	0	0	0	0	0	0	0
13	20	1	0	0	0	0	0	0	0	0	0	0	0
13	20	1	0	3	0	0	0	2	0	0	0	0	0
13	20	1	0	10	0	0	0	0	0	0	0	0	0
13	40	1	0	0	0	0	0	0	0	0	0	0	0
13	40	1	0	0.5	0	0	0	0	0	0	0	0	0
13	40	1	0	5	0	0	0	3	0	0	0	0	0
13	40	1	0	0	0	0	0	0	0	0	0	0	0
13	40	1	0	0	0	0	0	0	0	0	0	0	0
13	40	1	0	2	0	0	0	2	0	0	0	0	0
14	400	1	0	0	0	0	0	0	0	0	0	0	0
14	400	1	0.5	0	0	0	0	0	0	0	0	0	0
14	400	1	0.5	0	0	0	0	0	0	0	0	0	0
14	400	1	0	0	0	0	0	0	0	0	0	0	0
14	400	1	0	0	0	0	0	0	0	0	0	0	0
14	400	1	0	0	0	0	0	0	0	0	0	0	0
14	545	1	0	0	0	20	0	0	0	0	0	0	0
14	545	1	0	0	0	10	0	0	0	0	0	0	0
14	545	1	0	0	0	20	0	0	0	0	0	0	0
14	545	1	0	0	0	25	0	0	0	0	0	0	0
14	545	1	0	0	0	20	0	0	0	0	0	0	0
14	545	1	0	0	0	10	0	0	0	0	0	0	0
14	700	1	0	1	0	60	0	0	0	0	0	0	0
14	700	1	0	0	0	40	0	0	0	0	0	0	0
14	700	1	0	0	0	40	0	0	0	0	0	0	0
14	700	1	0	0.5	0	60	0	0	0	0	0	0	0
14	700	1	0	0.5	0	45	0	0	0	0	0	0	0
14	700	1	0	0	0	70	0	0	0	0	0	0	0
14	800	1	0	0.5	0	90	0	0	0	0	0	0	0
14	800	1	0	0.5	0	80	0	0	0	0	0	0	0
14	800	1	0	1	0	80	0	0	0	0	0	0	0
14	800	1	0	0.5	0	85	0	0	0	0	0	0	0
14	800	1	0	0	0	90	0	0	0	0	0	0	0
14	800	1	0	2	0	90	0	0	0	0	0	0	0
14	806	1	0	0	0	0	0	0	0	0	0	0	0
14	806	1	0	0	0	0	0	0	0	0	0	0	0
14	806	1	0	0	0	0	0	0	0	0	0	0	0
14	806	1	0	0	0	0	0	0	0	0	0	0	0
14	806	1	0	0	0	0	0	0	0	0	0	0	0
14	806	1	0	0	0	0	0	0	0	0	0	0	0
15	50	1	0	0	0	0	0	0	0	0	0	0	0
15	50	1	5	0	0	0	0	0	0	0	0	0	0
15	50	1	0	0	0	0	0	0	0	0	0	0	0
15	50	1	0.5	0	0	0	0	0	0	0	0	0	0
15	50	1	0	0	0	0	0	0	0	0	0	0	0
15	50	1	0.5	0	0	0	0	0	0	0	0	0	0
15	100	1	0	0	0	0	0	0	0	0	0	0	0
15	100	1	0	0	0	0	0	0	0	0	0	0	0
15	100	1	0.5	0	0	0	0	0	0	0	0	0	0
15	100	1	0	0	0	0	0	0	0	0	0	0	0
15	100	1	0	0	0	0	0	0	0	0	0	0	0
15	100	1	0.5	0	0	0	0	0	0	0	0	0	0
15	150	1	0	0	0	0	0	0	0	0	0	0	0
15	150	1	0	0	0	0	0	0	0	0	0	0	0
15	150	1	0	0	0	0	0	0	0	0	0	0	0
15	150	1	0	0	0	0	0	0	0	0	0	0	0
15	150	1	2	0	0	0	0	0	0	0	0	0	0
15	150	1	0	0	0	0	0	0	0	0	0	0	0
15	250	1	0	0	0	0	0	0	0	0	0	0	0
15	250	1	0	0	0	0	0	0	0	0	0	0	0
15	250	1	0.5	0	0	0	0	0	0	0	0	0	0
15	250	1	0	0	0	0	0	0	0	0	0	0	0
15	250	1	0.5	0	0	0	0	0	0	0	0	0	0
15	250	1	0	0	0	0	0	0	0	0	0	0	0
16	100	1	0	0	0	0	0	0	0	0	0	0	0
16	100	1	0	0	0	0	0	0	0	0	0	0	0
16	100	1	0	0	0	0	0	0	0	0	0	0	0
16	100	1	0	0	0	0	0	0	0	0	0	0	0
16	100	1	0	0	0	0	0	0	0	0	0	0	0
16	100	1	0	0	0	0	0	0	0	0	0	0	0
16	150	1	0	0	0	0	0	0	0	0	0	0	0
16	150	1	0	0	0	0	0	0	0	0	0	0	0
16	150	1	0	0	0	0	0	0	0	0	0	0	0
40	200	2	0	39	0	0	0	0	0	3	0	0	0
40	200	2	0	19	0	0	0	0	0	2	0	0	0
41	30	2	0	0	0	0	0	0	0	0	0	0	0
41	30	2	0	0	0	0	0	0	0	0	0	0	0
41	30	2	0	0	0	0	0	0	0	0	0	0	0
41	30	2	0	0	0	0	0	0	0	0	0	0	0
41	30	2	0	0	0	0	0	0	0	0	0	0	0
41	30	2	0	0	0	0	0	0	0	0	0	0	0
41	100	2	0	0	0	0	0	0	0	0	0	0	0
41	100	2	0	0	0	0	0	0	0	0	0	0	0
41	100	2	0	0	0	0	0	0	0	0	0	0	0
41	100	2	0	0	0	0	0	0	0	0	0	0	0
41	100	2	0	0	0	0	0	0	0	0	0	0	0
41	100	2	0	0	0	0	0	0	0	0	0	0	0
41	180	2	0	0	0	0	0	0	0	0	0	0	0
41	180	2	0.5	0	0	0	0	0	0	0.5	0	0	0
41	180	2	0	0	0	0	0	0	0	0	0	0	0
41	180	2	1	0	0	0	0	0	0	0.5	0	0	0
41	180	2	2	0	0	0	0	0	0	0	0	0	0
41	180	2	0	0	0	0	0	0	0	0.5	0	0	0
42	100	2	0	0	0	0	0	0	0	0	0	0	0
42	100	2	0	0	4	0	0	0	0	0	0	0	0
42	100	2	0	0	0	0	0	0	0	0	0	0	0
42	100	2	0	0	0	0	0	0	0	0	0	0	0
42	100	2	0	0	0	0	0	0	0	0	0	0	0
42	100	2	0	0	0	0	0	0	0	0	0	0	0
42	150	2	0	0	0	0	0	0	0	0	0	0	0
42	150	2	2	0	0	0	0	0	0	0.5	0	0	0
42	150	2	0	0	0	0	0	0	0	0	0	0	0
42	150	2	0.5	0	0	0	0	0	0	0	0	0	0
42	150	2	0.5	0	0	0	0	0	0	0	0	0	0
42	150	2	0	0	0	0	0	0	0	0.5	0	0	0
42	200	2	0	0	0	0	0	0	0	32	0	0	0
42	200	2	0	0	0	0	0	0	0	12	0	0	0
42	200	2	0	4	0	0	0	0	0	8	0	0	0
42	200	2	0	0	0	0	0	0	0	36	0	0	0
42	200	2	0	0	0	0	0	0	0	21	0	0	0
42	200	2	0	0	0	0	0	0	0	26	0	0	0
43	50	2	0	0	0	0	0	0	0	0	0	0	0
43	50	2	0	0	0	0	0	0	0	0	0	0	0
43	50	2	0	0	0	0	0	0	0	0	0	0	0
43	50	2	0	0	0	0	0	0	0	0	0	0	0
43	50	2	0	0	0	0	0	0	0	0	0	0	0
43	50	2	0	0	0	0	0	0	0	0	0	0	0
43	100	2	0	0	0	0	0	0	0	0	0	0	0
43	100	2	0	0	0	0	0	0	0	0	0	0	0
43	100	2	0	0	0	0	0	0	0	0	0	0	0
43	100	2	0	0	0	0	0	0	0	0	0	0	0
43	100	2	0	0	0	0	0	0	0	0	0	0	0
43	100	2	0	0	0	0	0	0	0	0	0	0	0
44	30	2	0	0	0	0	0	0	0	0	0	0	0
44	30	2	0	0	0	0	0	0	0	0	0	0	0
44	30	2	0	0	0	0	0	0	0	0	0	0	0
44	30	2	0	0	0	0	0	0	0	0	0	0	0
44	30	2	0	0	0	0	0	0	0	0	0	0	0
44	30	2	0	0	0	0	0	0	0	0	0	0	0
44	60	2	0	0	0	0	0	0	0	0	0	0	0
44	60	2	0	0	0	0	0	0	0	0	0	0	0
44	60	2	0	0	0	0	0	0	0	0	0	0	0
44	60	2	0	0	0	0	0	0	0	0	0	0	0
44	60	2	0	0	0	0	0	0	0	0	0	0	0
44	60	2	0	0	0	0	0	0	0	0	0	0	0
45	0	2	0	0	0	96	0	0	0	0	0	0	0
45	0	2	0	0	0	100	0	0	0	0	0	0	0
45	0	2	0	0	0	0	0	0	0	0	0	0	0
45	0	2	0	0	0	0	0	0	0	0	0	0	0
45	0	2	0	0	0	0	0	0	0	0	0	0	0
45	0	2	0	0	0	0	0	0	0	0	0	0	0
46	50	2	0	0	0	79	0	0	0	0	0	0	0
46	50	2	0	0	0	0	0	0	0	0	0	0	0
46	50	2	0	0	0	40	0	0	0	0	0	0	0
46	50	2	0	0	0	0	0	0	0	0	0	0	0
46	50	2	0	0	0	32	0	0	0	0	0	0	0
46	50	2	0	0	0	0	0	0	0	0	0	0	0
46	100	2	0	0	0	0	0	0	0	0	0	0	0
46	100	2	0	0	0	0	0	0	0	0	0	0	0
46	100	2	0	0	0	0	0	0	0	0	0	0	0
46	100	2	0	0	0	0	0	0	0	0	0	0	0
46	100	2	0	0	0	0	0	0	0	0	0	0	0
46	100	2	0	0	0	0	0	0	0	0	0	0	0
46	150	2	0	0	0	0	0	0	0	0	0	0	0
46	150	2	0	0	0	0	0	0	0	0	0	0	0
46	150	2	0	0	0	0	0	0	0	0	0	0	0
46	150	2	0	0	0	0	0	0	0	0	0	0	0
46	150	2	0	0	0	0	0	0	0	0	0	0	0
46	150	2	0	0	0	0	0	0	0	0	0	0	0
47	50	2	0	0	0	0	0	0	0	0	0	0	0
47	50	2	0	0	0	0	0	0	0	0	0	0	0
47	50	2	0.5	0	0	0	0	0	0	0	0	0	0
47	50	2	0	0	0	0	0	0	0	0	0	0	0
47	50	2	0	0	0	0	0	0	0	0	0	0	0
47	50	2	0.5	0	0	0	0	0	0	0	0	0	0
47	100	2	0	0	0	16	0	0	0	0	0	0	0
47	100	2	0	0	0	29	0	2	0	0	0	0	0
47	100	2	0	0	0	46	0	0	0	0	0	0	0
47	100	2	0	0.5	0	70	0	0	0	0	0	0	0
47	100	2	0	0	0	12	0	3	0	0	0	0	0
47	100	2	0	0	0	24	0	0	0	0	0	0	0
47	150	2	0	0	0	0	0	0	0	0	0	0	0
47	150	2	0	0	0	34	0	0	0	0	0	0	0
47	150	2	0	0	0	0	0	0	0	2	0	0	0
47	150	2	0	0	0	12	0	0	0	0	0	0	0
47	150	2	0	0	0	49	0	0	0	0.5	0	0	0
47	150	2	0	0	0	0	0	0	0	0	0	0	0
48	50	2	0	2	0	96	0	0	0	0	0	0	0
48	50	2	0	0	0	100	0	0	0	0	0	0	0
48	50	2	0	0	0	89	0	0	0	0	0	0	0
48	50	2	0	0	0	99	0	0	0	0	0	0	0
48	50	2	0	0	0	97	0	0	0	0	0	0	0
48	50	2	0	0	0	100	0	0	0	0	0	0	0
48	100	2	0	0	0	91	0	0	0	0	0	0	0
48	100	2	0	0.5	0	86	0	0	0	0	0	0	0
48	100	2	0	0	0	96	0.5	0	0	0	0	0	0
48	100	2	0	0.5	0	97	0	0	0	0	0	0	0
48	100	2	0	0	0	83	4	0	0	2	0	0	0
72	150	4	0	3	0	48	1	0	0	0	0	0	0
72	150	4	0	2	0	56	0.5	0	0	0	0	0	0
72	150	4	0	15	0	54	0	0	0	0	0	0	0
72	150	4	0	23	0	60	0	0	0	0	0	0	0
72	150	4	0	7	0	56	0	0	0	0	0	0	0
72	150	4	0	6	0	64	0	0	0	0	0	0	0
72	200	4	0	0.5	0	0	0	0	0	0	0	0	0
72	200	4	0	0	0	0	0	0	0	0	0	0	0
72	200	4	0	1	0	0	0	0	0	0	0	0	0
72	200	4	0	0	0	0	0	0	0	0	0	0	0
72	200	4	0	2	0	0	0	0	0	0	0	0	0
72	200	4	0	0	0	0	0	0	0	0	0	0	0
73	30	4	0	57	0	0	0	0	0	0	0	0	0
73	30	4	0	69	0	0	0	0	0	0	0	0	0
73	50	4	0	75	0	0	0	0	0	0	0	0	0
73	30	4	0	100	0	0	0	0	0	0	0	0	0
73	30	4	0	63	0	0	0	0	0	0	0	0	0
73	30	4	0	96	0	0	0	0	0	0	0	0	0
73	100	4	0	5	0	56	0	0	0	0	0	0	0
73	100	4	0	0	0	60	0	0	0	0	0	0	0
73	100	4	0	25	0	71	0	0	0	0	0	0	0
73	100	4	0	6	0	29	0	0	0	0	0	0	0
73	100	4	0	9	0	52	0	0	0	0	0	0	0
73	100	4	0	4	0	69	0	0	0	0	0	0	0
73	150	4	0	100	0	0	0	0	0	0	0	0	0
73	150	4	0	100	0	0	0	0	0	0	0	0	0
73	150	4	0	100	0	0	0	0	0	0	0	0	0
73	150	4	0	100	0	0	0	0	0	0	0	0	0
73	150	4	0	100	0	0	0	0	0	0	0	0	0
73	150	4	0	100	0	0	0	0	0	0	0	0	0
73	200	4	0	0	0	0	0	0	0	0	0	0	0
73	200	4	0	21	0	0	0	0	0	0	0	0	0
73	200	4	0	0	0	0	0	0	0	0	0	0	0
73	200	4	0	100	0	0	0	0	0	0	0	0	0
73	200	4	0	100	0	0	0	0	0	0	0	0	0
73	200	4	0	0	0	0	0	0	0	0	0	0	0
74	10	4	0	60	0	0	0	0	0	0	0	0	0
74	10	4	0	53	0	0	0	0	0	0	0	0	0
74	10	4	0	26	0	0	0	0	0	0	0	0	0
74	10	4	0	84	0	0	0	0	0	0	0	0	0
74	10	4	0	39	0	0	0	0	0	0	0	0	0
74	10	4	0	86	0	0	0	0	0	0	0	0	0
74	30	4	0	12	0	62	0	0	0	0	0	0	0
74	30	4	0	32	0	75	0	0	0	0	0	0	0
74	30	4	0	6	0	66	0	0	0	0.5	0	0	0
74	30	4	0	4	0	51	0	0	0	0	0	0	0
74	30	4	0	24	0	49	0	0	0	2	0	0	0
74	30	4	0	2	0	64	0	0	0	0	0	0	0
74	80	4	0	0	0	0	0	0	0	0	0	0	0
74	80	4	0	7	0	0	0	0	0	0	0	0	0
74	80	4	0	0	0	0	0	0	0	0	0	0	0
74	80	4	0	3	0	0	0	0	0	0	0	0	0
74	80	4	0	0	0	0	0	0	0	0	0	0	0
74	80	4	0	0	0	0	0	0	0	0	0	0	0
75	70	4	0	0	0	0	0	0	0	0	0	0	0
75	70	4	0	0	0	0	0	0	0	0	0	0	0
75	70	4	0	0	0	0	0	0	0	0	0	0	0
75	70	4	0	0	0	0	0	0	0	0	0	0	0
75	70	4	0	0	0	0	0	0	0	0	0	0	0
75	70	4	0	0	0	0	0	0	0	0	0	0	0
75	173	4	0	70	0	0	0	0	0	0	0	0	0
75	123	4	0	11	0	0	0	0	0	0	0	0	0
75	123	4	0	19	0	0	0	0	0	0	0	0	0
75	123	4	0	5	0	0	0	0	0	0	0	0	0
75	123	4	0	30	0	0	0	0	0	0	0	0	0
75	173	4	0	0	0	0	0	0	0	0	0	0	0
75	150	4	0	0	0	0	0	0	0	0	0	0	0
75	150	4	0	0	0	0	0	0	0	0	0	0	0
75	150	4	0	0	0	0	0	0	0	0	0	0	0
75	150	4	0	0	0	0	0	0	0	0	0	0	0
75	150	4	0	0	0	0	0	0	0	0	0	0	0
75	150	4	0	0	0	0	0	0	0	0	0	0	0
76	20	4	0	0	0	0	0	0	0	0	0	0	0
76	20	4	0	0	0	0	0	0	0	0	0	0	0
76	20	4	0	0	0	0	0	0	0	0	0	0	0
76	20	4	0	0	0	0	0	0	0	0	0	0	0
76	20	4	0	0	0	0	0	0	0	0	0	0	0
76	20	4	0	0	0	0	0	0	0	0	0	0	0
76	50	4	0	0	0	0	0	0	0	0	0	0	0
76	50	4	0	0	0	0	0	0	0	0	0	0	0
76	50	4	0	0	0	0	0	0	0	0	0	0	0
76	50	4	0	0	0	0	0	0	0	0	0	0	0
76	50	4	0	0	0	0	0	0	0	0	0	0	0
76	50	4	0	0	0	0	0	0	0	0	0	0	0
76	100	4	0	0	0	0	0	0	0	0	0	0	0
76	100	4	0	0.5	0	0	0	0	0	0	0	0	0
76	100	4	0	0	0	0	0	0	0	0	0	0	0
76	100	4	0	0	0	0	0	0	0	0	0	0	0
76	100	4	0	0	0	0	0	0	0	0	0	0	0
76	100	4	0	0	0	0	0	0	0	0	0	0	0
77	100	4	0	0	0	0	0	0	0	0	0	0	0
77	100	4	0	0	0	0	0	0	0	0	0	0	0
77	100	4	0	0	0	0	0	0	0	0	0	0	0
77	100	4	0	0	0	0	0	0	0	0	0	0	0
77	100	4	0	0	0	0	0	0	0	0	0	0	0
77	100	4	0	0	0	0	0	0	0	0	0	0	0
77	200	4	0	0	0	0	0	0	0	0	0	0	0
77	200	4	0	0	0	0	0	0	0	0	0	0	0
77	200	4	0	0	0	0	0	0	0	0	0	0	0
77	200	4	0	0	0	0	0	0	0	0	0	0	0
77	200	4	0	0	0	0	0	0	0	0	0	0	0
77	200	4	0	0	0	0	0	0	0	0	0	0	0
77	250	4	0	69	0	0	0	0	0	0	0	0	0
77	250	4	0	21	0	0	0	0	0	0	0	0	0
77	250	4	0	63	0	0	0	0	0	0	0	0	0
77	250	4	0	90	0	0	0	0	0	0	0	0	0
77	250	4	0	20	0	0	0	0	0	0	0	0	0
77	250	4	0	70	0	0	0	0	0	0	0	0	0
77	300	4	0	0	0	0	0	0	0	0	0	0	0
77	300	4	0	0	0	0	0	0	0	0	0	0	0
77	300	4	0	0	0	0	0	0	0	0	0	0	0
77	300	4	0	0	0	0	0	0	0	0	0	0	0
77	300	4	0	0	0	0	0	0	0	0	0	0	0
77	300	4	0	0	0	0	0	0	0	0	0	0	0
78	70	4	0	0	0	59	0	0	0	0	0	0	0

Appendix 1 Raw data for the % cover of all algal species in 0.25 m sq quadrats recorded along transects throughout Tauranga Harbour over the summer period in 1990/91 as part of the Tauranga Harbour Regional Plan Project. Codes for algal species are at the end of the appendix.

