Waitara Marine Outfall
Ecological Monitoring Programme
Annual Report
2004

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Taranaki Regional Council
Private Bag 713
STRATFORD

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Executive summary

The Waitara marine outfall provides for the disposal of wastewater from the Waitara municipal domestic sewage reticulation system, the Methanex Waitara Valley methanol plant and the Methanex Motunui methanol plant. The outfall discharges approximately 1250 metres offshore from the mouth of the Waitara River.

This report covers the monitoring of the effects of the Waitara outfall on local intertidal biological communities. Waitara outfall reports are generally based on a calendar year and this report covers the results of marine ecological monitoring during 2004. Comparisons are also made to previous marine ecological monitoring data at the same sites.

The Waitara marine outfall ecological monitoring programme has been operating in its present form for over fourteen years. Five survey sites are included in the programme consisting of three potential impact sites and two control sites. These five sites were surveyed during October 2004.

During this 2004 survey, high sand levels caused a significant decline in the ecological diversity at Airedale Reef. Orapa A (potential impact), and Greenwood Road (control) showed an increase in ecological diversity in comparison to October 2003, whereas Orapa B (potential impact) and Turangi Reef (control) decreased in ecological diversity. In the 2001 survey Orapa A was completely inundated with sand allowing no ecological surveys to be carried out, but in 2004 the reef had recovered to levels higher than all other sites, both potential impact and control sites.

It was concluded that the Waitara marine outfall discharge was not having any adverse effect on the intertidal reef communities in the Waitara embayment.

During the year, the consent holders demonstrated a high level of environmental performance and compliance with the resource consents in relation to the discharge via the Waitara marine outfall.

Given the established pattern of no evidence of adverse effects, continuation of the monitoring programme at its current residual level is recommended.

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1. Introduction

This report is the Annual Report for the period January-December 2004 by the Taranaki Regional Council describing the marine ecological monitoring programme associated with the Waitara marine outfall.

This report covers the results and findings of the monitoring programme implemented by the Council to assess the impact of the wastewater discharge on intertidal marine communities within the Waitara embayment. This is the twelfth Annual Report by the Taranaki Regional Council for the Waitara marine outfall marine ecological monitoring programme and its effects.

1.1 Process description

The Waitara marine outfall discharges into the Waitara embayment approximately 1250 metres offshore from the mouth of the Waitara River in approximately 10 metres of water. This outfall currently provides for the disposal of wastewater from the Waitara municipal domestic sewage reticulation system, the Methanex Waitara Valley methanol plant and the Methanex Motunui methanol plant. Until September 1997, it conveyed wastewater from AFFCO's meatworks. Domestic wastewater from the Methanex Motunui plant is treated at the Waitara plant.

The four major users of the outfall together have formed the Waitara Outfall Management Board (WOMB) to oversee the refurbishment and maintenance of the outfall. The Board undertook to refurbish the outfall to provide for a 25-year life and to improve initial dilution. Refurbishment of the outfall was carried out between July and December 1991. An impervious plastic liner was inserted through the pipeline, the stability of the pipeline on the seabed was improved, and a new diffuser was installed.

During 1991 and 1992, the New Plymouth District Council and the meat processing company, AFFCO, constructed a wastewater treatment plant for the combined domestic and meatworks effluents which previously had been discharged through the outfall with minimal treatment. Treatment comprises screening of wastewater to 0.5 millimetres particle diameter (meatworks wastewater was screened at the works), followed by disinfection through elevation of pH with lime to pH 11 and holding for a minimum of four hours. Treated wastewater is discharged through the outfall in batches at a constant rate, the frequency depending on influent flow rates.

1.2 Resource consents

1.2.1 Water discharge permit

Section 15(1)(a) of the Resource Management Act stipulates that no person may discharge any contaminant into water, unless the activity is expressly allowed for by a resource consent or a rule in a regional plan, or by national regulations.

Each of the users of the outfall was granted a separate but contemporaneous consent to discharge through the outfall until 2008. The present holders of the four consents are:

Consent holder	Consent	Discharge source
New Plymouth District Council	3397	Waitara municipal domestic and minor industrial sewage
Anzco Foods Waitara Ltd	3398	Waitara meatworks
Methanex Waitara Valley	3399	Methanol plant
Methanex Motunui	3400	Methanol plant

AFFCO's consent was transferred to Manawatu Food and Technology Limited on 8 June 1999, and subsequently to Aotearoa Coolstores Ltd on 21 August 2001. It was again transferred to Anzco Foods Waitara Ltd on 9 March 2004.

There are a number of special conditions attached to these consents in relation to the outfall, effluent, contingency plans and annual reports, responsibility for investigation and remedy of effects of unauthorised discharges and review of conditions. There are three special conditions specific to the marine outfall and these are as follows.

Special condition 5 stipulates that the minimum initial dilution of the effluent above the diffuser be 100:1.

Special condition 6 requires the consent holder to verify the performance of the outfall and diffuser within the first two years of exercise of this consent.

Special condition 7 requires the consent holder to undertake inspections of the outfall.

These consents were issued by the Taranaki Regional Council on 11 October 1989 as a resource consent under Section 87(e) of the Resource Management Act. They are due to expire on 12 March 2008. A copy of consent 3397 is attached in Appendix I.

1.3 Monitoring programme

1.3.1 Introduction

Section 35 of the Resource Management Act sets out an obligation for the Taranaki Regional Council to gather information, monitor, and conduct research on the exercise of resource consents, and the effects arising, within the Taranaki Region.

The Taranaki Regional Council may therefore make and record measurements of physical and chemical parameters, take samples for analysis, carry out surveys and inspections, conduct investigations, and seek information from consent holders. The background of marine ecological monitoring in relation to the Waitara marine outfall