Trans. #	Dist. (m)	Area	ALGAL SPECIES 1	2	3	4	5	6	7	8	9	10	11
16	150	1	0	0	0	0	0	0	0	0	0	0	0
16	150	1	0	0	0	0	0	0	0	0	0	0	0
16	150	1	0	0	0	0	0	0	0	0	0	0	0
16	200	1	0.5	0	0	0	0	0	0	0.5	0	0	0
16	200	1	0	0	0	0	0	0	0	0.5	0	0	0
16	200	1	0.5	0	0	0	0	0	0	0	0	0	0
16	200	1	0.5	0	0	0	0	0	0	0	0	0	0
16	200	1	0.5	0	0	0	0	0	0	0	0	0	0
16	200	1	0	0	0	0	0	0	0	0	0	0	0
16	250	1	1	0	0	0	0	0	0	0	0	0	0
16	250	1	0.5	0	0	0	0	0	0	0	0	0	0
16	250	1	1	0	0	0	0	0	0	0	0	0	0
16	250	1	0.5	0	0	0	0	0	0	0	0	0	0
16	250	1	0.5	0	0	0	0	0	0	0.5	0	0	0
16	250	1	0.5	0	0	0	0	0	0	0	0	0	0
16	350	1	0	0	0	12	0	0	0	0	0	0	0
16	350	1	0	0	0	15	0	0	0	0	0	0	0
16	350	1	0	0	0	0	0	0	0	0	0	0	0
16	350	1	0	2	0	34	0	0	0	0	0	0	0
16	350	1	0	0	0	92	0	0	0	2	0	0	0
16	350	1	0	0.5	0	49	0	0	0	0	0	0	0
17	320	1	0	0	0	95	0	0	0	0	0	0	0
17	320	1	0	0	0	95	0	0	0	0	0	0	0
17	320	1	0	5	0	90	0	0	0	0	0	0	0
17	320	1	0	0	0	90	0	0	0	0	0	0	0
17	320	1	0	0	0	80	0	0	0	0	0	0	0
17	320	1	0	0	0	90	0	0	0	0	0	0	0
17	370	1	0	0	0	90	0	0	0	0	0	0	0
17	370	1	0	0	0	93	0	0	0	0	0	0	0
17	370	1	0	0	0	85	0	0	0	0	0	0	0
17	370	1	0	0	0	88	0	0	0	0	0	0	0
17	370	1	0	0	0	91	0	0	0	0	0	0	0
17	370	1	0	0	0	81	0	0	0	0	0	0	0
17	500	1	0	0.5	0	0	0	0	0	0	0	0	0
17	500	1	0	0	0	0	0	0	0	0	0	0	0
17	500	1	0	0	0	0	0	0	0	0	0	0	0
17	500	1	0	0.5	0	0	0	0	0	0	0	0	0
17	500	1	0	0	0	0	0	0	0	0	0	0	0
17	500	1	0	0	0	0	0	0	0	0	0	0	0
17	620	1	0	10	0	0	0	0	0	0	0	0	0
17	620	1	0	0	0	0	0	0	0	0	0	0	0
17	620	1	0.5	2	0	0	0	0	0	0	0	0	0
17	620	1	0	0	0	0	0	0	0	0	0	0	0
17	620	1	0	0	0	0	0	0	0	0	0	0	0
17	620	1	0	0	0	0	0	0	0	0	0	0	0
18	300	1	0	0	0	0	0	0	0	0	0	0	0
18	300	1	0	0	0	0	0	0	0	0	0	0	0
18	300	1	0.5	0	0	0	0	0	0	0	0	0	0
18	300	1	0.5	0	0	0	0	0	0	0	0	0	0
18	300	1	0	0	0	0	0	0	0	0	0	0	0
18	300	1	0	0	0	0	0	0	0	0	0	0	0
18	400	1	0	0	0	0	0	0	0	0	0	0	0
18	400	1	0.5	0	0	0	0	0	0	0	0	0	0
18	400	1	0	0	0	0	0	0	0	0	0	0	0
18	400	1	0.5	0	0	0	0	0	0	0	0	0	0
18	400	1	0.5	0	0	0	0	0	0	0	0	0	0
18	400	1	0	0	0	0	0	0	0	0	0	0	0
18	500	1	1	0	0	0	0	0	0	0	0	0	0
18	500	1	1	0	0	0	0	0	0	0	0	0	0
18	500	1	0.5	0	0	0	0	0	0	0	0	0	0
18	500	1	1	0	0	0	0	0	0	0	0	0	0
18	500	1	1	0	0	0	0	0	0	0	0	0	0
18	500	1	2	0	0	0	0	0	0	0	0	0	0
18	600	1	0.5	0	0	0	0	0	0	0	0	0	0
18	600	1	0	0	0	0	0	0	0	0	0	0	0
18	600	1	0.5	0	0	0	0	0	0	0	0	0	0
18	600	1	0.5	0	0	0	0	0	0	0	0	0	0
18	600	1	0	0	0	0	0	0	0	0	0	0	0
18	600	1	0	0	0	0	0	0	0	0	0	0	0
18	640	1	0	0	0	0	0	0	0	0	0	0	0
18	640	1	0	0	0	0	0	0	0	0	0	0	0
18	640	1	0	0	0	0	0	0	0	0	0	0	0
18	640	1	0	0	0	0	0	0	0	0	0	0	0
18	640	1	0	0	0	0	0	0	0	0	0	0	0
18	640	1	0	0	0	0	0	0	0	0	0	0	0
19	20	1	0	0	0	0	0	0	0	0	0	0	0
19	20	1	0	0	0	0	0	0	0	0	0	0	0
19	20	1	0	0	0	0	0	0	0	0	0	0	0
19	20	1	0	0	0	0	0	0	0	0	0	0	0
19	20	1	0	0	0	0	0	0	0	0	0	0	0
19	20	1	0	0	0	0	0	0	0	0	0	0	0
19	50	1	0	0	0	0	0	0	0	0	0	0	0
19	50	1	0.5	0	0	0	0	0	0	0	0	0	0
19	50	1	0	0	0	0	0	0	0	0	0	0	0
19	50	1	0	0	0	0	0	0	0	0	0	0	0
19	50	1	0.5	0	0	0	0	0	0	0	0	0	0
19	50	1	0	0	0	0	0	0	0	0	0	0	0
19	100	1	0	0	0	0	0	0	0	0	0	0	0
19	100	1	0	0	0	0	0	0	0	0	0	0	0
19	100	1	0.5	0	0	0	0	0	0	0	0	0	0
19	100	1	0	0	0	0	0	0	0	0	0	0	0
19	100	1	0.5	0	0	0	0	0	0	0	0	0	0
19	100	1	0	0	0	0	0	0	0	0	0	0	0
19	150	1	0	0	0	0	0	0	0	0	0	0	0
19	150	1	0.5	0	0	0	0	0	0	0	0	0	0
19	150	1	0	0	0	0	0	0	0	0	0	0	0
19	150	1	1	0	0	0	0	0	0	0	0	0	0
19	150	1	0	0	0	0	0	0	0	0	0	0	0
19	150	1	0	0	0	0	0	0	0	0	0	0	0
22	0	1	0	0	0	90	0	0	0	0	0	0	0
22	0	1	0	0	0	98	0	0	0	0	0	0	0
22	0	1	0	0	0	5	0	0	0	0	0	0	0
22	0	1	0	0	0	70	0	0	0	0	0	0	0
22	0	1	0	0	0	88	0	0	0	0	0	0	0
22	0	1	0	0	0	98	0	0	0	0	0	0	0
22	-100	1	0	0	0	100	0	0	0	0	0	0	0
22	-100	1	0	0	0	95	0	0	0	0	0	0	0
22	-100	1	0	0	0	100	0	0	0	0	0	0	0
22	-100	1	0	0	0	98	0	0	0	0	0	0	0
22	-100	1	0	0	0	90	0	0	0	0	0	0	0
22	-100	1	0	0.5	0	40	0	0	0	0	0	0	0
22	-200	1	0	0	0	80	0	0	0	0	0	0	0
22	-200	1	0	0	0	60	0	0	0	0	0	0	0
22	-200	1	0	0	0	51	0	0	0	0	0	0	0
22	-200	1	0	0	0	71	0	0	0	0	0	0	0
48	100	2	0	2	0	79	3	0	0	3	0	0	0
48	150	2	0	0	0	82	0	0	0	0	0	0	0
48	150	2	0	0	0	56	0	0	0	0	0	0	0
48	150	2	0	0	0	94	0	0	0	0	0	0	0
48	150	2	0	0	0	100	0	0	0	0	0	0	0
48	150	2	0	0	0	43	0	0	0	0	0	0	0
48	150	2	0	0	0	96	0	0	0	0	0	0	0
48	200	2	0	0	0	81	2	0	0	0	0	0	0
48	200	2	0	0	0	26	0	0	0	0	0	0	0
48	200	2	2	0	0	54	3	0	0	0	0	0	0
48	200	2	0	0	0	90	0	0	0	0	0	0	0
48	200	2	0.5	0	0	29	2	0	0	0	0	0	0
48	200	2	1	0	0	56	0.5	0	0	0	0	0	0
48	300	2	0	0	0	61	0	0	0	0	0	0	0
48	300	2	0	0	0	82	0.5	0	0	0	0	0	0
48	300	2	0	0	0	87	1	0	0	0	0	0	0
48	300	2	0.5	0	0	21	0	0	0	0	0	0	0
48	300	2	0	0	0	39	2	0	0	0	0	0	0
48	300	2	1	0	0	91	0	0	0	0	0	0	0
49	50	2	0	0	0	0	0	0	0	0	0	0	0
49	50	2	0	0	0	0	0	0	0	0	0	0	0
49	50	2	0	0	0	0	0	0	0	0	0	0	0
49	50	2	0	0	0	0	0	0	0	0	0	0	0
49	50	2	0	0	0	0	0	0	0	0	0	0	0
49	50	2	0	0	0	0	0	0	0	0	0	0	0
49	100	2	0	0	0	0	0	0	0	0	0	0	0
49	100	2	0	0	0	0	0	0	0	0	0	0	0
49	100	2	0	0	0	0	0	0	0	0	0	0	0
49	100	2	0	0	0	0	0	0	0	0	0	0	0
49	100	2	0	0	0	0	0	0	0	0	0	0	0
49	100	2	0	0	0	0	0	0	0	0	0	0	0
50	100	2	0.5	0	0	0	0	0	0	0	0	0	0
50	100	2	0	0	0	0	0	0	0	0	0	0	0
50	100	2	2	0	0	0	0	0	0	0	0	0	0
50	100	2	0.5	0	0	0	0	0	0	0	0	0	0
50	100	2	1	0	0	0	0	0	0	0	0	0	0
50	100	2	0.5	0	0	0	0	0	0	0	0	0	0
50	200	2	0	0	0	23	0	0	0	0	0	0	0
50	200	2	0	0	0	12	0	0	0	0	0	0	0
50	200	2	1	0	0	18	0	0	0	0	0	0	0
50	200	2	0.5	0	0	8	0	0	0	0	0	0	0
50	200	2	0.5	0	0	16	0	0	0	0	0	0	0
50	200	2	0.5	0	0	25	0	0	0	0	0	0	0
50	300	2	0	0	0	52	0	0	0	0	0	0	0
50	300	2	0	0	0	16	0	0	0	0	0	0	0
50	300	2	1	0	0	5	0	0	0	0	0	0	0
50	300	2	0	0	0	14	0	0	0	0	0	0	0
50	300	2	0.5	0	0	26	0	0	0	0	0	0	0
50	300	2	0	0	0	37	0	0	0	0	0	0	0
50	400	2	0	0	0	82	0	0	0	0	0	0	0
50	400	2	0	0	0	27	0	0	0	0	0	0	0
50	400	2	0	0	0	16	0	0	0	0	0	0	0
50	400	2	0.5	0	0	56	0	0	0	0	0	0	0
50	400	2	0	0	0	61	0.5	0	0	0	0	0	0
50	400	2	0	0	0	63	0	0	0	0	0	0	0
50	500	2	0	0	0	70	0	0	0	0	0	0	0
50	500	2	0	0	0	41	0	0	0	0	0	0	0
50	500	2	0.5	0	0	16	0	0	0	0	0	0	0
50	500	2	0	0	0	8	0	0	0	0	0	0	0
50	500	2	0.5	0	0	29	0	0	0	0	0	0	0
50	500	2	0.5	0	0	36	0	0	0	0	0	0	0
51	50	2	0	0	0	0	0	0	0	0	0	0	0
51	50	2	0	0	0	0	0	0	0	0	0	0	0
51	50	2	0	0	0	0	0	0	0	0	0	0	0
51	50	2	0	0	0	0	0	0	0	0	0	0	0
51	50	2	0	0	0	0	0	0	0	0	0	0	0
51	50	2	0	0	0	0	0	0	0	0	0	0	0
51	100	2	0	0	0	0	0	0	0	0	0	0	0
51	100	2	0	0	0	0	0	0	0	0	0	0	0
51	100	2	0	0	0	0	0	0	0	0	0	0	0
51	100	2	0	0	0	0	0	0	0	0	0	0	0
51	100	2	0	0	0	0	0	0	0	0	0	0	0
51	100	2	0.5	0	0	0	0	0	0	0	0	0	0
51	150	2	0	0	0	0	0	0	0	0	0	0	0
51	150	2	0.5	0	0	0	0	0	0	0	0	0	0
51	150	2	0.5	0	0	0	0	0	0	0	0	0	0
51	150	2	0	0	0	0	0	0	0	0	0	0	0
51	150	2	1	0	0	0	0	0	0	0	0	0	0
51	150	2	1	0	0	0	0	0	0	0	0	0	0
51	200	2	2	0	0	0	0	0	0	0	0	0	0
51	200	2	2	0	0	0	0	0	0	0	0	0	0
51	200	2	1	0	0	0	0	0	0	0	0	0	0
51	200	2	1	0	0	0	0	0	0	0	0	0	0
51	200	2	1	0	0	0	0	0	0	0	0	0	0
51	200	2	3	0	0	0	0	0	0	0	0	0	0
51	250	2	0	0	0	0	0	0	1	0	0	0	0
51	250	2	0	0	0	0	0	0	0	0	0	0	0
51	250	2	0	0	0	0	0	0	0	0	0	0	0
51	250	2	0	0	0	0	0	0	0	0	0	0	0
51	250	2	0	0	0	0	0	0	1	0	0	0	0
51	250	2	0	0	0	0	0	0	0	0	0	0	0
52	50	2	0	0	0	30	0	0	0	0	0	0	0
52	50	2	0.5	0	0	41	0	0	0	0	0	0	0
52	50	2	0	0	0	5	0	0	0	0	0	0	0
52	50	2	2	0	0	0	0	0	0	0	0	0	0
52	50	2	0	0	0	26	0	0	0	0	0	0	0
52	50	2	1	0	0	34	0	0	0	0	0	0	0
52	100	2	0	0	0	0	0	0	0	0	0	0	0
52	100	2	0.5	0	0	0	0	0	0	0	0	0	0
52	100	2	0	0	0	0	0	0	0	0	0	0	0
52	100	2	2	0	0	0	0	0	0	0	0	0	0
52	100	2	0.5	0	0	0	0	0	0	0	0	0	0
52	100	2	0.5	0	0	0	0	0	0	0	0	0	0
52	150	2	0	0	0	33	0	0	0	0	0	0	0
52	150	2	0	0	0	44	0	0	0	0	0	0	0
52	150	2	0	0	0	29	0	0	0	0	0	0	0
52	150	2	0	0	0	52	0	0	0	0	0	0	0
52	150	2	0	0	0	48	0	0	0	0	0	0	0
52	150	2	0	0	0	43	0	0	0	0	0	0	0
52	200	2	0	0	0	60	0	0	0	0	0	0	0
52	200	2	0	0	0	42	0	0	0	0	0	0	0
52	200	2	0	0	0	19	0	0	0	0	3	0	0
52	200	2	0	0	0	27	0	0	0	0	0	0	0
52	200	2	0	0	0	36	0	0	0	0	0	0	0
52	200	2	0	0	0	51	0	0	0	0	2	0	0
78	70	4	0	0	0	60	0	0	0	0	0	0	0
78	70	4	0	0	0	84	0	0	0	0	0	0	0
78	70	4	0	0	0	100	0	0	0	0	0	0	0
78	70	4	0	0	0	75	0	0	0	0	0	0	0
78	70	4	0	0	0	91	0	0	0	0	0	0	0
78	100	4	0	0	0	80	0	0	0	0	0	0	0
78	100	4	0	0	0	5	0	0	0	0	0	0	0
78	100	4	0	0	0	82	0	0	0	0	0	0	0
78	100	4	0	0	0	28	0	0	0	0	0	0	0
78	100	4	0	0	0	96	0	0	0	0	0	0	0
78	100	4	0	0	0	95	0	0	0	0	0	0	0
78	180	4	0	0	0	0	0	0	0	0	0	0	0
78	180	4	0	0	0	0	0	0	0	0	0	0	0
78	180	4	0	0	0	0	0	0	0	0	0	0	0
78	180	4	0	0	0	0	0	0	0	0	0	0	0
78	180	4	0	0	0	0	0	0	0	0	0	0	0
78	180	4	0	0	0	0	0	0	0	0	0	0	0
79	180	4	0	0	0	95	0	0	1	1	0	0	0
79	180	4	0	0	0	90	0	0	0	0	0	0	0
79	160	4	0	1	0	74	0	0	1	0	0	0	0
79	180	4	0	0	0	81	0	0	0	0	0	0	0
79	160	4	0	0	0	85	0	0	2	2	0	0	0
79	160	4	0	0	0	90	0	0	2	2	0	0	0
79	250	4	0	0	0	78	0	0	0	0	0	0	0
79	250	4	0	0	0	75	0	0	0	0	0	0	0
79	250	4	0	0	0	76	0	0	0	0	0	0	0
79	250	4	0	0	0	61	0	0	0	0	0	0	0
79	250	4	0	0	0	60	0	0	0	0	0	0	0
79	250	4	0	0	0	70	0	0	0	0	0	0	0
79	300	4	0	0	0	0	0	0	0	0	0	0	0
79	300	4	0	0	0	0	0	0	0	0	0	0	0
79	300	4	0	0	0	0	0	0	0	0	0	0	0
79	300	4	0	0	0	0	0	0	0	0	0	0	0
79	300	4	0	0	0	0	0	0	0	0	0	0	0
79	300	4	0	0	0	0	0	0	0	0	0	0	0
79	400	4	0	0	0	70	0	0	0	0	0	0	0
79	400	4	0	0	0	92	0	0	0	0	0	0	0
79	400	4	0	0	0	73	0	0	1	1	0	0	0
79	400	4	0	0	0	87	0	0	0	0	0	0	0
79	400	4	0	0	0	70	0	0	0	0	0	0	0
79	400	4	0	0	0	71	0	0	1	0	0	0	0
79	500	4	0	0	0	72	0	0	0	1	0	0	0
79	500	4	0	0	0	36	0	0	1	1	0	0	0
79	500	4	0	0	0	81	0	0	0	1	0	0	0
79	500	4	0	0	0	40	0	0	0	1	0	0	0
79	500	4	0	0	0	44	0	0	5	0	0	0	0
79	500	4	0	0	0	72	0	0	0	0	0	0	0
80	100	4	0	89	0	0	0	0	0	0	0	0	0
80	100	4	0	100	0	0	0	0	0	1	0	0	0
80	100	4	0	99	0	0	0	0	0	0	0	0	0
80	100	4	0	98	0	0	0	0	0	0	0	0	0
80	100	4	0	61	0	0	0	0	0	0	2	0	0
80	100	4	0	50	0	0	0	0	0	1	0	0	0
80	300	4	0	0	0	0	0	0	0	0	0	0	0
80	300	4	0	0	0	0	0	0	0	0	0	0	0
80	300	4	0	25	0	0	0	0	0	1	0	0	0
80	300	4	0	2	0	0	0	0	0	0	0	0	0
80	300	4	1	0	0	0	0	0	0	0	0	0	0
80	300	4	0	50	0	0	0	0	0	0	0	0	0
80	400	4	0	0	0	89	0	0	0	0	0	0	0
80	400	4	0	0	0	90	0	0	0	0	0	0	0
80	400	4	0	1	0	80	0	0	0	0	0	0	0
80	400	4	0	1	0	62	0	0	0	0	0	0	0
80	400	4	0	0	0	65	0	0	0	0	0	0	0
80	400	4	0	1	0	59	0	0	0	0	0	0	0
80	600	4	0	5	0	69	0	0	0	0	0	0	0
80	600	4	0	10	0	30	0	0	0	0	0	0	0
80	600	4	0	2	0	41	0	0	0	0	0	0	0
80	600	4	0	3	0	5	0	0	0	1	0	0	0
80	600	4	0	2	0	2	0	0	0	0	0	0	0
80	600	4	0	1	0	5	0	0	0	1	0	0	0
80	700	4	0	2	0	71	0	0	0	0	0	0	0
80	700	4	0	2	0	40	0	0	0	0	0	0	0
80	700	4	0	5	0	60	0	0	0	0	0	0	0
80	700	4	0	1	0	50	0	0	0	0	0	0	0
80	700	4	0	2	0	39	0	0	0.5	0.5	0	0	0
80	700	4	0	0	0	70	0	0	0	0	0	0	0
81	10	4	0	5	0	0	0	0	0	0	0	0	0
81	10	4	0	30	0	0	0	0	0	0	0	0	0
81	10	4	0	48	2	0	0	0	0	0	0	0	0
81	10	4	0	32	0	0	0	0	0	0	0	0	0
81	10	4	0	40	0	0	0	0	0	0	0	0	0
81	10	4	0	5	0	0	0	0	0	0	0	0	0
81	50	4	0	6	0	5	0	0	0	0	0	0	0
81	50	4	0	5	0	6	0	0	0	0	0	0	0
81	50	4	0	31	0	20	0	0	0	0	0	0	0
81	50	4	0	100	0	0	0	0	0	0	0	0	0
81	50	4	0	1	0	0	0	0	0	0	0	0	0
81	50	4	0	100	0	0	0	0	0	0	0	0	0
81	150	4	0	0	0	94	0	0	0	0	0	0	0
81	150	4	0	1	0	95	0	0	0	0	0	0	0
81	150	4	0	0	0	90	0	0	0	0	0	0	0
81	150	4	0	0	0	96	0	0	0	0	0	0	0
81	150	4	0	0	0	94	0	0	0	0	0	0	0
81	150	4	0	0	0	95	0	0	0	0	0	0	0
81	250	4	0	0	0	82	0	0	0	0	0	0	0
81	250	4	0	2	0	97	0	0	0	0	0	0	0
81	250	4	0	0	0	98	0	0	0	0	0	0	0
81	250	4	0	7	0	93	0	0	0	0	0	0	0
81	250	4	0	0	0	96	0	0	0	0	0	0	0
81	250	4	0	1	0	74	0	0	0	0	0	0	0
82	0	4	0	5	0	95	0	0	0	0	0	0	0
82	0	4	0	0	0	100	0	0	0	0	0	0	0
82	0	4	0	0	0	94	0	0	0	0	0	0	0
82	0	4	0	5	0	30	0	0	0	0	0	0	0
82	0	4	0	0	0	96	0	0	0	0	0	0	0
82	0	4	0	0	0	95	0	0	0	0	0	0	0
82	-100	4	0	0	0	95	0	0	0	0	0	0	0
82	-100	4	0	3	0	95	0	0	0	0	0	0	0
82	-100	4	0	2	0	100	0	0	0	0	0	0	0
82	-100	4	0	3	0	98	0	0	0	0	0	0	0
82	-100	4	0	0	0	95	0	0	0	0	0	0	0
82	-100	4	0	1	0	94	0	0	0	0	0	0	0
82	-200	4	0	0	0	81	0	0	0	0	0	0	0
82	-200	4	0	0	0	70	0	0	0	0	0	0	0

Appendix 1 Raw data for the % cover of all algal species in 0.25 m sq quadrats recorded along transects throughout Tauranga Harbour over the summer period in 1990/91 as part of the Tauranga Harbour Regional Plan Project. Codes for algal species are at the end of the appendix.

Trans.	Dist.	Area	ALGAL SPECIES										
#	(m)		1	2	3	4	5	6	7	8	9	10	11
22	-200	1	0	0	0	79	0	0	0	0	0	0	0
22	-200	1	0	0	0	90	0	0	0	0	0	0	0
22	-300	1	0	0	0	85	0	0	0	0	0	0	0
22	-300	1	0	0	0	21	0	0	0	0	0	0	0
22	-300	1	0	0	0	68	0	0	0	0	0	0	0
22	-300	1	0	0	0	29	0	0	0	0	0	0	0
22	-300	1	0	0	0	80	0	0	0	0	0	0	0
22	-300	1	0	0	0	85	0	0	0	0	0	0	0
22	-400	1	0	0	0	19	0	0	0	0	0	0	0
22	-400	1	0	0	0	15	0	0	0	0	0	0	0
22	-400	1	0	0	0	10	0	0	0	0	0	0	0
22	-400	1	0	0	0	85	0	0	0	0	0	0	0
22	-400	1	0	0	0	30	0	0	0	0	0	0	0
22	-400	1	0	0	0	39	0	0	0	0	0	0	0
23	-50	1	0	0	0	16	0	0	0	0	0	0	0
23	-50	1	0	0	0	6	0	0	0	0	0	0	0
23	-50	1	0	0	0	21	0	0	0	0	0	0	0
23	-50	1	0	0	0	15	0	0	0	0	0	0	0
23	-50	1	0	0	0	18	0	0	0	0	0	0	0
23	-50	1	0	0	0	11	0	0	0	0	0	0	0
23	-100	1	0	0	0	40	0	0	0	0	0	0	0
23	-100	1	0	0	0	31	0	0	0	0	0	0	0
23	-100	1	0	0	0	22	0	0	0	0	0	0	0
23	-100	1	0	0	0	29	0	0	0	0	0	0	0
23	-100	1	0	0	0	36	0	0	0	0	0	0	0
23	-100	1	0	0	0	19	0	0	0	0	0	0	0
23	-200	1	0	0	0	37	0	0	0	0	0	0	0
23	-200	1	0	0	0	12	0	0	0	0	0	0	0
23	-200	1	0	0	0	26	0	0	0	0	0	0	0
23	-200	1	0	0	0	24	0	0	0	0	0	0	0
23	-200	1	0	0	0	20	0	0	0	0	0	0	0
23	-200	1	0	0	0	41	0	0	0	0	0	0	0
23	-300	1	0	0	0	73	0	0	0	0	0	0	0
23	-300	1	0	0	0	92	0	0	0	0	0	0	0
23	-300	1	0	0	0	69	0	0	0	0	0	0	0
23	-300	1	0	0	0	95	0	0	0	0	0	0	0
23	-300	1	0	0.5	0	99	0	0	0	0	0	0	0
23	-300	1	0	0	0	82	0	0	0	0	0	0	0
23	-350	1	0	0	0	92	0	0	0	0	0	0	0
23	-350	1	0	0	0	82	0	0	0	0	0	0	0
23	-350	1	0	0	0	51	0	0	0	0	0	0	0
23	-350	1	0	0	0	32	0	0	0	0	0	0	0
23	-350	1	0	0	0	45	0	0	0	0	0	0	0
23	-350	1	0	0	0	53	0	0	0	0	0	0	0
24	50	1	0	0	0	10	0	0	0	0	0	0	0
24	50	1	0	0	0	8	0	0	0	0	0	0	0
24	50	1	0	0	0	21	0	0	0	0	0	0	0
24	50	1	0	0	0	6	0	0	0	0	0	0	0
24	50	1	0	0	0	9	0	0	0	0	0	0	0
24	50	1	0	0	0	13	0	0	0	0	0	0	0
24	100	1	0	0	0	2	0	0	0	0	0	0	0
24	100	1	0	0	0	10	0	0	0	0	0	0	0
24	100	1	0	0	0	7	0	0	0	0	0	0	0
24	100	1	0	0	0	14	0	0	0	0	0	0	0
24	100	1	0	0	0	26	0	0	0	0	0	0	0
24	100	1	0	0	0	12	0	0	0	0	0	0	0
24	130	1	0	0	0	42	0	0	0	0	0	0	0
24	130	1	0	0	0	12	0	0	0	0	0	0	0
24	130	1	0	0	0	16	0	0	0	0	0	0	0
24	130	1	0	0	0	3	0	0	0	0	0	0	0
24	130	1	0	0	0	7	0	0	0	0	0	0	0
24	130	1	0	0	0	19	0	0	0	0	0	0	0
24	180	1	0	0	0	52	0	0	0	0	0	0	0
24	180	1	0	0	0	31	0	0	0	0	0	0	0
24	180	1	0	0	0	26	0	0	0	0	0	0	0
24	180	1	0	0	0	9	0	0	0	0	0	0	0
24	180	1	0	0	0	48	0	0	0	0	0	0	0
24	180	1	0	0	0	34	0	0	0	0	0	0	0
24	230	1	0	0	0	5	0	0	0	0	0	0	0
24	230	1	0	0	0	29	0	0	0	0	0	0	0
24	230	1	0	0	0	72	0	0	0	0	0	0	0
24	230	1	0	0	0	63	0	0	0	0	0	0	0
24	230	1	0	0	0	26	0	0	0	0	0	0	0
24	230	1	0	0	0	38	0	0	0	0	0	0	0
25	0	1	0	0	0	80	0	0	0	0	0	0	0
25	0	1	0	0	0	71	0	0	0	0	0	0	0
25	0	1	0	0	0	89	0	0	0	0	0	0	0
25	0	1	0	0	0	65	0	0	0	0	0	0	0
25	0	1	0	0	0	85	0	0	0	0	0	0	0
25	0	1	0	0	0	96	0	0	0	0	0	0	0
25	-70	1	0	0	0	74	0	0	0	0	0	0	0
25	-70	1	0	0	0	80	0	0	0	0	0	0	0
25	-70	1	0	0	0	30	0	0	0	0	0	0	0
25	-70	1	0	0	0	56	0	0	0	0	0	0	0
25	-70	1	0	0	0	84	0	0	0	0	0	0	0
25	-70	1	0	0	0	59	0	0	0	0	0	0	0
25	-270	1	0	0	0	41	0	0	0	0	0	0	0
25	-270	1	0	0	0	25	0	0	0	0	0	0	0
25	-270	1	0	0	0	40	0	0	0	0	0	0	0
25	-270	1	0	0	0	32	0	0	0	0	0	0	0
25	-270	1	0	0	0	15	0	0	0	0	0	0	0
25	-270	1	0	0	0	37	0	0	0	0	0	0	0
25	-360	1	0	0	0	85	0	0	0	0	0	0	0
25	-360	1	0	0	0	90	0	0	0	0	0	0	0
25	-360	1	0	0	0	91	0	0	0	0	0	0	0
25	-360	1	0	0	0	85	0	0	0	0	0	0	0
25	-360	1	0	0	0	94	0	0	0	0	0	0	0
25	-360	1	0	0	0	86	0	0	0	0	0	0	0
25	-450	1	0	0	0	0	0	0	0	0	0	0	0
25	-450	1	0	0	0	0	0	0	0	0	0	0	0
25	-450	1	0	0	0	0	0	0	0	0	0	0	0
25	-450	1	0	0	0	0	0	0	0	0	0	0	0
25	-450	1	0	0	0	0	0	0	0	0	0	0	0
25	-450	1	0	0	0	0	0	0	0	0	0	0	0
26	50	1	0	0	0	9	0	0	0	0	0	0	0
26	50	1	0	0	0	23	0	0	0	0	0	0	0
26	50	1	0	0	0	34	0	0	0	0	0	0	0
26	50	1	0	0	0	6	0	0	0	0	0	0	0
26	50	1	0	0	0	17	0	0	0	0	0	0	0
26	50	1	0	0	0	12	0	0	0	0	0	0	0
26	100	1	0	0	0	5	0	0	0	0	0	0	0
26	100	1	0	0	0	11	0	0	0	0	0	0	0
26	100	1	0	0	0	12	0	0	0	0	0	0	0
26	100	1	0	0	0	7	0	0	0	0	0	0	0
26	100	1	0	0	0	20	0	0	0	0	0	0	0

Trans.	Dist.	Area	ALGAL SPECIES										
#	(m)		1	2	3	4	5	6	7	8	9	10	11
53	50	2	2	0	0	56	0	0	0.5	0	0	0	0
53	50	2	0	0	0	16	0	0	2	0	0	0	0
53	50	2	0	0	0	48	0	0	3	0	0	0	0
53	50	2	0	0	0	15	0	0	2	0	0	0	0
53	50	2	2	0	0	79	0	0	1	0	0	0	0
53	50	2	1	0	0	35	0	0	2	0	0	0	0
53	100	2	0	0	0	63	0	0	0	0	0	0	0
53	100	2	2	0	0	41	0	0	0	0	0	0	0
53	100	2	2	0	0	46	0	0	0	0	0	0	0
53	100	2	0	0	0	37	0.5	0	1	0	0	0	0
53	100	2	1	0	0	38	0	0	0	0	0	0	0
53	100	2	0	0	0	9	0	0	0.5	0	0	0	0
53	200	2	56	0	0	0	0	0	0	0	0	0	0
53	200	2	32	0	0	0	0	0	0	0	0	0	0
53	200	2	28	0	0	0	0	0	0	0	0	0	0
53	200	2	23	0	0	0	0	0	0.5	0	0	0	0
53	200	2	62	0	0	0	0	0	0	0	0	0	0
53	200	2	34	0	0	0	0	0	2	0	0	0	0
53	300	2	0	0	0	84	2	0	5	0	0	0	0
53	300	2	0	0	0	79	0.5	0	1	0	0	0	0
53	300	2	0	0	0	67	0	0	3	0	0	0	0
53	300	2	0	0	0	60	0.5	0	5	0	0	0	0
53	300	2	0	0	0	64	0	0	0	0	0	0	0
53	300	2	0	0	0	75	5	0	6	0	0	0	0
53	350	2	0	100	0	0	0	0	0	0	0	0	0
53	350	2	0	54	0	0	40	0	3	0	0	0	0
53	350	2	0	24	0	0	12	0	0	0	0	0	0
53	350	2	1	5	0	0	8	0	0	0	0	0	0
53	350	2	0	29	0	2	26	0	0.5	0	0	0	0
53	350	2	1	26	0	0	17	0	2	0	0	0	0
54	-50	2	4	0	0	0	0	0	2	0	0	0	0
54	-50	2	3	0	0	0	0	0	0	0	0	0	0
54	-50	2	1	0	0	0	0	0	0.5	0	0	0	0
54	-50	2	0.5	0	0	0	0	0	2	0	0	0	0
54	-50	2	3	0	0	0	0	0	0	0	0	0	0
54	-50	2	1	0	0	0	0	0	0.5	0	0	0	0
54	-110	2	4	54	0	0	0	0	12	0	3	0	0
54	-110	2	8	17	0	0	0	0	0	0	0	0	0
54	-110	2	4	6	0	0	0	0	2	0	0	0	0
54	-110	2	9	14	0	0	0	0	1	0	0	0	0
54	-110	2	11	7	0	0	0	0	0	0	0	0	0
54	-110	2	3	65	0	0	0	0	4	0	0	0	0
54	-200	2	0	0	0	28	0	0	53	0	0	0	0
54	-200	2	0	8	0	6	0	0	69	0	0	0	0
54	-200	2	0	21	0	15	0	0	36	0	0	0	0
54	-200	2	0	0	0	0.5	0	0	17	0	0	0	0
54	-200	2	0	0	0	5	0	0	92	0	0	0	0
54	-200	2	0	7	0	11	0	0	28	0	0	0	0
54	-250	2	0	0	0	0	0	0	100	0	0	0	0
54	-250	2	0	0	0	3	0	0	82	0	0	0	0
54	-250	2	0	0	0	0	0	0	100	0	0	0	0
54	-250	2	0	0	0	14	0	0	44	0	0	0	0
54	-250	2	0	0	0	12	0	0	39	0	0	0	0
54	-250	2	0	0	0	4	0	0	87	0	0	0	0
54	-350	2	0	0	0	26	0	0	5	0	0	0	0
54	-350	2	0	0	0	22	0	0	7	0	0	0	0
54	-350	2	0	0	0	29	0	0	3	0	0	0	0
54	-350	2	0	0	0	21	0	0	4	0	0	0	0
54	-350	2	0	0	0	27	0	0	7	0	0	0	0
54	-350	2	0	0	0	29	0	0	8	0	0	0	0
55	0	2	0	12	0	56	0	0	0	0	0	0	0
55	0	2	0	0	0	41	0	0	0	0	0	0	0
55	0	2	0	3	0	37	0	0	0	0	0	0	0
55	0	2	0	9	0	50	0	0	0	0	0	0	0
55	0	2	0	0	0	47	0	0	0	0	0	0	0
55	0	2	0	6	0	43	0	0	0	0	0	0	0
55	-70	2	0	100	0	0	0	0	0	0	0	0	0
55	-70	2	2	81	0	0	0	0	0	0	0	0	0
55	-70	2	4	46	0	0	0	0	0	0	0	0	0
55	-70	2	0	96	0	0	0	0	0	0	0	0	0
55	-70	2	4	86	0	0	0	0	0	0	0	0	0
55	-70	2	11	32	0	0	0	0	0	0	0	0	0
55	-150	2	0	0	0	22	0	0	0	0	0	0	0
55	-150	2	0	0	0	41	0	0	0	0	0	0	0
55	-150	2	0	0	0	31	0	0	0	0	0	0	0
55	-150	2	0	0	0	28	0	0	0	0	0	0	0
55	-150	2	0	0	0	23	0	0	0	0	0	0	0
55	-150	2	0	0	0	44	0	0	0	0	0	0	0
56	50	2	0	0	0	50	0	0	0	0	0	0	0
56	50	2	0	0	0	45	0	0	0	0	0	0	0
56	50	2	0	0	0	50	0	0	0	0	0	0	0
56	50	2	0	0	0	10	0	0	0	0	0	0	0
56	50	2	0	0	0	90	0	0	0	0	0	0	0
56	50	2	0	0	0	80	0	0	0	0	0	0	0
56	100	2	0	0	0	60	0	0	5	0	0	0	0
56	100	2	0	0	0	42	0	0	1	0	0	0	0
56	100	2	0	0	0	91	0	0	10	0	0	0	0
56	100	2	0	0	0	95	0	0	21	0	0	0	0
56	100	2	0	0	0	86	0	0	2	0	0	0	0
56	100	2	0	0	0	80	0	0	5	0	0	0	0
56	125	2	0	0	0	0	0	0	100	0	0	0	0
56	125	2	0	0	0	0	0	0	100	0	0	0	0
56	125	2	0	0	0	0	0	0	100	0	0	0	0
56	125	2	0	0	0	0	0	0	100	0	0	0	0
56	125	2	0	0	0	0	0	0	100	0	0	0	0
56	125	2	0	0	0	0	0	0	100	0	0	0	0
56	170	2	0	0	0	0	0	0	100	0	0	0	0
56	170	2	0	0	0	0	0	0	100	0	0	0	0
56	170	2	0	0	0	0	0	0	100	0	0	0	0
56	170	2	0	0	0	0	0	0	100	0	0	0	0
56	170	2	0	0	0	0	0	0	100	0	0	0	0
56	170	2	0	0	0	0	0	0	100	0	0	0	0
57	25	2	0	0	0	90	0	0	8	0	0	0	0
57	25	2	0	0	0	91	0	0	10	0	0	0	0
57	25	2	0	0	0	79	0	0	5	0	0	0	0
57	25	2	0	0	0	95	0	0	14	0	0	0	0
57	25	2	0	0	0	100	0	0	22	0	0	0	0
57	25	2	0	0	0	95	0	0	15	0	0	0	0
57	75	2	0	0	0	0	0	0	60	0	0	0	0
57	75	2	0	0	0	0	0	0	100	0	0	0	0
57	75	2	0	0	0	20	0	0	61	0	0	0	0
57	75	2	0	0	0	0	0	0	79	0	0	0	0
57	75	2	0	0	0	0	0	0	100	0	0	0	0
57	75	2	0	0	0	0	0	0	100	0	0	0	0
57	125	2	0	0	0	0	0	0	100	0	0	0	0

Trans.	Dist.	Area	ALGAL SPECIES										
#	(m)		1	2	3	4	5	6	7	8	9	10	11
82	-200	4	0	3	0	80	1	0	0	0	0	0	0
82	-200	4	0	0	0	72	0	0	0	0	0	0	0
82	-200	4	0	0	0	78	1	0	0	0	0	0	0
82	-200	4	0	0	0	63	0	0	0	0	0	0	0
82	-270	4	0	0	0	90	0	0	0	0	0	0	0
82	-270	4	0	0	0	95	0	0	0	0	0	0	0
82	-270	4	0	0	0	94	0	0	0	0	0	0	0
82	-270	4	0	0	0	81	0	0	0	0	0	0	0
82	-270	4	0	0	0	91	0	0	0	0	0	0	0
82	-270	4	0	0	0	90	0	0	0	0	0	0	0
83	10	4	0	0	0	0	0	0	0	0	0	0	0
83	10	4	0	0	0	0	0	0	0	0	0	0	0
83	10	4	0	0	0	0	0	0	0	0	0	0	0
83	10	4	0	0	0	0	0	0	0	0	0	0	0
83	10	4	0	0	0	0	0	0	0	0	0	0	0
83	10	4	0	0	0	0	0	0	0	0	0	0	0
83	30	4	0	0	0	0	0	0	0	0	0	0	0
83	30	4	0	1	0	0	0	0	0	0	0	0	0
83	30	4	0	1	0	0	0	0	0	0	0	0	0
83	50	4	0	1	0	0	0	0	0	0	0	0	0
83	30	4	0	0	0	0	0	0	0	0	0	0	0
83	30	4	0	2	0	0	0	0	0	0	0	0	0
83	50	4	0	0	0	80	0	0	0	0	0	0	0
83	50	4	0	1	0	85	0	0	0	0	0	0	0
83	50	4	0	1	0	83	0	0	0	0	0	0	0
83	50	4	0	0	0	98	0	0	0	0	0	0	0
83	50	4	0	0	0	72	0	0	0	0	0	0	0
83	50	4	0	5	0	96	0	0	0	0	0	0	0
84	20	4	0	0	0	0	0	0	0	0	0	0	0
84	20	4	0	0	0	0	0	0	0	0	0	0	0
84	20	4	0	0	0	0	0	0	0	0	0	0	0
84	20	4	0	0	0	0	0	0	0	0	0	0	0
84	20	4	0	0	0	0	0	0	0	0	0	0	0
84	20	4	0	0	0	0	0	0	0	0	0	0	0
84	40	4	0	1	0	0	0	0	0	0	0	0	0
84	40	4	0	1	0	0	0	0	0	0	0	0	0
84	40	4	0	2	0	0	0	0	0	0	0	0	0
84	40	4	0	1	0	0	0	0	0	0	0	0	0
84	40	4	0	5	0	0	0	0	0	0	0	0	0
84	40	4	0	1	0	0	0	0	0	0	0	0	0
85	25	4	0	1	0	74	0	0	0	0	0	0	0
85	25	4	0	0	0	71	0	0	0	0	0	0	0
85	25	4	0	1	0	66	0	0	0	0	0	0	0
85	25	4	0	0	0	60	0	0	0	0	0	0	0
85	25	4	0	0	0	75	0	0	0	0	0	0	0
85	25	4	0	0	0	77	0	0	0	0	0	0	0
85	80	4	0	0	0	0	0	0	0	0	0	0	0
85	80	4	0	0	0	0	0	0	0	0	0	0	0
85	80	4	0	0	0	0	0	0	0	0	0	0	0
85	80	4	0	0	0	0	0	0	0	0	0	0	0
85	80	4	0	0	0	0	0	0	0	0	0	0	0
85	80	4	0	0	0	0	0	0	0	0	0	0	0
86	100	4	0	0	0	0	0	0	0	0	0	0	0
86	100	4	0	0	0	0	0	0	0	0	0	0	0
86	100	4	0	0	0	0	0	0	0	0	0	0	0
86	100	4	0	0	0	0	0	0	0	0	0	0	0
86	100	4	2	0	0	0	0	0	0	0	0	0	0
86	100	4	3	0	0	0	0	0	0	0	0	0	0
86	200	4	0	0	0	80	0	0	0	0	0	0	0
86	200	4	0	0	0	91	0	0	0	0	0	0	0
86	200	4	0	0	0	65	0	0	0	0	0	0	0
86	200	4	0	1	0	52	0	0	0	0	0	0	0
86	200	4	0	0	0	58	0	0	0	0	0	0	0
86	200	4	0	0	0	70	0	0	0	0	0	0	0
86	300	4	2	0	0	0	0	0	0	0	0	0	0
86	300	4	5	0	0	0	0	0	0	0	0	0	0
86	300	4	8	0	0	0	0	0	0	0	0	0	0
86	300	4	4	0.5	0	0	0	0	0	0	0	0	0
86	300	4	6	0.5	0	0	0	0	0	0	0	0	0
86	500	4	2	3	0	0	0	0	0	0	0	0	0
86	400	4	5	0.5	0	0	0	0	0	0	0	0	0
86	400	4	3	2	0	0	0	0	0	0	0	0	0
86	400	4	3	0	0	0	0	0	0	0	0	0	0
86	400	4	4	0	0	0	0	0	0	0	0	0	0
86	400	4	6	0.5	0	0	0	0	0	0	0	0	0
86	400	4	3	0	0	0	0	0	0	0	0	0	0
86	500	4	2	1	0	0	0	0	0	0	0	0	0
86	500	4	4	0	0	0	0	0	0	0	0	0	0
86	500	4	3	2	0	0	0	0	0	0	0	0	0
86	500	4	3	0.5	0	0	0	0	0	0	0	0	0
86	500	4	2	0.5	0	0	0	0	0	0	0	0	0
86	500	4	5	1	0	0	0	0	0	0	0	0	0
87	100	4	0	0	0	0	0	0	0	0	0	0	0
87	100	4	0	0	0	0	0	0	0	0	0	0	0
87	100	4	0	0	0	0	0	0	0	0	0	0	0
87	100	4	0	0	0	0	0	0	0	0	0	0	0
87	100	4	0	0	0	0	0	0	0	0	0	0	0
87	100	4	0	0	0	0	0	0	0	0	0	0	0
87	200	4	0	0	0	0	0	0	0	0	0	0	0
87	200	4	0	0	0	0	0	0	0	0	0	0	0
87	200	4	0	0	0	0	0	0	0	0	0	0	0
87	200	4	0	0	0	0	0	0	0	0	0	0	0
87	200	4	0	0	0	0	0	0	0	0	0	0	0
87	200	4	0	0	0	0	0	0	0	0	0	0	0
87	300	4	0	0	0	0	0	0	0	0	0	0	0
87	300	4	0	0	0	0	0	0	0	0	0	0	0
87	300	4	0	0	0	0	0	0	0	0	0	0	0
87	300	4	0	0	0	0	0	0	0	0	0	0	0
87	300	4	0	0	0	0	0	0	0	0	0	0	0
87	300	4	0	0	0	0	0	0	0	0	0	0	0
87	500	4	0	0	0	0	0	0	0	0	0	0	0
87	500	4	0	0	0	0	0	0	0	0	0	0	0
87	500	4	0	0	0	0	0	0	0	0	0	0	0
87	500	4	0	0	0	0	0	0	0	0	0	0	0
87	500	4	0	0	0	0	0	0	0	0	0	0	0
87	500	4	0	0	0	0	0	0	0	0	0	0	0
88	100	4	0	0	0	0	0	0	0	0	0	0	0
88	100	4	0	0	0	0	0	0	0	0	0	0	0
88	100	4	0	0	0	0	0	0	0	0	0	0	0
88	100	4	0	0	0	0	0	0	0	0	0	0	0
88	100	4	0	0	0	0	0	0	0	0	0	0	0
88	100	4	0	0	0	0	0	0	0	0	0	0	0
88	200	4	0	0	0	0	0	0	0	0	0	0	0
88	200	4	0	0	0	0	0	0	0	0	0	0	0
88	200	4	0	0	0	0	0	0	0	0	0	0	0

Appendix 1 Raw data for the % cover of all algal species in 0.25 m sq quadrats recorded along transects throughout Tauranga Harbour over the summer period in 1990/91 as part of the Tauranga Harbour Regional Plan Project. Codes for algal species are at the end of the appendix.

Trans. #	Dist. (m)	Area	1	2	3	4	5	6	7	8	9	10	11
26	100	1	0	0	0	18	0	0	0	0	0	0	0
26	150	1	0	0	0	31	0	0	0	0	0	0	0
26	150	1	0	0	0	46	0	0	0	0	0	0	0
26	150	1	0	0	0	44	0	0	0	0	0	0	0
26	150	1	0	0	0	20	0	0	0	0	0	0	0
26	150	1	0	0	0	8	0	0	0	0	0	0	0
26	150	1	0	0	0	17	0	0	0	0	0	0	0
26	200	1	0	0	0	62	0	0	0	0	0	0	0
26	200	1	0	0	0	71	0	0	0	0	0	0	0
26	200	1	0	0	0	17	0	0	0	0	0	0	0
26	200	1	0	0	0	53	0	0	0	0	0	0	0
26	200	1	0	0	0	44	0	0	0	0	0	0	0
26	200	1	0	0	0	59	0	0	0	0	0	0	0
26	250	1	0	0	0	2	0	0	0	0	0	0	0
26	250	1	0	0	0	36	0	0	0	0	0	0	0
26	250	1	0	0	0	18	0	0	0	0	0	0	0
26	250	1	0	0	0	7	0	0	0	0	0	0	0
26	250	1	0	0	0	41	0	0	0	0	0	0	0
26	250	1	0	0	0	36	0	0	0	0	0	0	0
27	100	1	0	0	0	0	0	0	0	0	0	0	0
27	100	1	0	0	0	0	0	0	0	0	0	0	0
27	100	1	0	0	0	0	0	0	0	0	0	0	0
27	100	1	0	0	0	0	0	0	0	0	0	0	0
27	100	1	0	0	0	0	0	0	0	0	0	0	0
27	100	1	0	0	0	0	0	0	0	0	0	0	0
27	200	1	0	0	0	0	0	0	0	0	0	0	0
27	200	1	0	0	0	0	0	0	0	0	0	0	0
27	200	1	0	0	0	0	0	0	0	0	0	0	0
27	200	1	0	0	0	0	0	0	0	0	0	0	0
27	200	1	0	0	0	0	0	0	0	0	0	0	0
27	200	1	0	0	0	0	0	0	0	0	0	0	0
27	300	1	0	0	0	0	0	0	0	0	0	0	0
27	300	1	0	0	0	0	0	0	0	0	0	0	0
27	300	1	0	0	0	0	0	0	0	0	0	0	0
27	300	1	0	0	0	0	0	0	0	0	0	0	0
27	300	1	0	0	0	0	0	0	0	0	0	0	0
27	300	1	0	0	0	0	0	0	0	0	0	0	0
28	50	2	0	0	0	0	0	0	0	0	0	0	0
28	50	2	0	0	0	0	0	0	0	0	0	0	0
28	50	2	0	0	0	0	0	0	0	0	0	0	0
28	50	2	0	0	0	0	0	0	0	0	0	0	0
28	50	2	0	0	0	0	0	0	0	0	0	0	0
28	50	2	0	0	0	0	0	0	0	0	0	0	0
28	100	2	0	0	0	0	0	0	0	0	0	0	0
28	100	2	0	0	0	0	0	0	0	0	0	0	0
28	100	2	0	0	0	27	0	0	0	0	0	0	0
28	100	2	0	0	0	0	0	0	0	0	0	0	0
28	100	2	0	0	0	0	0	0	0	0	0	0	0
28	100	2	0	0	0	0	0	0	0	0	0	0	0
28	150	2	0	0	0	41	0	0	0	0	0	0	0
28	150	2	0	0	0	73	0	0	0	0	0	0	0
28	150	2	0	0	0	82	0	0	0	0	0	0	0
28	150	2	0	0	0	9	0	0	0	0	0	0	0
28	150	2	0	0	0	51	0	0	0	0	0	0	0
28	150	2	0	0	0	0	0	0	0	0	0	0	0
28	200	2	0	0	0	78	0	0	0	0	0	0	0
28	200	2	0	0	0	56	0	0.5	0	0	0	0	0
28	200	2	0	0	0	50	0	0	0	0	0	0	0
28	200	2	0	0	0	73	0	1	0	0	0	0	0
28	200	2	0	0	0	32	0	3	0	0	0	0	0
28	200	2	0	0	0	68	0	0.5	0	0	0	0	0
28	250	2	0	0	0	76	0	5	0	0	0	0	0
28	250	2	0	0	0	80	0	0	0	0	0	0	0
28	250	2	0	0	0	51	0	2	0	0	0	0	0
28	250	2	0	0	0	27	0	1	0	0	0	0	0
28	250	2	0	0	0	49	0	0	0	0	0	0	0
28	250	2	0	0	0	58	0	0	0	0	0	0	0
29	50	2	0	0	0	0	0	0	0	0	0	0	0
29	50	2	0	0	0	0	0	0	0	0	0	0	0
29	50	2	0	0	0	0	0	0	0	0	0	0	0
29	50	2	0	0	0	0	0	0	0	0	0	0	0
29	50	2	0	0	0	0	0	0	0	0	0	0	0
29	50	2	0	0	0	0	0	0	0	0	0	0	0
29	100	2	0	0	0	0	0	0	0	0	0	0	0
29	100	2	0.5	0	0	0	0	0	0	0	0	0	0
29	100	2	0	0	0	0	0	0	0	0	0	0	0
29	100	2	0	0	0	0	0	0	0	0	0	0	0
29	100	2	0.5	0	0	0	0	0	0	0	0	0	0
29	100	2	0	0	0	0	0	0	0	0	0	0	0
29	150	2	0	0	0	0	0	0	0	0	0	0	0
29	150	2	0.5	0	0	0	0	0	0	0	0	0	0
29	150	2	0.5	0	0	0	0	0	0	0	0	0	0
29	150	2	0	0	0	0	0	0	0	0	0	0	0
29	150	2	0	0	0	0	0	0	0	0	0	0	0
29	150	2	0	0	0	0	0	0	0	0	0	0	0
29	200	2	0	0	0	0	0	0	0	0	0	0	0
29	200	2	0	0	0	0	0	0	0	0	0	0	0
29	200	2	0	0	0	0	0	0	0	0	0	0	0
29	200	2	0.5	0	0	0	0	0	0	0	0	0	0
29	200	2	0.5	0.5	0	0	0	0	0	0	0	0	0
29	200	2	0.5	0	0	0	0	0	0	0	0	0	0
29	250	2	0.5	0	0	0	0	0	0	0	0	0	0
29	250	2	0	0	0	0	0	0	0	0	0	0	0
29	250	2	0	0	0	0	0	0	0	0	0	0	0
29	250	2	0	0	0	0	0	0	0	0	0	0	0
29	250	2	0	0	0	0	0	0	0	0	0	0	0
29	250	2	0	0	0	0	0	0	0	0	0	0	0
30	0	2	0	0	0	0	0	0	0	0	0	0	0
30	0	2	0	0	0	0	0	0	0	0	0	0	0

Trans. #	Dist. (m)	Area	1	2	3	4	5	6	7	8	9	10	11
57	125	2	0	0	0	0	0	0	100	0	0	0	0
57	125	2	0	0	0	0	0	0	100	0	0	0	0
57	125	2	0	0	0	0	0	0	100	0	0	0	0
57	125	2	0	0	0	0	0	0	100	0	0	0	0
57	125	2	0	0	0	0	0	0	100	0	0	0	0
57	200	2	0	0	0	0	0	0	74	0	0	0	0
57	200	2	0	0	0	0	0	0	100	0	0	0	0
57	200	2	0	0	0	1	0	0	81	0	0	0	0
57	200	2	0	0	0	0	0	0	100	0	0	0	0
57	200	2	0	0	0	0	0	0	100	0	0	0	0
57	200	2	0	0	0	0	0	0	100	0	0	0	0
57	250	2	0	0	0	85	0	0	0	0	0	0	0
57	250	2	0	0	0	90	0	0	1	0	0	0	0
57	250	2	0	0	0	95	0	0	5	0	0	0	0
57	250	2	0	0	0	96	0	0	1	0	0	0	0
57	250	2	0	0	0	94	0	0	1	0	0	0	0
57	250	2	0	0	0	85	0	0	1	0	0	0	0
58	100	2	0	0	0	0	0	0	0	0	0	0	0
58	100	2	0	0	0	0	0	0	0	0	0	0	0
58	100	2	0	0	0	0	0	0	0	0	0	0	0
58	100	2	0	0	0	0	0	0	0	0	0	0	0
58	100	2	0	0	0	0	0	0	0	0	0	0	0
58	100	2	0	0	0	0	0	0	0	0	0	0	0
58	200	2	0	0	0	0	0	0	0	0	0	0	0
58	200	2	0	0	0	0	0	0	0	0	0	0	0
58	200	2	0	0	0	0	0	0	0	0	0	0	0
58	200	2	0	0	0	0	0	0	0	0	0	0	0
58	200	2	0	0	0	0	0	0	0	0	0	0	0
58	200	2	0	0	0	0	0	0	0	0	0	0	0
59	10	2	0	0	0	0	0	0	0	0	0	0	0
59	10	2	0	0	0	0	0	0	0	0	0	0	0
59	10	2	0	0	0	0	0	0	0	0	0	0	0
59	10	2	0	0	0	0	0	0	0	0	0	0	0
59	10	2	0	0	0	0	0	0	0	0	0	0	0
59	10	2	0	0	0	0	0	0	0	0	0	0	0
59	20	2	0	0	0	0	0	0	0	0	0	0	0
59	20	2	0	0	0	0	0	0	0	0	0	0	0
59	20	2	0	0	0	0	0	0	0	0	0	0	0
59	20	2	0	0	0	0	0	0	0	0	0	0	0
59	20	2	0	0	0	0	0	0	0	0	0	0	0
59	20	2	0	0	0	0	0	0	0	0	0	0	0
60	100	2	0	0	0	0	0	0	0	0	0	0	0
60	100	2	0	0	0	0	0	0	0	0	0	0	0
60	100	2	0	0	0	0	0	0	0	0	0	0	0
60	100	2	0	0	0	0	0	0	0	0	0	0	0
60	100	2	0	0	0	0	0	0	0	0	0	0	0
60	100	2	0	0	0	0	0	0	0	0	0	0	0
60	200	2	0	0	0	0	0	0	0	0	0	0	0
60	200	2	0	0	0	0	0	0	0	0	0	0	0
60	200	2	0	0	0	0	0	0	0	0	0	0	0
60	200	2	0	0	0	0	0	0	0	0	0	0	0
60	200	2	0	0	0	0	0	0	0	0	0	0	0
60	200	2	0	0	0	0	0	0	0	0	0	0	0
61	180	2	0	0.5	0	95	0	0	0	0	0	0	0
61	180	2	0	0	0	90	0	0	0	0	0	0	0
61	180	2	0	5	0	90	0	0	0	0	0	0	0
61	180	2	0	0	0	80	0	0	0	0	0	0	0
61	180	2	0	0.5	0	91	0	0	0	0	0	0	0
61	180	2	0	0.5	0	79	0	0	0	0	0	0	0
61	220	2	0	0.5	0	95	0	0	0	0	0	0	0
61	220	2	0	0	0	100	0	0	0	0	0	0	0
61	220	2	0	0.5	0	91	0	0	0	0	0	0	0
61	220	2	0	0.5	0	95	0	0	0	0	0	0	0
61	220	2	0	0	0	78	0	0	0	0	0	0	0
61	220	2	0	0.5	0	80	0	0	0	0	0	0	0
62	150	2	0.5	0	0	0	0	0	0	0	0	0	0
62	150	2	0.5	0	0	0	0	0	0	0	0	0	0
62	150	2	0.5	0	0	0	0	0	0	0	0	0	0
62	150	2	0.5	0	0	0	0	0	0	0	0	0	0
62	150	2	0.5	5	0	0	0	0	0	0	0	0	0
62	150	2	5	0	0	0	0	0	0	0	0	0	0
62	250	2	0	0	0	31	0	0	0	0	0	0	0
62	250	2	0	0	0	51	0	0	0	0	0	0	0
62	250	2	0.5	0	0	10	0	0	0	0	0	0	0
62	250	2	0	0	0	15	0	0	0	0	0	0	0
62	250	2	0	0	0	30	0	0	0	0	0	0	0
62	250	2	0	0	0	28	0	0	0	0	0	0	0
62	350	2	0	0.5	0	82	0	0	0	0	0	0	0
62	350	2	0	0.5	0	5	0	0	0	0	0	0	0
62	350	2	0.5	61	0	0.5	0	0	0	0	0	0	0
62	350	2	0	0.5	0	31	0	0	0	0	0	0	0
62	350	2	0	0.5	0	30	0	0	0	0	0	0	0
62	350	2	0	5	0	5	0	0	0	0	0	0	0
62	450	2	0	0.5	0	0.5	0	0	0	0	0	0	0
62	450	2	0	0.5	0	0	0	0	0	0	0	0	0
62	450	2	0	0.5	0	10	0	0	0	0	0	0	0
62	450	2	0	10	0	29	0	0	0	0	0	0	0
62	450	2	0	11	0	21	0	0	0	0	0	0	0
62	450	2	0	20	0	70	0	0	0	0	0	0	0
63	50	2	0	0	0	0	0	0	0	0	0	0	0
63	50	2	0	1	0	20	0	0	0	0	0	0	0
63	50	2	0	0	0	1	0	0	0	0	0	0	0
63	50	2	0	5	0	6	0	0	0	0	0	0	0
63	50	2	0	0	0	5	0	0	0	0	0	0	0
63	50	2	0	0	0	0	0	0	0	0	0	0	0
63	100	2	0	0.5	0	0.5	0.5	0	0	0	0	0	0
63	100	2	0	0	0	0	0	0	0	0	0	0	0
63	100	2	0	1	0	0	0	0	0	0	0	0	0
63	100	2	0.5	5	0	20	0.5	0	0	0.5	0	0	0

Trans. #	Dist. (m)	Area	1	2	3	4	5	6	7	8	9	10	11
88	200	4	0	0	0	0	0	0	0	0	0	0	0
88	200	4	0	0	0	0	0	0	0	0	0	0	0
88	200	4	0	0	0	0	0	0	0	0	0	0	0
89	10	4	0	0	0	0	0	0	0	0	0	0	0
89	10	4	0	0	0	0	0	0	0	0	0	0	0
89	10	4	0	0	0	0	0	0	0	0	0	0	0
89	10	4	0	0	0	0	0	0	0	0	0	0	0
89	10	4	0	0	0	0	0	0	0	0	0	0	0
89	10	4	0	0	0	0	0	0	0	0	0	0	0
89	100	4	0	0	0	0	0	0	0	0	0	0	0
89	100	4	2	0	0	0	0	0	0	0	0	0	0
89	100	4	0	0	0	0	0	0	0	0	0	0	0
89	100	4	0	0	0	0	0	0	0	0	0	0	0
89	100	4	0	0	0	0	0	0	0	0	0	0	0
89	100	4	0	0	0	0	0	0	0	0	0	0	0
89	180	4	0	0	0	0	0	0	0	0	0	0	0
89	180	4	0	0	0	0	0	0	0	0	0	0	0
89	180	4	0	0	0	0	0	0	0	0	0	0	0
89	180	4	0.5	0	0	0	0	0	0	0	0	0	0
89	180	4	0	0	0	0	0	0	0	0	0	0	0
89	180	4	0	0	0	0	0	0	0	0	0	0	0
89	300	4	1	0	0	0	0	0	0	0	0	0	0
89	300	4	0	0	0	0	0	0	0	0	0	0	0
89	300	4	0	0	0	0	0	0	0	0	0	0	0
89	300	4	0	0	0	0	0	0	0	0	0	0	0
89	300	4	0	0	0	0	0	0	0	0	0	0	0
89	300	4	0	0	0	0	0	0	0	0	0	0	0
89	350	4	0	0	0	99	0	0	0	0	0	0	0
89	350	4	0	0	0	95	0	0	0	0	0	0	0
89	350	4	0	0	0	98	0	0	0	0	0	0	0
89	350	4	0	0	0	94	0	0	0	0	0	0	0
89	350	4	0	0	0	90	0	0	0	0	0	0	0
89	350	4	0	0	0	98	0	0	0	0	0	0	0
90	60	4	0	0	0	0	0	0	0	0	0	0	0
90	60	4	0	0	0	0	0	0	0	0	0	0	0
90	60	4	0	0	0	0	0	0	0	0	0	0	0
90	60	4	0	0	0	0	0	0	0	0	0	0	0
90	60	4	0.5	0	0	0	0	0	0	0	0	0	0
90	60	4	0	0	0	0	0	0	0	0	0	0	0
90	200	4	0	0	0	0	0	0	0	0	0	0	0
90	200	4	0	0	0	0	0	0	0	0	0	0	0
90	200	4	0	0	0	0	0	0	0	0	0	0	0
90	200	4	0.5	0	0	0	0	0	0	0	0	0	0
90	200	4	0	0	0	0	0	0	0	0	0	0	0
90	200	4	0	0	0	0	0	0	0	0	0	0	0
90	270	4	0	0	0	0	0	0	0	0	0	0	0
90	270	4	0	0.5	0	0	0	0	0	0	0	0	0
90	270	4	0.5	0	0	0	0	0	0	0	0	0	0
90	270	4	0	0	0	0	0	0	0	0	0	0	0
90	270	4	0	0	0	0	0	0	0	0	0	0	0
90	270	4	0	0	0	0	0	0	0	0	0	0	0
90	480	4	0	0	0	0	0	0	0	5	0	0	0
90	480	4	0	0	0	0	0	0	0	4	0	0	0
90	480	4	0	0	0	0	0	0	0	1	0	0	0
90	480	4	0	0	0	0	0	0	0	7	0	0	0
90	480	4	0	0	0	0	0	0	0	2	0	0	0
90	480	4	0	0	0	0	0	0	0	5	0	0	0
90	580	4	0	0	0	88	0	0	0	0	0	0	0
90	580	4	0	0	0	91	0	0	0	0	0	0	0
90	580	4	0	0	0	90	0	0	0	0.5	0	0	0
90	580	4	0	0	0	85	0	0	0	1	0	0	0
90	580	4	0	0	0	78	0	0	0	0.5	0	0	0
90	580	4	0	0	0	84	0	0	0	0	0	0	0
90	660	4	0	0	0	96	0	0	0	0.5	0	0	0
90	660	4	0	0	0	89	0	0	0	0	0	0	0
90	660	4	0	0	0	95	0	0	0	0	0	0	0
90	660	4	0	0	0	95	0	0	0	0	0	0	0
90	660	4	0	0	0	90	0	0	0	0	0	0	0
90	660	4	0	0	0	97	0	0	0	0	0	0	0
91	150	4	0	0	0	0	0	0	0	0	0	0	0
91	150	4	0	0	0	0	0	0	0	0	0	0	0
91	150	4	0	0	0	0	0	0	0	0	0	0	0
91	150	4	0	0	0	0	0	0	0	0	0	0	0
91	150	4	0	0	0	0	0	0	0	0	0	0	0
91	150	4	0	0	0	0	0	0	0	0	0	0	0
91	250	4	0	0	0	0	0	0	0	0	0	0	0
91	250	4	0	0	0	0	0	0	0	0	0	0	0
91	250	4	0	0	0	0	0	0	0	0	0	0	0
91	250	4	0	0	0	0	0	0	0	0	0	0	0
91	250	4	0	0	0	0	0	0	0	0	0	0	0
91	250	4	0	0	0	0	0	0	0	0	0	0	0
91	350	4	0	0	0	0	0	0	0	0	0	0	0
91	350	4	0	0	0	0	0	0	0	0	0	0	0
91	350	4	0	0	0	0	0	0	0	0	0	0	0
91	350	4	0	0	0	0	0	0	0	0	0	0	0
91	350	4	0	0	0	0	0	0	0	0	0	0	0
91	350	4	0	0	0	0	0	0	0	0	0	0	0
91	400	4	0	0	0	0	0	0	0	0	0	0	0
91	400	4	0.5	0	0	0	0	0	0	0	0	0	0
91	400	4	0	0	0	0	0	0	0	0	0	0	0
91	400	4	0	0	0	0	0	0	0	0	0	0	0
91	400	4	0.5	0	0	0	0	0	0	0	0	0	0
91	400	4	0	0	0	0	0	0	0	0	0	0	0
91	500	4	0	0	0	0	0	0	0	0	0	0	0
91	500	4	0	0	0	0	0	0	0	0	0	0	0
91	500	4	0	0	0	0	0	0	0	0	0	0	0
91	500	4	0	0	0	0	0	0	0	0	0	0	0
91	500	4	0	0	0	0	0	0	0	0	0	0	0
91	500	4	0	0	0	0	0	0	0	0	0	0	0

Algal species:
1) Gracilaria secundata
2) Ulva lactuca
3) Enteromorpha sp.
4) Zostera sp.
5) Corallina officinalis
6) Ceramium sp.
7) Hormosira banksii
8) Gelidium caulacantheum
9) Codium fragile
10) Hymenena sp.
11) Polysiphonaria sp.

Transect numbers correspond to those shown in Figure 8.1 and area relates to the zones used in analysis of the data.

APPENDIX 2

Results for analysis of algal percentage cover data from transects throughout Tauranga Harbour using summarised data (means of each point on transects, n = 6 x 0.25 m^2 quadrats).

Tests for differences of *Ulva spp* abundance between harbour basins.

KRUSKAL-WALLIS ONE-WAY ANOVA (n=337) *Ulva spp* % cover

GROUP - AREA	COUNT	RANK SUM
Northern basin	102	16063.500
Southern basin	138	22198.500
Waikareao Estuary	12	2185.500
Town basin	85	16505.500

KRUSKAL-WALLIS TEST STATISTIC = 11.192 PROB 0.011 CHI-SQUARE DISTRIBUTION WITH 3 DF

Tests for differences of *Zostera* abundance between harbour basins.

KRUSKAL-WALLIS ONE-WAY ANOVA (n=337) *Zostera* % cover

GROUP - AREA	COUNT	RANK SUM
Northern basin	102	18642.500
Southern basin	138	23532.500
Waikareao Estuary	12	1140.000
Town basin	85	13638.000

KRUSKAL-WALLIS TEST STATISTIC = 11.716 PROB 0.008 CHI-SQUARE DISTRIBUTION WITH 3 DF

Test repeated dropping out Waikareao Estuary data. (n= 325) *Zostera* % cover

GROUP - AREA	COUNT	RANK SUM
Northern basin	102	17694.500
Southern basin	138	22320.500
Town basin	85	12960.000

KRUSKAL-WALLIS TEST STATISTIC = 2.814 PROB 0.245 CHI-SQUARE DISTRIBUTION WITH 2 DF

Tests for differences in abundance of *Gracilaria secundata* between harbour basins.

(n= 337) *Gracilaria secundanta* % cover

GROUP - AREA	COUNT	RANK SUM
Northern basin	102	18818.500
Southern basin	138	24089.000
Waikareao Estuary	12	1630.000
Town basin	85	12415.500

KRUSKAL-WALLIS TEST STATISTIC = 14.401 PROB 0.002 CHI-SQUARE DISTRIBUTION WITH 3 DF

(n= 325) *Gracilaria secundanta* % cover - Waikareao Estuary data dropped

GROUP - AREA	COUNT	RANK SUM
Northern basin	102	18037.000
Southern basin	138	23066.500
Town basin	85	11871.000

KRUSKAL-WALLIS TEST STATISTIC = 11.967 PROB 0.003 CHI-SQUARE DISTRIBUTION WITH 2 DF

PEARSON CORRELATION MATRIX (n=2022)

	COOF	GECA	GRSE	CESP	HOBA	ULVA	ZOSP
COOF -*Corallina officinallis*	1.000						
GECA -*Gelidium caulacantheum*	-0.009	1.000					
GRSE -*Gracilaria secundata*	-0.018	-0.008	1.000				
CESP -*Ceramium sp.*	-0.011	0.001	0.054	1.000			
HOBA -*Hormosira banksii*	-0.016	0.005	-0.016	-0.026	1.000		
ULVA -*Ulva spp*	0.039	0.018	0.008	0.013	-0.042	1.000	
ZOSP -*Zostera sp.*	0.145***	-0.041	-0.090***	0.058	-0.063**	-0.096***	1.000

SPEARMAN CORRELATION MATRIX

	COOF	GECA	GRSE	CESP	HOBA	ULVA
GECA	0.117***					
GRSE	-0.014	0.095***				
CESP	-0.025	-0.030	-0.002			
HOBA	0.146***	0.140***	0.115***	-0.021		
ULVA	0.153***	0.126***	-0.014	0.063**	-0.061**	
ZOSP	0.234***	-0.010	-0.198***	0.051*	0.128***	0.070**

Descriptive statistics of mean algal cover for each common species by Area. Untransformed data.

THE FOLLOWING RESULTS ARE FOR: Northern basin, n= 612.

	COOF	GECA	GRSE	CESP	HOBA	ULVA	ZOSP
MINIMUM	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MAXIMUM	5.000	4.000	20.000	8.000	100.000	29.000	100.000
MEAN	0.064	0.142	0.438	0.047	1.516	0.573	25.252
STANDARD DEV	0.404	0.487	1.607	0.456	7.287	2.524	30.852
STD. ERROR	0.016	0.020	0.065	0.018	0.295	0.102	1.247

THE FOLLOWING RESULTS ARE FOR: Southern basin, n = 828.

	COOF	GECA	GRSE	CESP	HOBA	ULVA	ZOSP
MINIMUM	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MAXIMUM	80.000	36.000	62.000	5.000	100.000	100.000	100.000
MEAN	1.505	0.211	0.495	0.031	4.656	2.042	21.910
STANDARD DEV	7.462	2.113	3.636	0.291	19.674	9.455	32.676
STD. ERROR	0.259	0.073	0.126	0.010	0.684	0.329	1.136

THE FOLLOWING RESULTS ARE FOR: Waikareao Estuary, n = 72.

	COOF	GECA	GRSE	CESP	HOBA	ULVA	ZOSP
MINIMUM	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MAXIMUM	0.000	0.000	1.000	0.000	0.000	100.000	0.000
MEAN	0.000	0.000	0.042	0.000	0.000	15.125	0.000
STANDARD DEV	0.000	0.000	0.163	0.000	0.000	34.100	0.000
STD. ERROR	0.000	0.000	0.019	0.000	0.000	4.019	0.000

THE FOLLOWING RESULTS ARE FOR: Town basin, n = 510.

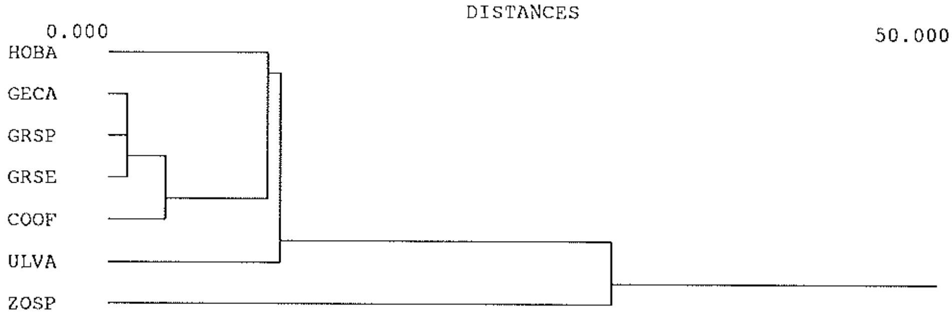
	COOF	GECA	GRSE	CESP	HOBA	ULVA	ZOSP
MINIMUM	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MAXIMUM	1.000	7.000	8.000	0.000	5.000	100.000	100.000
MEAN	0.007	0.126	0.176	0.000	0.028	8.844	23.167
STANDARD DEV	0.080	0.647	0.818	0.000	0.273	23.730	35.982
STD. ERROR	0.004	0.029	0.036	0.000	0.012	1.051	1.593

APPENDIX 3

Cluster analysis of algal transects throughout Tauranga Harbour using the commonly occurring species. Results for analysis by species.

DISTANCE METRIC IS EUCLIDEAN DISTANCE
AVERAGE LINKAGE METHOD

TREE DIAGRAM



PCA (covariance) on mean % cover of algal species recorded on each transect

LATENT ROOTS (EIGENVALUES)

1	2	3	4	5	6	7
499.537	84.020	74.020	9.399	1.037	0.690	0.013

COMPONENT LOADINGS

	1	2	3
ZOSP	22.317	0.262	0.245
HOBA	0.915	-6.980	-5.563
COOF	0.788	0.205	0.044
ULVA	0.065	5.932	-6.558
GRSE	0.032	0.009	-0.059
GRSP	0.013	0.004	0.007
GEPU	-0.070	0.004	0.003

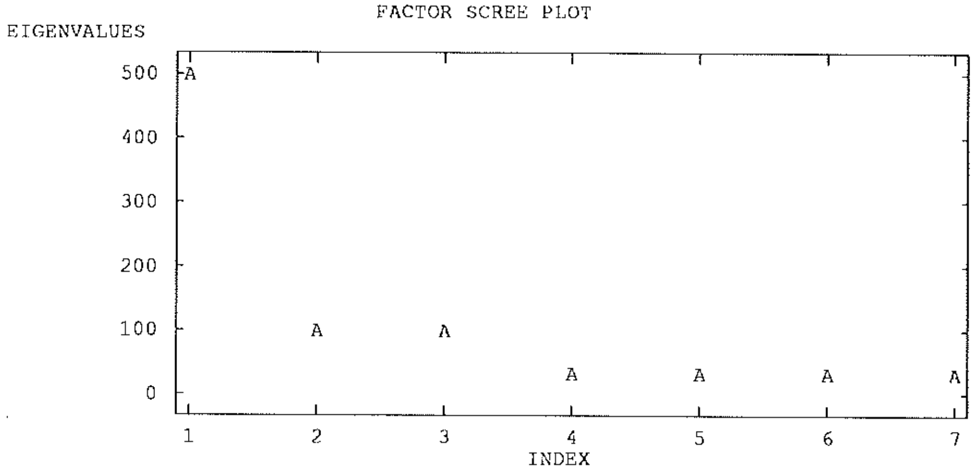
VARIANCE EXPLAINED BY COMPONENTS

1	2	3
499.537	84.020	74.020

PERCENT OF TOTAL VARIANCE EXPLAINED

1	2	3
74.701	12.564	11.069

FACTOR SCREE PLOT



FACTOR SCORE COEFFICIENTS

	1	2	3
ZOSP	0.045	0.003	0.003
HOBA	0.002	-0.083	-0.075
COOF	0.002	0.002	0.001
ULVA	0.000	0.071	-0.089
GRSE	0.000	0.000	-0.001
GRSP	0.000	0.000	0.000
GEPU	-0.000	0.000	0.000

APPENDIX 4

The results of one-way ANOVAs used to test for differences in the mean values of eel grass biomass between the sites sampled in Tauranga Harbour as part of the Tauranga Harbour Regional Plan Project.

One-way ANOVA to compare biomass of eel grass between sites.

ANALYSIS OF VARIANCE

Blue Gum Bay   Duck Bay   Otumoetai   Town Reach   Wairoa Delta

Biomass - dry-weight (g) N: 30 MULTIPLE R: 0.613 SQUARED MULTIPLE R: 0.376

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
SITES	120.640	4	30.160	3.760	0.016
ERROR	200.535	25	8.021		

Above repeated with the Town Reach data dropped.

ANALYSIS OF VARIANCE

Blue Gum Bay   Duck Bay   Otumoetai   Wairoa Delta

Biomass N: 24 MULTIPLE R: 0.486 SQUARED MULTIPLE R: 0.236

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
SITES	59.721	3	19.907	2.063	0.137
ERROR	192.975	20	9.649		

Relationship between the percentage cover of Zostera and percentage of silt in surface sediments.

PEARSON CORRELATION MATRIX (n=75)

	ZOSP	LZOSP
SILT	-0.453	-0.595
LSILT	-0.459	-0.561

BARTLETT CHI-SQUARE STATISTIC: 195.193 DF= 6 PROB= .000

MATRIX OF PROBABILITIES

	ZOSP	LZOSP
SILT	0.000	0.000
LSILT	0.000	0.000

DEP VAR: SILT N: 75 MULTIPLE R: 0.595 SQUARED MULTIPLE R: 0.354
ADJUSTED SQUARED MULTIPLE R: .345 STANDARD ERROR OF ESTIMATE: 6.652

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	9.064	0.790	0.000	.	11.472	0.000
LZOSP	-3.029	0.479	-0.595	1.000	-6.327	0.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	1771.074	1	1771.074	40.026	0.000
RESIDUAL	3230.073	73	44.248		

APPENDIX 5

Results of Pearson and Spearman correlations between the mean percentage cover of *Ulva lactuca* at all sampling points along each algal transect, and the mean value of all sampling occasions at the closest water chemistry site (n=12) in Tauranga Harbour measured over 1990/91 as part of the Tauranga Harbour Regional Plan Project.

PEARSON CORRELATION MATRIX (n=87)

	DRP	TP	NH4	NO3	SALN	SS	TURB
TP	0.336						
NH4	0.529	0.311					
NO3	0.464	0.787	0.623				
SALN	-0.362	-0.707	-0.616	-0.920			
SS	-0.015	0.570	0.151	0.680	-0.738		
TURB	-0.467	0.243	0.080	0.245	-0.380	0.487	
% ULVA COVER	0.321	0.196	0.182	0.233	-0.121	0.039	-0.257

BARTLETT CHI-SQUARE STATISTIC: 506.352 DF= 28 PROB= .000

MATRIX OF PROBABILITIES

	DRP	TP	NH4	NO3	SALN	SS	TURB
TP	0.001						
NH4	0.000	0.003					
NO3	0.000	0.000	0.000				
SALN	0.001	0.000	0.000	0.000			
SS	0.893	0.000	0.164	0.000	0.000		
TURB	0.000	0.025	0.466	0.024	0.000	0.000	
% ULVA COVER	**0.002**	0.069	0.091	**0.030**	0.266	0.723	0.018

SPEARMAN CORRELATION MATRIX

	DRP	TP	NH4	NO3	SALN	SS	TURB
TP	0.436						
NH4	0.659	0.673					
NO3	0.496	0.469	0.784				
SALN	-0.394	-0.516	-0.752	-0.925			
SS	0.055	0.538	0.444	0.672	-0.782		
TURB	-0.204	0.341	0.306	0.473	-0.600	0.675	
% ULVA COVER	0.415	0.172	0.320	0.323	-0.228	0.034	-0.151

BARTLETT CHI-SQUARE STATISTIC: 562.115 DF= 28 PROB= .000

MATRIX OF PROBABILITIES

	DRP	TP	NH4	NO3	SALN	SS	TURB
TP	0.000						
NH4	0.000	0.000					
NO3	0.000	0.000	0.000				
SALN	0.000	0.000	0.000	0.000			
SS	0.622	0.000	0.000	0.000	0.000		
TURB	0.063	0.002	0.005	0.000	0.000	0.000	
% ULVA COVER	**0.000**	0.117	**0.003**	**0.003**	**0.037**	0.760	0.170

NUMBER OF OBSERVATIONS: 84

APPENDIX 6

Descriptive statistics for species diversity and sediment parameters for the subtidal macrofaunal descriptive sites sampled throughout Tauranga Harbour over the summer period 1990/91 as part of the Tauranga Harbour Regional Plan Project.

	SPDI	GMEAN	SAND	SILT	GRAVEL	SPS	TOC	TKN	TP
N OF CASES	16	20	20	20	20	20	20	20	20
MINIMUM	0.000	-1.551	44.000	0.000	0.000	0.840	0.020	72.000	52.00
MAXIMUM	13.800	2.354	100.000	4.000	55.000	4.240	0.180	562.000	173.00
MEAN	6.938	1.339	90.150	0.850	9.000	1.825	0.057	147.000	92.20
STANDARD DEV	3.026	0.966	13.311	1.137	13.231	0.873	0.035	106.847	32.53
C.V.	0.436	0.721	0.148	1.337	1.470	0.478	0.605	0.727	0.353

Pearson correlation matrix for log10(x+1) transformed species abundances and sediment parameters from the subtidal descriptive macrofauna sites sampled throughout Tauranga Harbour as part of the Tauranga Harbour Regional Plan Project.

	BAUST	BFEZE	BGAST	BNUHA	BPAAU
BFEZE	0.088				
BGAST	-0.081	-0.005			
BNUHA	0.167	-0.055	-0.061		
BPAAU	0.813***	-0.106	-0.065	0.075	
BTELI	0.266**	-0.128	-0.078	0.515***	0.348***
CAF	0.106	-0.094	-0.080	-0.057	0.110
CAG	-0.095	-0.100	0.056	-0.072	-0.076
CAJ	-0.091	0.054	-0.085	-0.008	-0.104
CAM	-0.086	-0.090	-0.055	-0.065	-0.068
CCAFI	-0.091	-0.033	-0.059	-0.069	-0.073
CELMO	-0.097	-0.041	0.894***	-0.074	-0.056
ECHUI	-0.092	-0.097	-0.059	-0.070	-0.073
GAMAU	-0.053	-0.081	-0.076	-0.090	-0.094
GCOAD	-0.097	0.132	-0.063	-0.074	-0.077
PAGMA	-0.196	-0.158	-0.084	-0.182	-0.191
PARE	-0.071	-0.126	0.216*	-0.090	-0.095
PARMA	-0.051	-0.079	-0.075	0.244*	-0.093
PARSP	-0.104	-0.035	-0.067	-0.079	-0.083
PAXAU	-0.158	-0.111	-0.102	0.169	-0.110
PGLLA	-0.130	0.104	0.032	-0.099	-0.081
PHESP	-0.164	-0.006	-0.106	-0.079	-0.131
PLECO	-0.091	0.219*	-0.059	-0.069	-0.073
PLEJA	-0.091	-0.033	-0.059	-0.069	-0.073
PLUSP	-0.134	-0.142	0.139	-0.102	-0.107
PMAPA	0.016	-0.145	-0.088	-0.104	-0.109
PNASP	0.625***	0.005	0.009	0.042	0.769***
PNIAE	-0.023	0.249*	-0.062	-0.073	-0.077
PNOSPA	0.040	-0.136	0.031	0.280**	0.045
PNOSPB	0.091	0.643***	-0.066	-0.078	-0.082
PORIS	-0.118	0.131	-0.076	-0.090	-0.094
PORPA	-0.117	-0.124	-0.076	-0.089	-0.094
POWFU	-0.095	0.224*	-0.068	0.024	-0.114
PPESP	0.061	0.102	-0.018	-0.127	0.047
PPRAU	-0.040	-0.162	-0.112	0.386***	-0.096
PSABE	-0.054	-0.099	-0.061	0.413***	-0.035
PTHPL	-0.117	0.053	-0.106	-0.125	-0.132
TRDE	-0.021	-0.006	-0.091	0.321**	-0.084
SPDI	0.017	0.075	0.098	0.237*	0.011
DEPTH	-0.314**	-0.088	0.580***	-0.249*	-0.242*
GMEAN	-0.069	-0.014	-0.430***	-0.147	-0.078
GRAVEL	0.001	-0.128	0.339**	0.131	0.042
GSKEW	-0.206	0.108	-0.109	-0.312**	-0.215*
GSTD	0.175	-0.197	0.219*	0.280**	0.193
SAND	-0.002	0.135	-0.323**	-0.132	-0.045
SILT	0.019	-0.112	-0.173	0.033	0.041
SPS	0.117	0.028	0.456***	0.157	0.130
TKNSMGK	-0.078	-0.179	-0.081	-0.017	-0.038
TOCGP100	0.061	-0.153	-0.259*	-0.067	0.058
TPSMGKG	0.104	-0.200	-0.286**	0.006	0.151

	BTELI	CAF	CAG	CAJ	CAM
CAF	0.127				
CAG	0.070	-0.093			
CAJ	0.055	0.071	-0.099		
CAM	-0.083	-0.085	-0.065	-0.089	
CCAFI	-0.088	-0.090	0.446***	-0.095	-0.062
CELMO	-0.094	-0.096	0.040	-0.102	-0.066
ECHUI	-0.088	-0.091	-0.069	-0.096	0.050
GAMAU	-0.114	-0.116	-0.089	-0.070	0.239**
GCOAD	-0.094	-0.027	-0.073	0.528***	0.031
PAGMA	-0.067	-0.005	-0.047	0.008	0.100
PARE	-0.043	0.049	0.062	0.011	-0.081
PARMA	0.278**	-0.115	0.143	0.080	-0.079
PARSP	-0.100	0.020	-0.079	-0.109	-0.071
PAXAU	0.098	-0.010	0.462***	-0.077	-0.108
PGLLA	-0.125	0.076	-0.018	0.215*	-0.089
PHESP	-0.058	-0.014	-0.066	0.336**	-0.112
PLECO	-0.088	0.013	-0.069	0.448***	-0.062
PLEJA	-0.088	0.074	-0.069	0.254**	-0.062
PLUSP	-0.075	-0.069	0.106	-0.094	-0.092
PMAPA	-0.003	0.239*	-0.103	-0.044	0.099
PNASP	0.228*	0.024	-0.124	-0.004	-0.112
PNIAE	-0.093	0.395***	-0.073	0.265**	-0.066
PNOSPA	0.112	0.072	-0.085	0.187	-0.156
PNOSPB	-0.099	0.241*	-0.078	0.192	-0.070
PORIS	-0.114	0.135	-0.010	0.219*	-0.081
PORPA	-0.113	-0.116	-0.089	-0.122	0.535***
POWFU	-0.076	0.156	-0.092	0.216*	-0.108
PPESP	-0.161	-0.086	-0.064	0.027	-0.114
PPRAU	0.260*	-0.137	-0.131	0.043	0.032
PSABE	0.219*	0.392***	-0.071	0.107	-0.064
PTHPL	0.024	0.186	-0.022	0.230*	-0.113
TRDE	0.183	-0.007	-0.006	0.075	-0.096

Felaniella zelandica
Gari stangeri
Nucula hartvigiana
Paphies australis
Tellina liliana
Cephalophoxus regium
Liljeborgia barhami
Paramoera chevreuxi
Amphipod sp. M
Callianassa filholi
Elminius modestus

Amalda australis
Cominella adspersa
Aglaophamus macroura
Patiriella regularis
Armandia maculata
Aricidea sp.
Macroclymenella stewartensis
Glycera lamellipoda
Chaetozone platycera
Lepidasthaniella comma
Lepidonotus jacksoni
Lumbrinereis sphaerocephala
Magelona dakini
Aonides oxycephala
Nicon aestuariensis
Heteromastus filiformis
Notomastus sp. B
Oriopsis sp.
Orbinia papilosa
Owenia fusiformis

Aquilaspio aucklandica
Sabellaria sp.
Thelepus plagiostoma
Trochodota dendyi
Species diversity
water depth
sediment Graphic mean

sediment graphic skewness
" " standard deviation

TKN
TOC
TP

SPDI	0.206	0.214*	0.009	0.370***	-0.100
DEPTH	-0.286**	-0.215*	0.172	-0.156	0.098
GMEAN	-0.050	0.185	0.043	0.052	0.215*
GRAVEL	0.064	-0.070	-0.063	0.074	-0.152
GSKEW	-0.344**	-0.251*	-0.038	-0.156	0.616***
GSTD	0.261*	-0.022	-0.023	-0.012	-0.213*
SAND	-0.077	0.034	0.066	-0.104	0.165
SILT	0.187	0.474***	-0.052	0.405***	-0.183
SPS	0.089	-0.136	-0.050	-0.036	-0.255*
TKNSMGK	0.094	0.319**	0.065	0.300**	-0.081
TOCGP100	0.145	0.424***	0.054	0.236*	-0.068
TPSMGKG	0.166	0.265**	0.263**	0.118	0.030

	CCAFI	CELMO	ECHUI	GAMAU	GCOAD
CELMO	-0.071				
ECHUI	-0.067	-0.071			
GAMAU	-0.086	0.002	-0.029		
GCOAD	-0.071	-0.075	-0.071	-0.009	
PAGMA	-0.041	-0.061	0.274**	0.275**	-0.062
PARE	-0.087	0.245*	-0.087	-0.112	0.003
PARMA	0.285**	-0.090	-0.085	-0.109	0.285**
PARSP	-0.076	0.020	0.066	0.231*	-0.081
PAXAU	0.326**	-0.122	0.006	-0.094	0.066
PGLLA	0.126	0.063	-0.044	-0.046	0.205
PHESP	0.167	-0.067	-0.120	0.044	-0.043
PLECO	-0.067	-0.071	-0.067	0.037	0.471***
PLEJA	-0.067	-0.071	-0.067	0.037	0.047
PLUSP	0.039	0.125	-0.098	-0.031	-0.058
PMAPA	-0.100	-0.106	-0.100	0.254*	-0.064
PNASP	-0.120	-0.035	-0.120	-0.132	-0.004
PNIAE	-0.070	-0.075	-0.071	-0.091	0.017
PNOSPA	-0.214*	0.039	-0.195	0.097	0.099
PNOSPB	-0.075	-0.080	-0.075	-0.097	-0.012
PORIS	0.077	-0.091	-0.086	0.028	0.251*
PORPA	-0.086	-0.091	0.417***	0.043	0.026
POWFU	-0.019	-0.090	-0.116	-0.039	0.162
PPESP	-0.036	-0.002	-0.059	-0.157	-0.016
PPRAU	-0.034	-0.134	0.039	0.169	-0.006
PSABE	-0.068	-0.073	-0.069	-0.088	-0.073
PTHPL	-0.031	-0.128	-0.121	-0.031	0.239*
TRDE	-0.103	-0.109	-0.103	-0.133	0.007
SPDI	0.042	0.129	-0.058	-0.007	0.243*
DEPTH	0.067	0.599***	0.258*	-0.193	-0.048
GMEAN	0.103	-0.440***	0.205	0.150	0.048
GRAVEL	-0.117	0.341**	-0.146	-0.180	-0.042
GSKEW	-0.052	-0.119	0.340**	0.158	0.099
GSTD	-0.049	0.214*	-0.155	-0.190	-0.162
SAND	0.116	-0.322**	0.160	0.186	0.040
SILT	0.005	-0.208*	-0.196	-0.097	0.021
SPS	-0.111	0.463***	-0.227*	-0.166	-0.070
TKNSMGK	0.048	-0.109	-0.165	-0.176	-0.066
TOCGP100	0.049	-0.301**	-0.141	-0.067	-0.119
TPSMGKG	0.230*	-0.347**	-0.090	-0.236*	-0.113

	PAGMA	PARE	PARMA	PARSP	PAXAU
PARE	-0.068				
PARMA	-0.186	-0.110			
PARSP	0.329**	-0.099	-0.096		
PAXAU	-0.006	-0.017	0.332**	-0.072	
PGLLA	-0.102	-0.124	-0.044	-0.108	0.061
PHESP	0.138	-0.156	0.079	0.206*	0.012
PLECO	-0.071	-0.087	0.038	-0.076	-0.036
PLEJA	0.263**	0.003	-0.085	0.189	0.043
PLUSP	-0.062	0.098	0.018	0.050	-0.092
PMAPA	0.227*	0.136	-0.127	-0.039	-0.100
PNASP	-0.298**	0.150	-0.130	-0.113	-0.122
PNIAE	-0.121	-0.092	-0.089	-0.080	0.037
PNOSPA	-0.236*	0.260*	0.063	-0.055	-0.097
PNOSPB	-0.196	-0.098	-0.095	-0.085	0.006
PORIS	-0.027	-0.112	0.085	-0.057	0.175
PORPA	0.125	-0.111	-0.109	-0.015	-0.098
POWFU	-0.020	-0.106	-0.002	0.123	-0.017
PPESP	-0.170	-0.014	-0.036	0.022	-0.135
PPRAU	-0.144	0.125	0.149	-0.144	0.013
PSABE	-0.144	-0.089	0.101	-0.078	0.320**
PTHPL	0.085	-0.013	0.095	0.097	-0.042
TRDE	-0.178	0.040	0.148	-0.052	0.086
SPDI	-0.014	0.105	0.198	-0.005	0.144
DEPTH	-0.049	0.060	-0.016	-0.041	0.038
GMEAN	0.346***	-0.502***	0.047	0.157	0.083
GRAVEL	-0.300**	0.486***	-0.066	-0.144	-0.075
GSKEW	0.063	0.069	-0.158	-0.072	-0.029
GSTD	-0.239*	0.334**	0.037	-0.107	-0.087
SAND	0.296**	-0.477***	0.065	0.144	0.079
SILT	0.022	-0.061	0.002	-0.026	-0.060
SPS	-0.363***	0.490***	-0.057	-0.174	-0.112
TKNSMGK	-0.074	0.004	0.027	-0.049	0.027
TOCGP100	-0.001	-0.077	-0.008	-0.104	0.012
TPSMGKG	-0.163	-0.110	0.172	-0.216*	0.242*

	PGLLA	PHESP	PLECO	PLEJA	PLUSP
PHESP	0.238*				
PLECO	0.476***	0.272			
PLEJA	0.016	0.293**	0.289**		
PLUSP	-0.004	-0.034	-0.098	-0.098	
PMAPA	-0.012	0.046	-0.100	-0.100	-0.146
PNASP	-0.140	-0.187	-0.088	0.020	-0.121
PNIAE	0.307**	0.200	0.424***	0.148	-0.019
PNOSPA	-0.011	0.206*	0.221*	-0.032	0.050
PNOSPB	0.094	0.126	0.189	0.129	-0.110
PORIS	0.439***	0.296**	0.769***	0.358***	-0.084
PORPA	-0.053	-0.154	-0.086	-0.086	-0.125
POWFU	0.477***	0.447***	0.703***	0.324**	-0.154
PPESP	0.208*	0.086	-0.036	-0.122	0.166
PPRAU	-0.051	-0.004	-0.068	0.048	0.024
PSABE	-0.097	0.098	-0.068	0.233*	-0.054
PTHPL	0.167	0.340**	0.431***	0.342***	-0.055
TRDE	-0.006	0.108	0.161	-0.015	-0.117
SPDI	0.347***	0.419***	0.524***	0.258*	-0.083
DEPTH	0.024	-0.190	-0.172	-0.120	0.014
GMEAN	0.120	0.190	0.211*	0.002	-0.103
GRAVEL	-0.055	-0.057	-0.144	0.038	0.017
GSKEW	-0.006	-0.256*	0.093	0.025	0.021
GSTD	-0.286**	-0.105	-0.545***	-0.138	0.065
SAND	0.040	0.021	0.125	-0.047	-0.002
SILT	0.203	0.468***	0.246*	0.125	-0.191
SPS	-0.109	-0.169	-0.220*	-0.013	0.105
TKNSMGK	0.069	0.272**	-0.119	-0.047	-0.084
TOCGP100	0.028	0.229*	-0.097	-0.073	-0.156
TPSMGKG	-0.098	0.089	-0.201	-0.089	-0.184

	PMAPA	PNASP	PNIAE	PNOSPA	PNOSPB
PNASP	-0.179				
PNIAE	-0.106	-0.078			
PNOSPA	0.145	0.202	0.092		
PNOSPB	-0.112	-0.063	0.687***	-0.080	
PORIS	-0.129	-0.154	0.467***	0.120	0.235*
PORPA	0.072	-0.134	-0.090	-0.235*	-0.096
POWFU	-0.104	-0.179	0.404***	0.288**	0.184
PPESP	-0.152	0.141	0.043	0.184	0.117
PPRAU	0.000	0.115	-0.088	0.332**	-0.109
PSABE	-0.102	-0.067	0.494***	0.155	0.370***
PTHPL	0.200	-0.200	0.337**	0.095	0.109
TRDE	-0.074	0.043	0.067	0.335**	0.065
SPDI	-0.093	0.067	0.447***	0.442***	0.267**
DEPTH	-0.223*	-0.230*	-0.171	-0.378***	-0.142
GMEAN	0.216*	-0.501***	0.146	-0.316**	0.048
GRAVEL	-0.151	0.500***	-0.109	0.408***	-0.109
GSKEW	-0.092	-0.078	0.033	-0.231*	0.082
GSTD	-0.009	0.466***	-0.329**	0.304**	-0.212*
SAND	0.126	-0.496***	0.090	-0.433***	0.105
SILT	0.307**	0.015	0.240*	0.385***	0.037
SPS	-0.189	0.520***	-0.133	0.340**	-0.031
TKNSMGK	0.222*	0.038	-0.065	0.195	-0.103
TOCGP100	0.452***	0.003	-0.004	0.124	-0.040
TPSMGKG	0.158	0.166	-0.032	0.006	-0.062

	PORIS	PORPA	POWFU	PPESP	PPRAU
PORPA	-0.110				
POWFU	0.746***	-0.148			
PPESP	-0.058	-0.072	0.108		
PPRAU	-0.107	-0.054	-0.056	-0.072	
PSABE	0.073	-0.088	0.048	-0.125	0.140
PTHPL	0.359***	-0.154	0.438***	-0.025	-0.062
TRDE	0.121	-0.132	0.188	0.045	0.265**
SPDI	0.529***	-0.105	0.567***	0.123	0.199
DEPTH	-0.163	0.199	-0.206*	-0.080	-0.255*
GMEAN	0.262**	0.268**	0.241*	-0.218*	-0.331**
GRAVEL	-0.184	-0.197	-0.159	0.181	0.357***
GSKEW	0.117	0.587***	-0.057	0.018	0.058
GSTD	-0.638***	-0.240*	-0.504***	0.149	0.329**
SAND	0.163	0.214*	0.130	-0.177	-0.352***
SILT	0.256*	-0.251*	0.362***	-0.026	-0.018
SPS	-0.276**	-0.310**	-0.241*	0.224*	0.311**
TKNSMGK	-0.105	-0.166	-0.026	-0.024	-0.016
TOCGP100	-0.071	-0.148	-0.051	-0.117	-0.077
TPSMGKG	-0.129	-0.069	-0.205	-0.159	-0.036

	PSABE	PTHPL	TRDE	SPDI
PTHPL	0.177			
TRDE	0.181	-0.001		
SPDI	0.314**	0.394***	0.317**	
DEPTH	-0.201	-0.229*	-0.259*	-0.269**
GMEAN	-0.022	0.233*	-0.211*	-0.101
GRAVEL	0.038	-0.186	0.275**	0.200
GSKEW	-0.213*	-0.169	-0.163	-0.115
GSTD	0.102	-0.237*	0.200	-0.070
SAND	-0.051	0.153	-0.286**	-0.227*
SILT	0.171	0.411***	0.188	0.378***
SPS	0.039	-0.211*	0.210*	0.117
TKNSMGK	-0.001	0.032	0.084	0.024
TOCGP100	0.003	0.120	0.011	-0.070
TPSMGKG	0.068	-0.011	0.060	-0.120

Results of regression between the physical parameters of sediment, depth etc and species diversity, plus some of the common macrofaunal species (log10 (x+1)) which had significant correlations with the parameters measured at the subtidal descriptive macrofauna sites sampled throughout Tauranga Harbour as part of the Tauranga Harbour Regional Plan Project.

Species diversity N: 96 MULTIPLE R: 0.378 SQUARED MULTIPLE R: 0.143
ADJUSTED SQUARED MULTIPLE R: .134 STANDARD ERROR OF ESTIMATE: 3.174

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	5.978	0.406	0.000	.	14.713	0.000
SILT	1.194	0.302	0.378	1.000	3.956	0.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	157.654	1	157.654	15.647	0.000
RESIDUAL	947.085	94	10.075		

Species diversity N: 96 MULTIPLE R: 0.269 SQUARED MULTIPLE R: 0.073
ADJUSTED SQUARED MULTIPLE R: .063 STANDARD ERROR OF ESTIMATE: 3.302

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	8.531	0.674	0.000	.	12.655	0.000
DEPTH	-0.390	0.144	-0.269	1.000	-2.711	0.008

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	80.114	1	80.114	7.350	0.008
RESIDUAL	1024.625	94	10.900		

Austrovenus stutchburyi N: 96 MULTIPLE R: 0.314 SQUARED MULTIPLE R: 0.099
ADJUSTED SQUARED MULTIPLE R: .089 STANDARD ERROR OF ESTIMATE: 0.132

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.123	0.027	0.000	.	4.587	0.000
DEPTH	-0.018	0.006	-0.314	1.000	-3.208	0.002

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.178	1	0.178	10.288	0.002
RESIDUAL	1.627	94	0.017		

Nucula hartvigiana N: 96 MULTIPLE R: 0.249 SQUARED MULTIPLE R: 0.062
ADJUSTED SQUARED MULTIPLE R: .052 STANDARD ERROR OF ESTIMATE: 0.198

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.142	0.040	0.000	.	3.507	0.001
DEPTH	-0.022	0.009	-0.249	1.000	-2.496	0.014

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.244	1	0.244	6.228	0.014
RESIDUAL	3.681	94	0.039		

Notomastus sp. a N: 96 MULTIPLE R: 0.378 SQUARED MULTIPLE R: 0.143
ADJUSTED SQUARED MULTIPLE R: .134 STANDARD ERROR OF ESTIMATE: 0.278

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.491	0.057	0.000	.	8.657	0.000
DEPTH	-0.048	0.012	-0.378	1.000	-3.964	0.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	1.213	1	1.213	15.710	0.000
RESIDUAL	7.256	94	0.077		

Gari stangeri N: 96 MULTIPLE R: 0.430 SQUARED MULTIPLE R: 0.185
ADJUSTED SQUARED MULTIPLE R: .176 STANDARD ERROR OF ESTIMATE: 0.147

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.126	0.024	0.000	.	5.154	0.000
GMEAN	-0.067	0.015	-0.430	1.000	-4.619	0.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.459	1	0.459	21.336	0.000
RESIDUAL	2.020	94	0.021		

Patiriella regularis N: 96 MULTIPLE R: 0.502 SQUARED MULTIPLE R: 0.252
ADJUSTED SQUARED MULTIPLE R: .244 STANDARD ERROR OF ESTIMATE: 0.126

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.141	0.021	0.000	.	6.758	0.000
GMEAN	-0.070	0.012	-0.502	1.000	-5.629	0.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.499	1	0.499	31.683	0.000
RESIDUAL	1.481	94	0.016		

Aglaophamus macroura N: 96 MULTIPLE R: 0.346 SQUARED MULTIPLE R: 0.120
ADJUSTED SQUARED MULTIPLE R: .110 STANDARD ERROR OF ESTIMATE: 0.238

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.058	0.040	0.000	.	1.458	0.148
GMEAN	0.085	0.024	0.346	1.000	3.574	0.001

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.726	1	0.726	12.775	0.001
RESIDUAL	5.342	94	0.057		

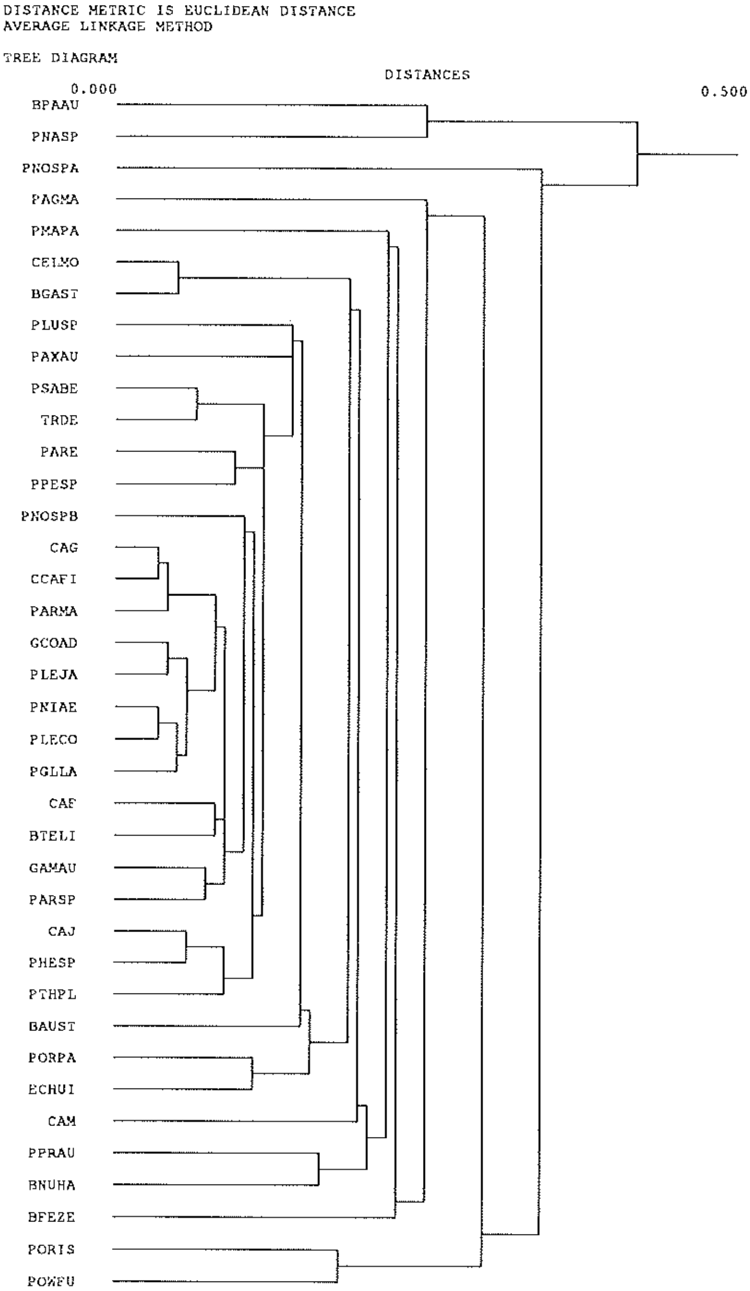
Nainereis sp. N: 96 MULTIPLE R: 0.501 SQUARED MULTIPLE R: 0.251
ADJUSTED SQUARED MULTIPLE R: .243 STANDARD ERROR OF ESTIMATE: 0.363

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.460	0.060	0.000	.	7.610	0.000
GMEAN	-0.202	0.036	-0.501	1.000	-5.609	0.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	4.146	1	4.146	31.460	0.000
RESIDUAL	12.387	94	0.132		

Cluster analysis on site means of log10 (x+1) transformed species abundances recorded at the subtidal descriptive macrofauna sites sampled throughout Tauranga Harbour as part of the Tauranga Harbour Regional Plan Project. Species associations shown.



PCA analysis (co-variance) on site means of log10 (x+1) transformed species abundances recorded at the subtidal descriptive macrofauna sites sampled throughout Tauranga Harbour as part of the Tauranga Harbour Regional Plan Project.

LATENT ROOTS (EIGENVALUES)

1	2	3	4	5	6	7	8	9	10
0.309	0.189	0.100	0.073	0.062	0.048	0.038	0.036	0.031	0.022
11	12	13	14	15	16	17	18	19	20
0.017	0.013	0.010	0.009	0.005	0.000	0.000	0.000	0.000	0.000
21	22	23	24	25	26	27	28	29	30
0.000	0.000	0.000	0.000	0.000	0.000	-0.000	-0.000	-0.000	-0.000
31	32	33	34	35	36	37	38		
-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000		

Component loadings - Bolded scores account for 95.7% of component 1, 75% of comp. 2.

	1	2	3
PNOSPA	-0.038	**0.119**	-0.156
PPRAU	-0.017	0.001	-0.143
BNUHA	-0.021	0.028	-0.141
BPAAU	**-0.330**	0.059	0.084
TRDE	-0.002	0.043	-0.078
PSABE	0.009	0.034	-0.069
BFEZE	0.020	0.048	0.062
PAGMA	**0.075**	-0.045	0.052
PORIS	**0.075**	**0.196**	0.047
POWFU	**0.114**	**0.298**	0.043
PARE	-0.015	-0.013	-0.037
BTELI	-0.033	0.011	-0.030
PAXAU	0.021	0.006	-0.028
PNOSPB	0.014	0.035	0.023
ECHUI	0.016	-0.039	0.023
PARMA	0.009	0.003	-0.021
PORPA	0.015	-0.036	0.020
CAM	0.016	-0.041	0.019
BAUST	**-0.106**	0.018	0.018
PARSP	0.013	-0.005	0.016
PMAPA	0.031	-0.037	-0.015
PGLLA	0.026	0.048	0.013
PLECO	0.019	0.056	0.012
PTHPL	0.042	0.062	0.012
PLUSP	0.014	-0.034	-0.012
CAJ	0.023	0.059	-0.012
PNIAE	0.019	0.046	0.010
CELMO	0.002	-0.030	0.009
GCOAD	0.014	0.026	0.007
PNASP	**-0.389**	0.068	-0.006
CAF	-0.002	0.026	0.006
CAG	0.009	-0.012	0.005
CCAFI	0.008	-0.003	0.005
BGAST	-0.001	-0.021	0.004
GAMAU	0.015	-0.011	0.003
PPESP	-0.017	0.011	-0.002
PLEJA	0.008	0.022	0.002
PHESP	0.037	0.062	0.000

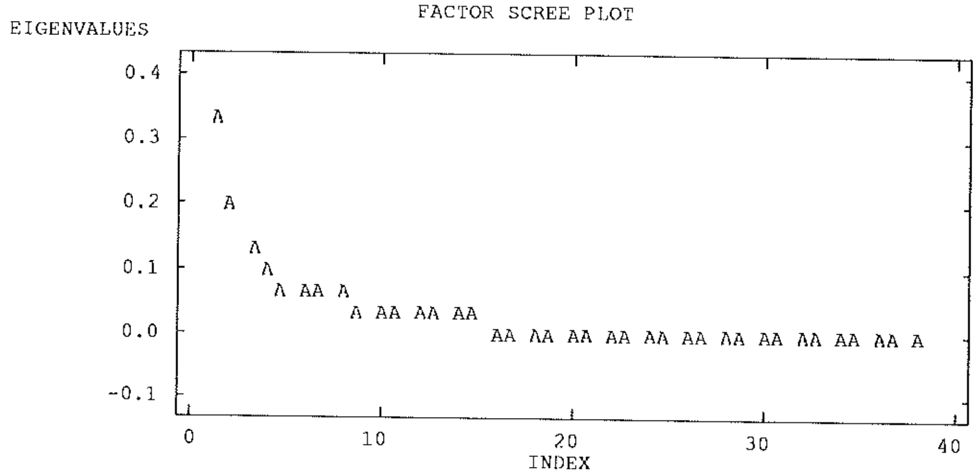
VARIANCE EXPLAINED BY COMPONENTS

1	2	3
0.309	0.189	0.100

PERCENT OF TOTAL VARIANCE EXPLAINED

1	2	3
32.046	19.619	10.417

FACTOR SCREE PLOT



APPENDIX 7

Descriptive statistics for the intertidal macrofauna sites sampled throughout Tauranga Harbour over the summer period 1990/91 as part of the Tauranga Harbour Regional Plan Project. Results are presented as overall harbour wide values for all the habitats sampled.

TOTAL OBSERVATIONS: 640

	ANAU	BAUST	BCOZE	BFEZE	BMAOV
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	67.000	29.000	2.000	20.000	3.000
MEAN	1.992	2.534	0.006	0.319	0.034

	BMYST	BNUHA	BPAAU	BSOPA	BSOSI
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	0.000	52.000	33.000	1.000	5.000
MEAN	0.000	1.977	0.377	0.005	0.078

	BTELI	CAA	CAF	CAG	CAL
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	12.000	1.000	1.000	1.000	0.000
MEAN	2.569	0.005	0.006	0.005	0.000

	CCAFI	CCIA	CELMO	CEXA	CEXB
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	7.000	1.000	16.000	9.000	1.000
MEAN	0.064	0.002	0.188	0.070	0.003

	CHAWH	CHECRA	CHECRE	CISSP	CLYSP
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	4.000	1.000	3.000	1.000	1.000
MEAN	0.131	0.005	0.059	0.002	0.002

	CMAHI	CPASP	CPINO	CPOAU	DEAE
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	4.000	1.000	0.000	1.000	24.000
MEAN	0.173	0.002	0.000	0.002	0.059

	EDTR	FEZE	GACZE	GAMAU	GAMCR
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	3.000	1.000	0.000	1.000	5.000
MEAN	0.019	0.002	0.000	0.003	0.052

	GAMGL	GCOGL	GDISU	GEPTE	GHAZE
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	4.000	34.000	9.000	1.000	1.000
MEAN	0.036	0.480	0.308	0.002	0.008

	GMIHU	GNESI	GNOHE	GTUSM	GXYPL
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	14.000	2.000	5.000	0.000	1.000
MEAN	0.302	0.016	0.048	0.000	0.006

	GZELU	GZESU	ISOL	NEMERT	PAGMA
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	13.000	24.000	1.000	1.000	1.000
MEAN	1.133	0.605	0.002	0.039	0.009

	PARE	PARMA	PASTH	PAXAU	PBOSY
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	2.000	1.000	1.000	5.000	1.000
MEAN	0.006	0.005	0.006	0.161	0.017

	PEUSP	PGLLA	PHESP	PLEAC	PLEJA
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	1.000	2.000	1.000	1.000	1.000
MEAN	0.002	0.066	0.005	0.016	0.002

	PLUSP	PMADA	PNASP	PNIAE	PNOSPA
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	1.000	3.000	11.000	2.000	9.000
MEAN	0.003	0.031	0.178	0.017	0.323

	PNOSPB	PONPA	PORIS	PORSP	POWFU
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	1.000	4.000	0.000	6.000	3.000
MEAN	0.003	0.059	0.000	0.084	0.067

	PPENU	PPOCA	PPOSPB	PPRAU	PSABE
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	9.000	0.500	1.000	23.000	2.000
MEAN	0.398	0.002	0.006	0.242	0.014

	PSCBE	PSCSP	PSCSPA	PSYSP	PTHPL
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	7.000	27.000	2.000	0.000	2.000
MEAN	0.402	1.150	0.003	0.000	0.014

	PTHSP	TRDE	TUBIFICI
MINIMUM	0.000	0.000	0.000
MAXIMUM	2.000	1.000	2.000
MEAN	0.008	0.006	0.008

Pearson correlations on species abundances (Log10 X+1) found in samples recorded at the descriptive macrofauna sites from throughout Tauranga Harbour over the summer period in 1990/91 as part of the Tauranga Harbour Regional Plan Project.

	ANAU	BAUST	BFEZE	BMAOV	BNUHA
BAUST	**0.504*** **				
BFEZE	-0.072	-0.175***			
BMAOV	0.024	0.034	-0.033		
BNUHA	0.186***	**0.285*** **	0.129**	0.036	
BPAAU	-0.037	-0.095*	-0.055	0.040	-0.025
BSOSI	0.115**	0.069	0.131**	0.006	0.119**
BTELI	**0.290*** **	**0.357*** **	-0.070	-0.047	0.180***
CCAFI	-0.061	-0.076	**0.450*** **	-0.022	-0.073
CELMO	0.064	0.141***	-0.035	0.232***	-0.024
CEXA	-0.033	0.029	0.049	-0.024	-0.027
CHAWH	0.074	0.140***	-0.000	-0.049	0.227***
CHECRE	0.010	0.135**	0.018	-0.006	0.113**
CMAHI	-0.058	-0.097*	-0.041	0.043	-0.044
GAMCR	-0.095	-0.135**	-0.037	-0.025	-0.084*
GAMGL	0.030	0.031	-0.029	0.005	0.093*
GCOGL	0.178***	0.185***	-0.049	0.019	0.186***
GDISU	0.136**	**0.262*** **	-0.059	-0.021	0.133**
GMIHU	0.077	0.207***	0.024	0.063	**0.461*** **
GNESI	0.090*	0.117**	-0.025	-0.017	0.080*
GNOHE	0.187***	0.237***	-0.035	-0.024	0.027
GZELU	0.028	0.029	-0.079*	-0.007	0.005
GZESU	**0.338*** **	**0.380*** **	-0.071	-0.015	0.151***
PAXAU	0.102**	0.113**	0.180***	-0.016	0.233***
PBOSY	0.089*	0.097*	-0.029	-0.020	0.121**
PGLLA	0.043	-0.021	0.126**	0.017	0.130**
PLEAC	0.094*	0.080*	0.049	-0.019	0.104**
PMADA	0.146***	0.097*	-0.013	-0.022	0.041
PNASP	0.020	0.084*	0.064	-0.006	-0.035
PNOSPA	0.082*	0.059	0.006	0.103**	0.055
PONPA	-0.011	0.014	0.155***	-0.029	0.196***
PORSP	0.050	0.061	0.081*	-0.036	0.021
POWFU	0.158***	0.135**	0.048	0.009	0.205***
PPENU	-0.073	-0.122**	-0.092*	-0.056	-0.137***
PPRAU	0.150***	0.147***	0.022	0.035	0.008
PSCBE	-0.027	-0.120**	-0.106**	-0.046	-0.143***
PSCSP	-0.007	-0.093	-0.110**	-0.002	-0.191***

	BPAAU	BSOSI	BTELI	CCAFI	CELMO
BSOSI	-0.037				
BTELI	-0.172***	0.062			
CCAFI	-0.038	-0.029	-0.113**		
CELMO	-0.002	0.009	0.015	-0.023	
CEXA	0.084*	-0.032	-0.069	0.016	0.058
CHAWH	-0.013	-0.029	0.068	-0.046	0.059
CHECRE	0.003	-0.003	0.037	0.003	0.026
CMAHI	-0.066	-0.019	-0.169***	-0.027	-0.030
GAMCR	0.108**	-0.012	-0.186***	-0.024	0.131**
GAMGL	**0.436*** **	-0.026	-0.062	-0.019	-0.011
GCOGL	0.023	0.070	0.063	-0.024	0.002
GDISU	-0.039	-0.048	0.199***	-0.062	0.011
GMIHU	-0.056	-0.053	0.087*	-0.044	-0.026
GNESI	-0.031	-0.023	0.073	-0.016	0.001
GNOHE	0.001	-0.032	0.137***	-0.022	0.009
GZELU	-0.119**	0.021	0.145***	-0.073	0.053
GZESU	-0.044	0.144***	0.125**	-0.055	0.125**
PAXAU	-0.049	0.025	0.100*	0.064	-0.034
PBOSY	-0.015	0.013	0.058	0.049	0.035
PGLLA	-0.002	0.140***	-0.046	0.009	-0.030
PLEAC	-0.034	0.017	0.045	-0.018	-0.004
PMADA	-0.039	0.044	0.117**	0.031	0.011
PNASP	0.056	0.154***	-0.041	0.135**	0.044
PNOSPA	0.188***	0.027	-0.002	-0.004	0.096*
PONPA	-0.031	0.076	0.069	-0.027	-0.014
PORSP	-0.018	0.040	0.108**	0.111**	-0.017
POWFU	-0.052	0.009	0.040	0.012	-0.009
PPENU	0.043	0.039	-0.193***	-0.066	0.023
PPRAU	0.131**	0.033	0.006	-0.010	0.053
PSCBE	-0.051	-0.021	-0.062	-0.041	0.066
PSCSP	-0.036	0.032	0.062	-0.060	0.046

	CEXA	CHAWH	CHECRE	CMAHI	GAMCR
CHAWH	0.025				
CHECRE	0.052	0.122**			
CMAHI	-0.047	0.026	0.025		
GAMCR	-0.026	0.027	-0.038	0.070	
GAMGL	-0.001	-0.011	0.086*	-0.050	-0.022
GCOGL	0.007	0.038	0.029	0.040	-0.017
GDISU	-0.019	0.127**	0.220***	0.031	-0.072
GMIHU	0.006	0.243***	0.115**	0.013	-0.050
GNESI	-0.018	0.140***	-0.026	-0.016	-0.019
GNOHE	-0.025	0.023	0.059	-0.035	-0.026
GZELU	-0.047	-0.032	-0.064	-0.049	-0.036
GZESU	0.003	0.167***	0.077	-0.087*	-0.063
PAXAU	0.008	0.178***	0.090*	-0.043	-0.054
PBOSY	0.020	0.023	0.019	-0.021	-0.022
PGLLA	-0.016	-0.007	0.057	-0.000	-0.039
PLEAC	-0.020	-0.006	-0.029	-0.048	-0.021
PMADA	0.002	0.057	-0.003	-0.020	-0.024
PNASP	**0.488*** **	0.040	0.035	-0.065	-0.040
PNOSPA	-0.013	0.029	0.070	0.075	0.032
PONPA	-0.030	0.115**	0.020	-0.044	-0.032
PORSP	-0.037	0.056	-0.054	-0.090*	-0.039
POWFU	-0.012	-0.024	-0.044	-0.012	-0.032
PPENU	-0.006	0.040	-0.009	0.066	0.101*
PPRAU	-0.035	0.081*	0.100*	-0.000	-0.037
PSCBE	-0.075	-0.058	-0.072	0.066	0.113**
PSCSP	-0.063	-0.074	0.011	0.017	0.003

	GAMGL	GCOGL	GDISU	GMIHU	GNESI
GCOGL	0.069				
GDISU	0.020	0.126**			
GMIHU	0.013	0.085	0.220***		
GNESI	0.111**	0.126**	0.129**	0.146***	
GNOHE	0.145***	0.074	0.277***	0.174***	0.353***
GZELU	-0.020	0.046	0.039	-0.116**	0.012
GZESU	0.026	0.067	0.149***	-0.001	0.089*
PAXAU	0.064	0.004	-0.007	0.102*	-0.010
PBOSY	-0.017	-0.057	0.042	-0.020	0.073
PGLLA	0.013	0.007	0.013	0.038	0.061
PLEAC	-0.017	0.019	-0.032	0.005	0.078*
PMADA	-0.019	0.004	-0.037	0.004	-0.017
PNASP	-0.019	-0.029	-0.000	-0.074	0.031
PNOSPA	0.101*	0.026	-0.030	-0.022	0.042
PONPA	-0.025	-0.008	0.030	0.175***	0.067
PORSP	-0.031	0.012	-0.069	-0.072	-0.027
POWFU	-0.026	0.077	-0.029	0.097*	0.084*
PPENU	-0.011	0.031	-0.027	-0.039	-0.026
PPRAU	0.043	0.025	0.005	-0.028	0.010
PSCBE	-0.060	0.014	-0.022	-0.091*	-0.042
PSCSP	-0.011	0.015	0.005	-0.148***	-0.035

	GNOHE	GZELU	GZESU	PAXAU	PBOSY
GZELU	-0.024				
GZESU	0.036	-0.076			
PAXAU	-0.039	-0.047	0.068		
PBOSY	-0.021	-0.018	0.257***	0.200***	
PGLLA	-0.006	-0.067	-0.007	0.174***	0.061
PLEAC	-0.020	0.028	-0.004	0.310***	0.177***
PMADA	-0.023	-0.024	0.178***	0.118**	0.205***
PNASP	-0.020	-0.050	0.119**	-0.025	0.036
PNOSPA	0.021	0.052	0.026	0.114**	0.129**
PONPA	-0.030	-0.102**	-0.025	-0.048	-0.025
PORSP	-0.037	-0.016	0.038	0.070	-0.031
POWFU	-0.031	-0.067	0.075	0.276***	0.282***
PPENU	-0.028	0.130**	-0.049	-0.158***	-0.075
PPRAU	0.028	0.016	0.040	0.119**	0.077
PSCBE	-0.066	0.130**	-0.061	-0.122**	-0.070
PSCSP	-0.036	0.302***	-0.086*	-0.144***	-0.054

	PGLLA	PLEAC	PMADA	PNASP	PNOSPA
PLEAC	0.116**				
PMADA	-0.034	0.040			
PNASP	0.053	0.041	0.050		
PNOSPA	0.077	0.123**	0.058	0.026	
PONPA	0.060	-0.024	-0.028	-0.033	-0.031
PORSP	0.064	0.012	-0.034	0.142***	-0.017
POWFU	0.210***	0.350***	0.065	-0.047	0.074
PPENU	-0.071	-0.072	-0.083*	-0.048	0.040
PPRAU	0.076	0.219***	0.192**	0.016	0.281***
PSCBE	-0.063	-0.067	-0.029	-0.099*	0.043
PSCSP	-0.099*	-0.031	-0.072	-0.043	0.054

	PONPA	PORSP	POWFU	PPENU	PPRAU	PSCBE
PORSP	-0.045					
POWFU	-0.038	0.012				
PPENU	0.015	-0.059	-0.111**			
PPRAU	-0.043	-0.014	0.108**	-0.022		
PSCBE	-0.076	-0.062	-0.065	0.253***	-0.052	
PSCSP	-0.090*	-0.096	-0.075	0.156***	-0.032	0.338***

NUMBER OF OBSERVATIONS: 640 * = prob. <0.05, ** = prob. <0.01, *** = <0.001

BARTLETT CHI-SQUARE STATISTIC: 3353.394 DF= 666 PROB= .000

Pearson correlation between the mean numbers of polycheates and bivalves found at each descriptive intertidal macrofauna site throughout Tauranga Harbour.

	BIVALVES	POLYS
BIVALVES	1.000	
POLYS	-0.066	1.000

NUMBER OF OBSERVATIONS: 160

APPENDIX 8

Tauranga Harbour descriptive data analysis - differences between macrofauna for tide heights and presence/absence of zostera.

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE WITH 640 CASES FOR ALL FOLLOWING VARIABLES

First grouping variable tested for differences between mid tide and low tide.

```
     GROUP      COUNT    RANK SUM        Species Diversity
      1.000    304     94843.000
      2.000    336    110277.000

MANN-WHITNEY U TEST STATISTIC =  48483.0   PROB  0.264, CHI-SQUARE APPROX =   1.245,  1 DF

     GROUP      COUNT    RANK SUM        Anthopleura aureoradiata
      1.000    304     98695.000
      2.000    336    106425.000

MANN-WHITNEY U TEST STATISTIC =  52335.0   PROB  0.516, CHI-SQUARE APPROX =   0.422,  1 DF

     GROUP      COUNT    RANK SUM        Nucula hartvigiana
      1.000    304     84610.000
      2.000    336    120510.000

MANN-WHITNEY U TEST STATISTIC =  38250.0   PROB  0.000, CHI-SQUARE APPROX =  51.443,  1 DF

     GROUP      COUNT    RANK SUM        Austrovenus stutchburyi
      1.000    304     94744.000
      2.000    336    110376.000

MANN-WHITNEY U TEST STATISTIC =  48384.0   PROB  0.226, CHI-SQUARE APPROX =   1.467,  1 DF

     GROUP      COUNT    RANK SUM        Felaniella zelandica
      1.000    304     95191.000
      2.000    336    109929.000

MANN-WHITNEY U TEST STATISTIC =  48831.0   PROB  0.019, CHI-SQUARE APPROX =   5.487,  1 DF

     GROUP      COUNT    RANK SUM        Paphies australis
      1.000    304     97242.000
      2.000    336    107878.000

MANN-WHITNEY U TEST STATISTIC =  50882.0   PROB  0.872, CHI-SQUARE APPROX =   0.026,  1 DF

     GROUP      COUNT    RANK SUM        Tellina liliana
      1.000    304     93881.500
      2.000    336    111238.500

MANN-WHITNEY U TEST STATISTIC =  47521.5   PROB  0.124, CHI-SQUARE APPROX =   2.371,  1 DF

     GROUP      COUNT    RANK SUM        Halicarcinus whitei
      1.000    304     96580.500
      2.000    336    108539.500

MANN-WHITNEY U TEST STATISTIC =  5220.5 PROB  0.489, CHI-SQUARE APPROX =   0.478,  1 DF

     GROUP      COUNT    RANK SUM        Macrophthalmus hirtipes
      1.000    304    101121.000
      2.000    336    103999.000

MANN-WHITNEY U TEST STATISTIC =  54761.0   PROB  0.008, CHI-SQUARE APPROX =   7.052,  1 DF

     GROUP      COUNT    RANK SUM        Micrelenchus huttoni
      1.000    304     93925.000
      2.000    336    111195.000

MANN-WHITNEY U TEST STATISTIC =  47565.0   PROB  0.004, CHI-SQUARE APPROX =   8.205,  1 DF

     GROUP      COUNT    RANK SUM        Zeacumantus lutulentus
      1.000    304    102511.000
      2.000    336    102609.000

MANN-WHITNEY U TEST STATISTIC =  56151.0   PROB  0.015, CHI-SQUARE APPROX =   5.905,  1 DF

     GROUP      COUNT    RANK SUM        Macroclymenella stewartensis
      1.000    304     91583.000
      2.000    336    113537.000

MANN-WHITNEY U TEST STATISTIC =  45223.0   PROB  0.000, CHI-SQUARE APPROX =  21.941,  1 DF

     GROUP      COUNT    RANK SUM        Perinereis nuntia
      1.000    304    103943.500
      2.000    336    101176.500

MANN-WHITNEY U TEST STATISTIC =  57583.5   PROB  0.000, CHI-SQUARE APPROX =  12.845,  1 DF

     GROUP      COUNT    RANK SUM        Aquilaspio aucklandica
      1.000    304     95451.000
      2.000    336    109669.000

MANN-WHITNEY U TEST STATISTIC =  49091.0   PROB  0.038, CHI-SQUARE APPROX =   4.288,  1 DF

     GROUP      COUNT    RANK SUM        Scolecolepides benhami
      1.000    304    101466.500
      2.000    336    103653.500

MANN-WHITNEY U TEST STATISTIC =  55106.5   PROB  0.022, CHI-SQUARE APPROX =   5.247,  1 DF
```

```
GROUP       COUNT   RANK SUM        Scolecolepides sp.
    1.000   304   101668.500
    2.000   336   103451.500

MANN-WHITNEY U TEST STATISTIC =  55308.5   PROB  0.015, CHI-SQUARE APPROX =   5.884,  1 DF
```

Second grouping variable tested for differences is presence/absence of Zostera.

```
GROUP       COUNT   RANK SUM        Species diversity
    0.000   524   162321.500
    1.000   116    42798.500

MANN-WHITNEY U TEST STATISTIC =  24771.5   PROB  0.002, CHI-SQUARE APPROX =   9.863,  1 DF

GROUP       COUNT   RANK SUM        Anthopleura aureoradiata
    0.000   524   168807.000
    1.000   116    36313.000

MANN-WHITNEY U TEST STATISTIC =  31257.0   PROB  0.564, CHI-SQUARE APPROX =   0.332,  1 DF

GROUP       COUNT   RANK SUM        Nucula hartvigiana
    0.000   524   162452.500
    1.000   116    42667.500

MANN-WHITNEY U TEST STATISTIC =  24902.5   PROB  0.000, CHI-SQUARE APPROX =  15.846,  1 DF

GROUP       COUNT   RANK SUM        Austrovenus stutchburyi
    0.000   524   168478.500
    1.000   116    36641.500

MANN-WHITNEY U TEST STATISTIC =  30928.5   PROB  0.754, CHI-SQUARE APPROX =   0.098,  1 DF

GROUP       COUNT   RANK SUM        Felaniella zelandica
    0.000   524   164668.000
    1.000   116    40452.000

MANN-WHITNEY U TEST STATISTIC =  27118.0   PROB  0.000, CHI-SQUARE APPROX =  19.680,  1 DF

GROUP       COUNT   RANK SUM        Paphies australis

    0.000   524   169831.500
    1.000   116    35288.500

MANN-WHITNEY U TEST STATISTIC =  32281.5   PROB  0.038, CHI-SQUARE APPROX =   4.302,  1 DF

GROUP       COUNT   RANK SUM        Tellina liliana
    0.000   524   170494.500
    1.000   116    34625.500

MANN-WHITNEY U TEST STATISTIC =  32944.5   PROB  0.151, CHI-SQUARE APPROX =   2.059,  1 DF

GROUP       COUNT   RANK SUM        Halicarcinus whitei
    0.000   524   160547.500
    1.000   116    44572.500

MANN-WHITNEY U TEST STATISTIC =  22997.5   PROB  0.000, CHI-SQUARE APPROX =  60.584,  1 DF

GROUP       COUNT   RANK SUM        Macrophthalmus hirtipes
    0.000   524   167357.500
    1.000   116    37762.500

MANN-WHITNEY U TEST STATISTIC =  29807.5   PROB  0.585, CHI-SQUARE APPROX =   0.298,  1 DF

GROUP       COUNT   RANK SUM        Micrelenchus huttoni
    0.000   524   160231.500
    1.000   116    44888.500

MANN-WHITNEY U TEST STATISTIC =  22681.5   PROB  0.000, CHI-SQUARE APPROX =  66.651,  1 DF

GROUP       COUNT   RANK SUM        Zeacumantus lutulentus
    0.000   524   170557.500
    1.000   116    34562.500

MANN-WHITNEY U TEST STATISTIC =  33007.5   PROB  0.105, CHI-SQUARE APPROX =   2.631,  1 DF

GROUP       COUNT   RANK SUM        Macroclymenella stewartensis
    0.000   524   166191.000
    1.000   116    38929.000

MANN-WHITNEY U TEST STATISTIC =  28641.0   PROB  0.069, CHI-SQUARE APPROX =   3.304,  1 DF

GROUP       COUNT   RANK SUM        Perinereis nuntia
    0.000   524   164957.500
    1.000   116    40162.500

MANN-WHITNEY U TEST STATISTIC =  27407.5   PROB  0.033, CHI-SQUARE APPROX =   4.534,  1 DF

GROUP       COUNT   RANK SUM        Aquilaspio aucklandica
    0.000   524   166963.500
    1.000   116    38156.500

MANN-WHITNEY U TEST STATISTIC =  29413.5   PROB  0.185, CHI-SQUARE APPROX =   1.758,  1 DF

GROUP       COUNT   RANK SUM        Scolecolepides benhami
    0.000   524   170659.000
    1.000   116    34461.000

MANN-WHITNEY U TEST STATISTIC =  33109.0   PROB  0.046, CHI-SQUARE APPROX =   3.999,  1 DF

GROUP       COUNT   RANK SUM        Scolecolepides sp.
    0.000   524   172231.500
    1.000   116    32888.500
```

MANN-WHITNEY U TEST STATISTIC = 34681.5, PROB 0.001, CHI-SQUARE APPROX = 10.137, 1 DF

Descriptive statistics (on site means) for macrofauna showing significant variation in abundance between habitats in which they were collected from sites throughout Tauranga Harbour over the summer period 1990/91.

(A) Bare substrate - mid-tide sites. (N=252)

	BFEZE	BNUHA	CHAWH	CMAHI	GMIHU
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	3.750	10.750	0.750	1.250	2.250
MEAN	0.071	0.627	0.056	0.214	0.147
STANDARD DEV	0.476	1.911	0.138	0.339	0.493
C.V.	6.665	3.048	2.484	1.580	3.359

	GZELU	PAXAU	PSCBE	PSCSP	SPDI
MINIMUM	0.000	0.000	0.000	0.000	1.250
MAXIMUM	9.000	1.500	2.750	9.250	11.500
MEAN	1.274	0.060	0.468	1.341	5.250
STANDARD DEV	1.796	0.249	0.636	2.294	2.273
C.V.	1.410	4.181	1.358	1.710	0.433

(B) Bare substrate - low-tide sites. (N=272)

	BFEZE	BNUHA	CHAWH	CMAHI	GMIHU
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	13.000	23.750	2.000	2.750	7.500
MEAN	0.265	2.412	0.088	0.140	0.195
STANDARD DEV	1.610	5.540	0.286	0.397	1.025
C.V.	6.083	2.297	3.238	2.840	5.259

	GZELU	PAXAU	PSCBE	PSCSP	SPDI
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	7.500	2.000	3.000	17.750	12.750
MEAN	1.040	0.235	0.401	1.279	5.404
STANDARD DEV	1.605	0.444	0.706	3.214	2.621
C.V.	1.543	1.889	1.762	2.512	0.485

(C) Zostera mid-tide sites. (N=52)

	BFEZE	BNUHA	CHAWH	CMAHI	GMIHU
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	12.750	0.500	2.000	0.500	2.000
MEAN	0.981	0.058	0.385	0.192	0.212
STANDARD DEV	3.536	0.150	0.565	0.232	0.558
C.V.	3.606	2.596	1.468	1.205	2.636

	GZELU	PAXAU	PSCBE	PSCSP	SPDI
MINIMUM	0.000	0.000	0.000	0.000	4.000
MAXIMUM	7.250	0.750	2.250	7.000	9.500
MEAN	1.654	0.096	0.462	0.865	5.942
STANDARD DEV	2.540	0.240	0.644	2.002	1.678
C.V.	1.536	2.498	1.396	2.313	0.282

(D) Zostera low-tide sites. (N=64)

	BFEZE	BNUHA	CHAWH	CMAHI	GMIHU
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	12.000	38.750	1.750	0.500	5.500
MEAN	0.984	7.000	0.406	0.141	1.438
STANDARD DEV	2.976	9.939	0.446	0.182	1.682
C.V.	3.023	1.420	1.098	1.293	1.170

	GZELU	PAXAU	PSCBE	PSCSP	SPDI
MINIMUM	0.000	0.000	0.000	0.000	4.250
MAXIMUM	3.000	1.750	0.500	1.000	12.750
MEAN	0.547	0.297	0.094	0.078	6.406
STANDARD DEV	0.818	0.534	0.180	0.254	2.177
C.V.	1.495	1.799	1.917	3.246	0.340

APPENDIX 9

PCA (covariance) on macrofauna abundance (means of log10 x+1 values) for species occurring in 5% or more of 160 descriptive sites sampled throughout Tauranga Harbour.

LATENT ROOTS (EIGENVALUES)

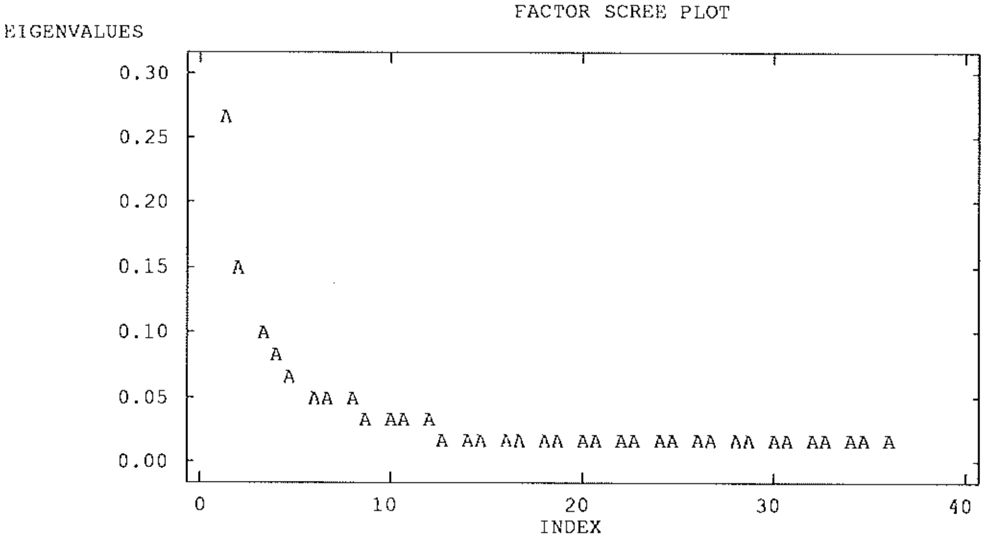
1	2	3	4	5	6	7	8	9	10
0.267	0.135	0.097	0.067	0.055	0.048	0.043	0.038	0.029	0.027
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
0.024	0.018	0.016	0.015	0.014	0.013	0.011	0.010	0.009	0.008
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.002	0.002
31	**32**	**33**	**34**	**35**	**36**				
0.002	0.002	0.001	0.001	0.001	0.001				

COMPONENT LOADINGS

	1	2	3
GZELU	0.001	**-0.095**	-0.163
PSCSP	-0.061	**-0.157**	-0.162
BNUHA	**0.234**	**0.240**	-0.149
BTELI	**0.152**	**-0.083**	-0.074
ANAU	**0.240**	**-0.123**	0.055
GZESU	**0.109**	-0.024	0.052
PSCBE	-0.035	-0.047	-0.048
BAUST	**0.302**	-0.078	0.044
GNOHE	0.083	-0.045	0.043
BPAAU	-0.019	0.021	0.032
GMIHU	0.064	0.064	-0.024
PNASP	0.007	-0.001	0.023
PPENU	-0.038	-0.023	-0.021
GAMGL	0.025	0.026	0.021
PPRAU	0.021	-0.010	0.020
PMADA	0.029	-0.007	0.018
GCOGL	0.042	-0.001	-0.015
CEXA	-0.002	0.005	0.011
CCAFI	-0.009	0.008	0.010
PNOSPA	0.016	-0.008	-0.008
PBOSY	0.019	0.003	0.007
CHAWH	0.022	0.018	-0.006
BSOSI	0.012	0.001	-0.004
GNESI	0.023	-0.005	0.004
PLEAC	0.015	0.006	-0.004
PORSP	0.006	-0.000	0.004
GDISU	0.050	-0.011	-0.004
PONPA	0.006	0.017	-0.004
GAMCR	-0.013	0.003	0.004
CMAHI	-0.014	0.005	-0.003
PAXAU	0.028	0.025	-0.002
BFEZE	-0.013	0.055	-0.002
BMAOV	0.010	0.001	-0.001
PGLLA	0.006	0.013	0.001
POWFU	0.018	0.009	0.000
CHECRE	0.011	0.006	0.000

	1	2	3
VARIANCE EXPLAINED BY COMPONENTS	0.267	0.135	0.097
PERCENT OF TOTAL VARIANCE EXPLAINED	26.759	13.575	9.718

FACTOR SCREE PLOT



APPENDIX 10

Descriptive statistics for species diversity and sediment parameters for the intertidal macrofaunal descriptive sites sampled throughout Tauranga Harbour over the summer period 1990/91 as part of the Tauranga Harbour Regional Plan Project.

	SPDI	GMEAN	SAND	SILT	GRAVEL	SPS	TOC	TKN	TP
N OF CASES	37	38	38	38	38	38	37	38	38
MINIMUM	0.00	0.72	48.00	0.00	0.00	0.40	0.01	69.00	35.00
MAXIMUM	11.30	3.26	100.00	40.00	20.00	3.01	0.42	578.00	302.00
MEAN	5.02	2.13	87.53	8.55	3.66	1.19	0.12	244.74	123.90
STANDARD DEV	2.23	0.52	12.00	9.18	4.50	0.47	0.07	131.81	64.494
C.V.	0.44	0.24	0.14	1.07	1.23	0.40	0.57	0.54	0.52

Pearson correlations between the factor scores of principal component 1 for the PCA of macrofauna species and the sediment parameters and species diversity for the macrofauna sites at which all these parameters were measured.

	FACT1
GMEAN	-0.143
GRAVEL	0.142
GSKEW	-0.070
GSTD	-0.098
SAND	0.189
SILT	-0.296
SPDI	**0.691*** **
SPS	0.124
TKN	-0.209
TOC	-0.298
TP	-0.283

N = 36 list-wise deletion used.

Pearson correlations for macrofauna species abundances (log10 x+1) from the intertidal descriptive macrofauna sites which have sediment data available. Only species which showed significant correlations have been presented.

	BAUST	BNUHA	BTELI	CEXA	CHECRE
GSKEW	0.248**	-0.080	-0.356***	0.180	0.216*
GSTD	0.018	0.050	0.315***	-0.186	-0.136
GMEAN	-0.128	-0.106	-0.000	-0.286**	-0.123
GRAVEL	0.206*	0.069	-0.233**	0.235**	0.217*
SAND	0.124	0.131	0.226**	0.017	0.004
SILT	-0.239**	-0.191*	-0.187*	-0.132	-0.104
OSI	-0.228**	-0.200*	-0.231**	-0.105	-0.079
TOC	-0.241**	-0.217*	-0.251**	-0.117	-0.067
TKN	-0.173*	-0.267**	-0.106	-0.103	-0.070
TP	-0.256**	-0.233**	-0.127	-0.029	-0.054

	CMAHI	GAMCR	GAMGL	GCOGL	GMIHU
GSKEW	0.085	0.010	0.258**	-0.042	0.018
GSTD	-0.005	0.008	-0.211*	0.167	0.240**
GMEAN	0.303***	0.225**	-0.080	-0.012	0.063
GRAVEL	-0.061	-0.123	0.260**	-0.062	-0.125
SAND	-0.152	-0.050	-0.088	0.195	0.225**
SILT	0.215*	0.132	-0.009	-0.207*	-0.222**
OSI	0.454***	0.434***	0.002	-0.169	-0.147
TOC	0.474***	0.421***	-0.001	-0.148	-0.186
TKN	0.285**	0.285**	0.042	-0.172	-0.255**
TP	0.352***	0.226**	0.014	-0.217*	-0.240**

	GZESU	PNASP	PNOSPA	PSCSP	SPDI
GSKEW	0.207	0.222**	-0.063	-0.165	-0.007
GSTD	-0.011	-0.263**	-0.023	-0.080	0.104
GMEAN	-0.214*	-0.287**	0.279**	-0.063	-0.059
GRAVEL	0.151	0.303***	-0.137	-0.102	-0.033
SAND	0.099	-0.045	-0.159	0.019	0.241**
SILT	-0.195*	-0.086	0.271**	0.039	-0.268**
OSI	-0.127	-0.072	0.568***	0.045	-0.152
TOC	-0.144	-0.074	0.551***	0.016	-0.126
TKN	-0.104	-0.067	0.357***	0.213*	-0.125
TP	-0.125	-0.009	0.404***	0.066	-0.171

NUMBER OF OBSERVATIONS: 140

Regression of species diversity at intertidal descriptive macrofauna sites in Tauranga Harbour and the common species which showed the strongest correlations with any of the sediment parameters.

Species diversity N: 144 MULTIPLE R: 0.199 SQUARED MULTIPLE R: 0.040
ADJUSTED SQUARED MULTIPLE R: .033 STANDARD ERROR OF ESTIMATE: 2.410

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	1.289	1.473	0.000	.	0.875	0.383
SAND	0.040	0.017	0.199	1.000	2.423	0.017

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	34.103	1	34.103	5.873	0.017
RESIDUAL	824.556	142	5.807		

Species diversity N: 144 MULTIPLE R: 0.226 SQUARED MULTIPLE R: 0.051
ADJUSTED SQUARED MULTIPLE R: .044 STANDARD ERROR OF ESTIMATE: 2.396

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	5.323	0.269	0.000	.	19.813	0.000
SILT	-0.060	0.022	-0.226	1.000	-2.762	0.007

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	43.781	1	43.781	7.629	0.007
RESIDUAL	814.878	142	5.739		

Austrovenus stutchburyi N: 144 MULTIPLE R: 0.215 SQUARED MULTIPLE R: 0.046
ADJUSTED SQUARED MULTIPLE R: .039 STANDARD ERROR OF ESTIMATE: 0.354

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.350	0.040	0.000	.	8.799	0.000
SILT	-0.008	0.003	-0.215	1.000	-2.617	0.010

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.860	1	0.860	6.851	0.010
RESIDUAL	17.824	142	0.126		

Nucula hartvigiana N: 148 MULTIPLE R: 0.250 SQUARED MULTIPLE R: 0.063
ADJUSTED SQUARED MULTIPLE R: .056 STANDARD ERROR OF ESTIMATE: 0.395

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.436	0.068	0.000	.	6.373	0.000
TKN	-0.001	0.000	-0.250	1.000	-3.120	0.002

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	1.522	1	1.522	9.736	0.002
RESIDUAL	22.818	146	0.156		

Tellina liliana N: 144 MULTIPLE R: 0.226 SQUARED MULTIPLE R: 0.051
ADJUSTED SQUARED MULTIPLE R: .044 STANDARD ERROR OF ESTIMATE: 0.322

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.631	0.054	0.000	.	11.640	0.000
TOC	-1.060	0.383	-0.226	1.000	-2.764	0.006

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.789	1	0.789	7.637	0.006
RESIDUAL	14.678	142	0.103		

Macrophthalmus hirtipes N: 148 MULTIPLE R: 0.291 SQUARED MULTIPLE R: 0.085
ADJUSTED SQUARED MULTIPLE R: .078 STANDARD ERROR OF ESTIMATE: 0.099

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	-0.085	0.034	0.000	.	-2.472	0.015
GMEAN	0.058	0.016	0.291	1.000	3.672	0.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.132	1	0.132	13.484	0.000
RESIDUAL	1.425	146	0.010		

Macrophthalmus hirtipes N: 144 MULTIPLE R: 0.509 SQUARED MULTIPLE R: 0.260
ADJUSTED SQUARED MULTIPLE R: .254 STANDARD ERROR OF ESTIMATE: 0.090

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	-0.054	0.015	0.000	.	-3.567	0.000
TOC	0.757	0.107	0.509	1.000	7.055	0.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.402	1	0.402	49.770	0.000
RESIDUAL	1.148	142	0.008		

APPENDIX 11

Length-frequency data for shellfish collected at macrofauna monitoring sites in Tauranga Harbour.

Appendix 11 Frequency counts of the size classes of cockles (Austrovenus stutchburyi) collected from sites throughout Tauranga Harbour over the summer (1990/91) at the mid and low water neap tide levels as part of the Tauranga Harbour Regional Plan Project.

SITE	SIZE CLASS INTERVAL MID POINTS (mm)										
	2.5	7.5	12.5	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5
1				3	1						
2		2	5	8	6						
3											
4											
5				3	3	1	11	14	1		
6		1	2	2	6	10	2				
7				1	1	7	1				
8					3	19	4				
9		3	2	1	7	8					
10		12	17	17	6						
11		2	2	3	1	2					
12		3	9	6	6	1					
13				3	3						
14			3	5							
15		2	5	35	7	1					
16											
17		1	1	1	2	4					
18		1		1	9						
19											
20											
21											
22				2	5						
23		2		4	3						
24				2							
25											
26					1						
27				1							
28					1						
29					1						
30				5	6						
31											
32											
33											
34				5	6						
35		3	4	3	3						
36											
37											
38											
39		1		1	1						
40				1	1						
41		1			3						
42											
43		1	2	11							
44	1	2	3	6	1						
45		1	5	2							
46			2	9	2						
47				3							
48											
49				1							
50				1							
51			1								
52			1	2							
53			2	3							
54				2	5						
55											
56			1	2	2						
57					1						
58		1		4	1						
59											
60		1									
61	2	1	2	7							
62											
63				1							
64											
65			1	4	2						
66	1	2	3	13	7						
67				4	6	2	1				
68											
69						1	2				
70											
71			6	7	8	4					
72						4	6				
73								1			
74					1	1	5	5	2		
75	1			2	3						
76											
77											
78	5	1	8	5	1						
79		2	1	3	1						
80				1	2						
81		2	2	3	3						
82		1	3	9	11	13					
83				4	3						
84											
85											
86	1	2	2	2	11	1					
87			1								
88			1	11	27	6					
89			1	2		8	2				
90		1	2	4	12						
91		2	10	25	12	12					
92			1								
93											
94			5	13	2						
95		4	5	4	5						
96	2	2	7	13	63	11					
97		1	7	2	6	14	10				
98		1	5	1	6	16	12	1			
99			1	2	2						
100				1		8	15	3			
101		1									
102		1	6	1	1	8	4				
103				1	1	2					
104											
105											
106											
107		4	3	6	1						
108				1	6						
109		1			1						
110											
111				1	1						
112		11	5	22	11	5					
113			1	1		1					
114		4	1	11	4	1					
115		1	1	3							
116											
117	2	1	6								
118			3	2							
119	1	1	5	4	1						
120			1								
121											
122			1	1							
123		1									
124		1									
125			1								
126											
127											
128		5	4	1							
129		8	4								
130		7	14	2							
131		1	9	6							
132			9	8	2						
133		1	2								
134		1	2	2							
135	2	6	11	8	3						
136	1	2	3	13	26						
137			1		1						
138	5	10	6	23	22	16					
139				1							
140	1		1		1						
141		1	3	8	30	8					
142		2	6	4	2						
143		1	6	7							
144	1	1	8	5	4						
145											
146											
147		2	18	1							
148			1	1							
149		1		1							
150				4							
151											
152					1						
153			1								
154											
155				1	4						
156											
157		1	2	1		1					
158			3	1							
159											
160											

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Appendix 11 Frequency counts of the size classes of wedge shells (Telllina liliana) collected from sites throughout Tauranga Harbour over the summer (1990/91) at the mid and low water neap tide levels as part of the Tauranga Harbour Regional Plan Project.

SITE	SIZE CLASS INTERVAL MID POINTS (mm) 2.5	7.5	12.5	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5
1											
2		1		2	2	2	2				
3				1							
4								1			
5		1	4	2	3		2	2	2		
6		1	2		2	1					
7		1	1	4	1	3					
8		3	1	3	1	1					
9		2	3		2	5	1				
10			2		3	6	1				
11		4	6	2	3	3					
12		1	2		4	8	2				
13			3	2							
14		1	3		9	5					
15			1	7	7	1					
16						2					
17	1	2	4	2	6	4					
18			1	2		1	2				
19		1			1						
20											
21		2	1	1							
22				3		2	3	7	4		
23		1	4	3	8	4	1				
24		1	3	13	2	1					
25				4	4	2					
26			1			6					
27		5	1	3	3	3	1				
28					5	1	1				
29		2			1						
30		3	1	2	9	3					
31			3	1							
32		7	3		5	3	1	2			
33		1					2				
34		1	1	2	2	2	3				
35		3	2	1	1	4	2				
36					2	2	1	1			
37			2	1	1	3					
38							2				
39				1	10	4					
40				1	2	1					
41		6	4			2					
42			3	3		2	2	1	3		1
43		2	2	2	1	4	3				
44				1	1	2	2				
45			1		1	1	3				
46			1	1		3	3				
47		1	1					1	1		
48											
49											
50				1	1						
51		4	3	4	7	4					
52		2	1	7	2						
53		1	3	1			1				
54				2	1	1					
55		1	1		4		2	2			
56			3	2	2	5					
57		3	1		5	5	1				
58		1									
59		1	2	2		1					
60	1	3									
61	1	8	9	14	3						
62					3	1	4				
63							2	2			
64			2	6	4	1					
65		1		2	2	2	4				
66		3	2	3	7	4					
67		1	0	0	6	5					
68								1			
69											
70			1							1	
71			1			1					
72							2	1			
73			1				3				
74				1	1	3	4				
75		1	2	4	4	8	2				
76		1				2	6	2	1		
77	1	2	2	2	1						
78		2	1		11	6	3	2			
79			1		1	4	3	2			
80				4	15	1					
81			1		5	5					
82	1	2	3	2		1	2				
83		3	7	2	3	1					
84		1	2				1			1	
85											
86		1				1	3				
87				12		2	5				
88						1					
89			1	1	2	1					
90		3		1	2	5	1				
91		2	4	1	1	9	6				
92			2	1	2	2	3	1			
93											
94		1	2	3	2	2	5				
95		0	2	1	4	2	1				
96		4	3	4	3	8	8				
97				1	5	2					
98		1	4	5	14	3					
99		1		2	3	4	3	1			
100				3	8	4					
101		2	1	3	9		1				
102		1	1	5	4	2	3				
103				1	2	4	3				
104		1	2	0	2	3	1	3	1		
105					1						
106											
107											
108											
109			1				2	7			
110							4	2			
111											
112		1	1	1	1	1	1	1			
113						1				1	
114	1		1	1	1			1	3		
115		1	2	2	1	5	4	1			
116											
117			2	1	2	2	4				
118			2		2	4	5				
119		2	7	1	10	9					
120											
121											
122				1	7	4	2				
123					2	1	2				
124			2	2	2	1	0				
125					1	2	1				
126								1			
127											
128			1	2	8						
129			1		1	1	1				
130		1			1	2	6				
131						3	3				
132		3	5	3	4						
133											
134											
135		1		2	3	2	1				
136		6	1		2	3	2				
137						1					
138		3	2	2	2	2	1	3	1		
139		2									
140		10	11				2	5	1		
141	1		2	7	8	1	1	2			
142	1	8			1	3	2	5	1		
143	1	3	1	1	5	5		1			
144		2	4	8	15	1	1				
145			1			2					
146					1	3	1				
147		1	2	8	7	2					
148					2	5	2				
149		2	4		6	9	6	2			
150		1		2		2	2				
151		1		1		8	4	2			
152								1			
153		3	3	1	1	4	7	3			
154		1		1		1	2	3			
155				2	3	3					
156						1	7	2			
157		1	3	3	2	5					
158		1	1	6	2	4					
159			1		1	1	3				
160				1	3	2					

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Appendix 11 Frequency counts of the size classes of pipis (*Paphies australis*) collected from sites throughout Tauranga Harbour over the summer (1990/91) at the mid and low water neap tide levels as part of the Tauranga Harbour Regional Plan Project.

SITE	SIZE CLASS INTERVAL MID POINTS (mm)														
	2.5	7.5	12.5	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5
1															
2															
3													4	15	4
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															
21															
22															
23															
24															
25															
26															
27															
28															
29															
30															
31															
32															
33															
34															
35						2	1								
36															
37															
38															
39															
40															
41															
42					1	1									1
43				2											
44					1		1	1							
45															
46															
47															
48															
49															
50															
51															
52															
53															
54															
55															
56															
57															
58															
59															
60															
61															
62			1				1								
63	1	1				1							1		
64															
65							1								
66															
67						1									
68						1	12	23	19	6	1	1			
69															
70									1						
71															
72															
73															
74															
75															
76															
77															
78															
79															
80															

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SITE	SIZE CLASS INTERVAL MID POINTS (mm)														
	2.5	7.5	12.5	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5
81															
82															
83															
84															
85															
86															
87															
88															
89															
90															
91															
92															
93															
94															
95						2		1							
96															
97															
98															
99															
100															
101															
102															
103															
104															
105															
106		9	2												
107															
108															
109															
110		3													
111															
112			1	2											
113	1														
114	1	1	1	2											
115															
116															
117															
118															
119															
120															
121															
122															
123															
124															
125															
126															
127															
128			1		3										
129															
130															
131			3												
132															
133															
134		2													
135					1	1			1	1					
136															
137															
138															
139															
140															
141															
142															
143															
144															
145															
146				1	2										
147															
148															
149															
150															
151															
152		3	13		1	2									
153															
154															
155															
156															
157															
158															
159			1												
160															

APPENDIX 12

Species codes for macroinvertebrates

	Code
Ephemeroptera (Mayflies)	
Coloburiscus humeralis	1
Mauiulus luma	2
Austroclima sepia	3
Neozephlebia scita	4
Nesameletus spp.	5
Zephlebia versicolor	6
Zephlebia spp.	7
Deleatidium spp.	8
Rallidens mcfarlanei	9
Trichoptera (Caddisflies)	
Aoteapsyche colonica	10
Hydrobiosis parumbripennis	11
Hydrobiosis umbripennis	12
Hydrobiosis spp.	13
Tiphobiosis spp.	14
Neurochorema spp.	15
Costachorema callista	16
Costachorema xanthoptera	17
Costachorema spp.	18
Oxyethira albiceps	19
Beraeoptera roria	20
Pycnocentrodes spp.	21
Olinga feredayi	22
Helicopsyche spp.	23
Triplectides spp.	24
Polyplectropus puerilis	25
Pycnocentrella eruensis	26
Plecoptera (Stoneflies)	
Stenoperla prasina	27
Zelandoperla fenestrata	28

Appendix 12: Northern Tauranga Harbour Streams. Raw Macroinvertebrate data. Note: Species codes given oveleaf.

Site	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
Waiaua Up	0	0	0	0	0	0	0	0	0	12	1	0	0	1	0	0	0	0	26	0	10	0	0	0	0	0	0	0	9	5	0	0	0	0	144	3	0	0	4	0	0	0	3	1
Waiaua Up	2	3	0	0	0	0	2	0	0	28	3	0	0	0	1	2	0	0	7	0	6	0	0	0	0	0	0	0	5	4	0	0	0	0	186	8	0	0	0	0	0	0	4	1
Waiaua Up	6	2	0	0	1	0	2	0	0	31	2	0	1	6	2	0	0	0	44	0	15	0	0	0	0	1	0	0	8	19	1	0	0	0	161	2	0	0	3	1	0	0	32	7
Waiaua Up	2	3	0	0	0	0	5	0	0	10	3	0	0	3	2	0	0	0	4	0	1	2	0	0	0	0	0	1	7	11	0	0	0	0	234	3	0	0	1	1	0	2	0	1
Waiaua Up	1	5	0	0	0	0	2	0	0	59	2	0	1	3	1	0	0	0	3	0	4	1	0	0	0	0	0	0	13	21	0	0	0	0	221	5	0	0	1	0	0	0	0	6
Waiaua Lo	1	2	0	1	0	0	0	1	1	23	2	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	2	18	0	1	0	0	51	6	0	0	0	0	0	1	1	9
Waiaua Lo	4	3	0	0	0	0	0	0	0	31	7	0	0	0	1	0	1	4	0	0	14	0	0	0	0	0	0	0	2	9	1	0	0	0	132	8	0	0	0	0	0	1	30	6
Waiaua Lo	8	1	0	0	0	0	4	0	0	43	3	0	0	0	6	0	4	3	0	0	5	0	0	0	0	0	0	0	3	11	1	0	0	0	403	12	0	0	0	0	0	1	0	10
Waiaua Lo	7	3	0	0	1	0	1	0	0	43	7	0	0	0	0	0	0	1	0	0	7	0	0	1	0	0	0	1	4	12	0	0	0	0	98	2	0	0	0	0	0	1	1	12
Waiaua Lo	7	10	0	11	0	0	6	0	0	34	1	0	0	3	3	0	0	0	0	0	16	0	0	0	0	0	0	0	0	2	1	2	0	0	22	0	0	0	0	0	0	5	0	19
Uretara Up	0	1	1	1	0	0	2	1	2	0	0	0	0	1	0	0	0	0	0	28	90	13	1	0	1	0	0	1	0	0	0	0	0	0	35	1	0	0	0	0	0	0	0	0
Uretara Up	5	0	0	0	0	3	0	10	0	2	0	0	0	4	0	0	0	0	0	112	51	44	3	0	0	0	0	9	3	0	1	0	0	0	24	0	0	0	0	1	0	0	4	0
Uretara Up	5	0	0	0	0	2	1	37	0	2	0	0	1	1	0	0	0	0	0	209	62	55	2	0	0	0	0	3	2	0	0	0	0	0	38	8	0	0	0	1	0	0	1	0
Uretara Up	0	0	0	2	0	4	2	13	0	0	1	0	0	5	0	0	0	0	0	33	59	32	3	0	0	0	1	1	1	0	0	0	0	0	140	22	0	0	0	1	0	0	18	0
Uretara Up	0	0	0	0	0	0	0	4	1	0	1	0	0	3	0	0	0	0	0	32	33	11	2	0	0	0	0	0	1	0	0	0	0	0	33	6	0	0	0	0	0	0	2	0
Uretara Lo	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	32	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	13	0	2	10
Uretara Lo	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	179	1	0	0	0	0	0	0	0	0	0	1	0	0	3	2	0	0	0	0	4	0	10	0
Uretara Lo	1	0	0	0	0	0	5	2	0	2	0	0	0	0	0	0	0	0	0	2	444	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	23	0	13	0
Uretara Lo	2	0	0	0	0	0	1	6	0	4	0	0	0	0	0	0	0	0	0	4	351	0	0	0	0	0	0	0	1	3	0	0	0	0	2	6	0	0	0	1	12	0	13	13
Uretara Lo	2	0	1	0	0	0	1	12	0	5	0	0	0	0	0	0	0	0	0	2	140	0	0	0	0	0	0	0	0	2	0	0	0	0	2	11	0	0	0	0	8	0	7	0
TeRere Up	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	4	106	38	1	0	0	0	0	0	6	7	0	0	0	6	0	275	3	0	0	0	0	0	0	1	1
TeRere Up	4	0	0	0	0	0	0	0	0	6	1	0	0	2	0	0	0	0	1	281	29	0	0	0	0	0	0	86	10	17	0	0	0	0	251	2	0	0	0	0	0	0	1	0
TeRere Up	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	3	140	35	1	0	0	0	0	0	7	5	0	0	0	2	0	172	0	1	0	2	1	0	1	0	0
TeRere Up	2	0	0	0	0	0	0	0	1	1	2	0	0	1	0	0	0	0	0	98	11	0	0	0	0	0	0	47	2	2	0	0	0	0	66	0	0	0	0	0	0	0	0	0
TeRere Up	6	0	0	0	0	0	0	0	1	3	0	0	0	4	0	1	0	0	0	60	1	0	0	0	0	0	0	109	6	6	0	0	3	0	159	1	0	0	0	0	0	0	0	0
TeRere Lo	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	1	165	0	0	0	0	0	0	0	10	2	0	1	0	0	128	1	0	0	0	0	0	2	24	2
TeRere Lo	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	1	1	163	0	0	0	0	0	0	0	3	1	1	0	0	0	49	0	0	0	0	0	0	0	10	3
TeRere Lo	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	62	0	0	0	0	0	0	0	0	0	0	0	0	0	8	1	0	0	0	0	0	0	37	39
TeRere Lo	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	1	0	188	0	0	0	0	0	0	0	7	7	0	0	0	0	8	0	0	0	0	0	0	0	323	44
TeRere Lo	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	184	0	0	0	0	0	0	0	9	2	1	0	0	0	57	0	0	0	0	0	0	1	12	6
Tuapiro Up	18	1	1	0	0	0	1	1	0	17	2	0	0	5	13	1	0	1	44	23	24	2	1	0	0	0	0	9	16	4	2	0	0	0	260	0	0	0	1	0	0	0	6	1
Tuapiro Up	23	2	0	0	0	0	0	0	4	30	2	0	0	1	4	0	0	0	11	5	15	1	1	0	0	0	0	10	11	6	1	0	0	0	182	1	0	0	2	5	0	0	2	2
Tuapiro Up	18	1	1	0	0	0	0	0	0	14	3	2	0	2	7	1	0	0	76	3	9	3	0	0	0	0	0	8	7	18	0	0	0	0	271	2	0	0	0	0	0	0	2	10
Tuapiro Up	9	0	1	0	0	0	0	0	0	5	1	0	0	2	4	0	0	0	24	2	22	1	0	0	0	0	0	0	6	13	0	0	0	0	170	2	0	0	0	1	2	0	1	1
Tuapiro Up	3	0	0	0	0	0	0	0	0	1	0	0	0	2	2	0	0	0	58	7	53	2	0	0	0	0	0	0	6	2	3	0	0	0	148	2	0	1	0	1	0	0	0	0
Tuapiro Lo	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	5	0	18	1	0	2	0	0	0	0	4	0	0	1	0	0	12	0	0	0	0	0	1	0	3	101
Tuapiro Lo	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	54	0	14	0	0	3	0	0	0	0	2	0	0	0	0	0	29	0	0	0	0	0	4	2	103	46
Tuapiro Lo	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5	0	2	0	0	0	155	2	0	0	0	0	0	0	0	8
Tuapiro Lo	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	6	0	18	0	0	1	0	0	0	0	8	2	0	0	0	1	20	0	0	0	0	1	0	5	1	91
Tuapiro Lo	1	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	7	0	3	0	0	0	0	0	0	0	3	4	0	0	0	0	58	0	0	0	0	0	0	0	0	65

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Appendix 13: Northern Tauranga Harbour streams.
Descriptive statistics for the macroinvertebrate variables.

TAXA NUMBER Site	Mean	Median	Minimum	Maximum	Standard Deviation	Coefficient of variation (%)
Waiuau Upper	16.8	17.00	12.00	21.0	3.5	20.80
Waiaua Lower	16.4	17.00	15.00	17.0	0.9	5.50
Uretara Upper	15.0	15.00	12.00	17.0	2.1	14.10
Uretara Lower	10.6	10.00	7.00	14.0	2.6	24.60
TeRere Upper	12.8	13.00	11.00	14.0	1.1	8.60
TeRere Lower	8.8	9.00	6.00	11.0	1.9	21.90
Tuapiro Upper	19.4	20.00	14.00	23.0	3.6	18.40
Tuapiro Lower	10.0	10.00	7.00	12.0	2.1	21.20

TOTAL ABUNDANCE Site	Mean	Median	Minimum	Maximum	Standard Deviation	Coefficient of variation (%)
Waiuau Upper	294.6	296.00	219.00	349	55.87	19.00
Waiaua Lower	247.8	202.00	123.00	518	159.62	64.40
Uretara Upper	270.2	275.00	129.00	430	120.84	44.70
Uretara Lower	274	205.00	60.00	494	177.60	64.80
TeRere Upper	421.6	373.00	233.00	691	169.68	40.20
TeRere Lower	322.6	276.00	148.00	596	169.34	52.50
Tuapiro Upper	357.6	323.00	267.00	458	91.16	25.50
Tuapiro Lower	181.6	164.00	146.00	258	46.05	25.40

MCI INDEX Site	Mean	Median	Minimum	Maximum	Standard Deviation	Coefficient of variation (%)
Waiuau Upper	99.66	103.16	85.46	107.78	8.89	8.90
Waiaua Lower	97.38	96.00	86.15	108.75	8.15	8.90
Uretara Upper	131.72	131.77	128.24	136.00	3.48	2.60
Uretara Lower	112.76	116.00	91.43	122.22	12.62	11.20
TeRere Upper	117.47	111.67	110.00	128.00	8.76	7.50
TeRere Lower	77.39	80.00	68.57	84.44	7.00	9.00
Tuapiro Upper	112.78	116.00	111.77	122.86	12.62	11.20
Tuapiro Lower	83.06	76.00	71.43	97.50	12.77	15.40

EPT INDEX Site	Mean	Median	Minimum	Maximum	Standard Deviation	Coefficient of variation (%)
Waiuau Upper	9.20	11.00	5.00	11.00	2.68	29.00
Waiaua Lower	9.00	9.00	8.00	10.00	0.71	7.90
Uretara Upper	11.00	12.00	8.00	13.00	2.00	18.20
Uretara Lower	5.20	6.00	2.00	7.00	1.92	37.00
TeRere Upper	7.40	7.00	7.00	8.00	0.55	7.40
TeRere Lower	2.80	3.00	2.00	4.00	0.84	29.90
Tuapiro Upper	12.00	13.00	8.00	16.00	3.08	25.70
Tuapiro Lower	4.20	4.00	2.00	6.00	1.48	35.30

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APPENDIX 14

Key and units for the water quality variables given in Appendix 14.

Abbrev.	Description	Units
Temp	Temperature	Degrees Celsius
DO	Dissolved oxygen	g/m^{-3}
BOD	5 day biological oxygen demand	g/m^{-3}
pH	$-\log[H^+]$	pH units
Cond	Conductivity	Millisiemens/m^{-1} @25°C
Turb	Turbidity	Nephelometric turbidity units
SS	Suspended solids	g/m^{-3}
DRP	Dissolved reactive phosphorus	g/m^{-3}
NH_4	Ammoniacal nitrogen	g/m^{-3}
NO_3	Nitrate nitrogen	g/m^{-3}
TKN	Total Kjeldahl nitrogen	g/m^{-3}
TP	Total phosphorus	g/m^{-3}

Appendix 14: Northern Tauranga Harbour Streams. Mean values for the water quality variables.

Site	Temp	DO	BOD	pH	Cond	Turb	SS	DRP	NH4	NO3	TKN	TP
Waiaua Upper	13.65	10.77	1.35	7.35	8.70	1.30	1.60	0.022	0.008	0.130	0.163	0.026
Waiaua Lower	14.40	10.73	1.13	7.33	9.33	1.30	1.48	0.020	0.012	0.070	0.147	0.024
Uretara Upper	14.75	10.93	1.43	7.18	7.03	0.25	0.63	0.009	0.006	0.022	0.140	0.010
Uretara Lower	15.50	10.00	1.43	7.18	7.73	2.13	2.10	0.006	0.013	0.051	0.146	0.009
TeRere Upper	13.83	10.98	0.73	7.33	7.33	0.38	0.18	0.005	0.006	0.132	0.116	0.008
TeRere Lower	17.05	10.33	1.10	7.40	7.63	0.78	1.10	0.006	0.009	0.059	0.177	0.010
Tuapiro Upper	14.35	11.15	1.00	7.38	6.93	0.88	1.48	0.016	0.006	0.012	0.114	0.018
Tuapiro Lower	16.23	10.45	1.48	7.35	7.45	0.95	1.18	0.005	0.013	0.013	0.155	0.011

Note: Abbreviations and units given overleaf

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APPENDIX 15

Tauranga Harbour catchment streams. Matrix of rank correlation coefficients of the environmental and biotic variables for all sites. Significant correlations for the biotic variables are shown in bold type.

MATRIX OF SPEARMAN CORRELATION COEFFICIENTS

	MCI	TAXA	TOTAL	EPT	CHLAM2
MCI	1.000				
TAXA	0.476	1.000			
TOTAL	0.333	0.190	1.000		
EPT	0.690*	0.929***	0.167	1.000	
CHLAM2	0.119	-0.024	0.024	0.024	1.000
BOD5	-0.180	-0.287	-0.850**	-0.192	0.072
COND	-0.571	-0.095	-0.381	-0.357	-0.381
DO	0.667	0.714*	0.476	0.786*	0.429
TEMP	-0.524	-0.810*	-0.429	-0.690*	-0.262
DRP	-0.071	0.714*	-0.119	0.595	-0.310
TP	-0.429	0.548	-0.286	0.333	0.000
NH4	-0.667	-0.405	-0.619*	-0.548	-0.429
NO3	-0.024	-0.024	0.310	-0.190	0.048
TKN	-0.833*	-0.476	-0.357	-0.619	-0.024
PH	-0.599	0.012	0.240	-0.120	0.168
SS	-0.214	0.333	-0.167	0.143	-0.476
TURB	-0.419	0.108	-0.347	-0.156	-0.431

	BOD5	COND	DO	TEMP	DRP
BOD5	1.000				
COND	0.216	1.000			
DO	-0.539	-0.619	1.000		
TEMP	0.443	-0.000	-0.714	1.000	
DRP	-0.024	0.357	0.190	-0.405	1.000
TP	0.084	0.405	0.095	-0.286	0.833
NH4	0.599	0.595	-0.857	0.571	-0.024
NO3	-0.395	0.548	-0.024	-0.452	0.024
TKN	0.347	0.667	-0.690	0.405	0.190
PH	-0.337	-0.084	0.096	0.120	0.263
SS	0.287	0.452	-0.333	-0.119	0.476
TURB	0.337	0.731	-0.539	-0.036	0.299

	TP	NH4	NO3	TKN	PH
TP	1.000				
NH4	0.190	1.000			
NO3	-0.071	-0.238	1.000		
TKN	0.381	0.500	0.262	1.000	
PH	0.539	-0.036	-0.180	0.395	1.000
SS	0.476	0.619	-0.190	0.143	-0.012
TURB	0.419	0.790	0.060	0.311	-0.114

	SS	TURB
SS	1.000	
TURB	0.886	1.000

NUMBER OF OBSERVATIONS: 8

* = p<0.05, ** = p<0.01, *** = p<0.001

APPENDIX 16

Key and units for the physical variables given in Appendix 16.

Abbrev.	Description	Units
VEL.	Water velocity	m/s^{-1}
Depth	Water depth	m
R	Bedrock	% cover
B	Boulders (256mm+)	% cover
LC	Large cobbles (128-256mm)	% cover
SC	Small cobbles (64-128mm)	% cover
LG	Large gravel (16-64mm)	% cover
SG	Small gravel (2-16mm)	% cover
Sand	(0.063-2mm)	% cover
Silt	(<0.063mm)	% cover
SI	Substrate Index	mm
GRFIL	Periphyton green filamentous	% cover
BRFIL	Periphyton brown filamentous	% cover
MATS	Periphyton mats	% cover
GRFILM	Periphyton green film	% cover
BRFILM	Periphyton brown film	% cover

Appendix 16: Northern Tauranga Harbour streams physical variables.
Note: Key to variables given overleaf.

Site$	Vel (m/s)	Depth (m)	R	B	LC	SC	LG	SG	SAND	SILT	SI	GRFIL	BRFIL	MATS	GRFIL	BRFILM	PERIVE	PERIDE
Waiaua Up	0.6	0.29	0	0	80	20	0	0	0	0	0	50	0	0	0	50	0.65	0.31
Waiaua Up	0.65	0.26	0	0	0	60	30	10	0	0	0	0	0	0	70	30	0.5	0.36
Waiaua Up	0.65	0.2	0	0	0	80	0	20	0	0	0	0	0	0	60	30	0.5	0.36
Waiaua Up	0.6	0.26	0	0	0	60	30	10	0	0	0	80	0	0	0	20	0.6	0.26
Waiaua Up	0.6	0.21	0	0	20	60	10	10	0	0	0	30	0	0	0	70	0.6	0.27
Waiaua Lo	0.9	0.19	0	0	30	40	20	10	0	0	0	0	0	0	0	100	0.7	0.21
Waiaua Lo	0.9	0.2	0	0	0	70	20	0	10	0	0	20	0	0	0	80	0.8	0.21
Waiaua Lo	0.8	0.21	0	0	0	80	10	10	0	0	0	30	0	0	0	70	0.9	0.2
Waiaua Lo	0.7	0.15	0	0	0	60	30	10	0	0	0	40	60	0	0	0	0.6	0.14
Waiaua Lo	0.6	0.19	0	0	0	20	60	10	10	0	0	10	0	0	0	0	0.7	0.4
Uretara Up	0.25	0.19	0	0	0	30	60	10	0	0	0	0	0	0	10	90	0.4	0.17
Uretara Up	0.45	0.27	0	0	0	20	70	10	0	0	0	0	0	0	10	90	0.35	0.2
Uretara Up	0.5	0.24	0	0	20	0	40	40	0	0	0	0	0	0	10	90	0.4	0.18
Uretara Up	0.35	0.19	0	0	0	30	20	50	0	0	0	0	30	0	0	70	0.35	0.17
Uretara Up	0.2	0.15	0	0	0	30	20	40	10	0	0	0	0	0	100	0	0.5	0.2
Uretara Lo	0.25	0.14	0	0	0	0	80	0	20	0	0	0	0	0	0	100	0.2	0.1
Uretara Lo	0.22	0.14	0	0	30	10	20	20	20	0	0	0	0	0	0	100	0.3	0.1
Uretara Lo	0.32	0.2	0	0	60	0	20	10	10	0	0	0	0	0	0	100	0.3	0.1
Uretara Lo	0.5	0.15	0	0	0	20	60	20	0	0	0	0	0	0	0	100	0.2	0.11
Uretara Lo	0.3	0.12	0	0	0	20	30	50	0	0	0	0	0	0	0	100	0.2	0.08
TeRere Up	0.4	0.23	0	0	0	50	50	0	0	0	0	20	30	0	50	0	0.3	0.17
TeRere Up	0.5	0.14	0	0	20	0	20	60	0	0	0	0	20	0	0	80	0.5	0.15
TeRere Up	0.25	0.21	0	0	0	20	40	40	0	0	0	30	20	0	0	50	0.4	0.15
TeRere Up	0.45	0.17	0	0	0	0	40	60	0	0	0	30	20	0	0	50	0.35	0.17
TeRere Up	0.45	0.24	0	0	60	20	20	0	0	0	0	10	20	0	20	50	0.4	0.13
TeRere Lo	0.6	0.16	0	0	0	30	40	30	0	0	0	20	0	0	0	80	0	0
TeRere Lo	0.35	0.2	0	0	0	60	20	20	0	0	0	10	0	0	0	90	0	0
TeRere Lo	0.35	0.32	0	0	50	20	10	20	0	0	0	0	0	0	80	0	0	0
TeRere Lo	0.35	0.2	0	0	0	30	60	10	0	0	0	0	0	0	80	0	0	0
TeRere Lo	0.3	0.22	0	0	40	30	10	10	10	0	0	0	0	0	10	10	0	0
Tuapiro Up	0.3	0.2	0	0	0	90	10	0	0	0	0	10	0	0	90	0	0.5	0.16
Tuapiro Up	0.5	0.22	0	0	20	70	10	0	0	0	0	30	0	0	70	0	0.5	0.16
Tuapiro Up	0.4	0.2	0	0	20	10	40	30	0	0	0	20	0	0	50	0	0.5	0.17
Tuapiro Up	0.35	0.25	0	0	0	50	20	30	0	0	0	30	0	0	70	0	0.5	0.16
Tuapiro Up	0.25	0.28	0	20	0	30	20	30	0	0	0	30	0	0	70	0	0.4	0.1
Tuapiro Lo	0.6	0.2	0	0	60	20	20	0	0	0	0	20	0	0	0	80	0.17	0.5
Tuapiro Lo	0.45	0.18	0	0	80	0	20	0	0	0	0	80	0	0	0	20	0.25	0.6
Tuapiro Lo	0.8	0.34	0	0	80	20	0	0	0	0	0	100	0	0	0	0	0.3	0.6
Tuapiro Lo	0.5	0.15	0	0	70	10	20	0	0	0	0	50	0	0	0	50	0.22	0.6
Tuapiro Lo	0.7	0.13	0	0	0	80	20	0	0	0	0	50	0	0	0	50	0.36	0.5

BOPRC Computer File R:\ pc \ qpro \ rmn \ fem \ loflophy.wq1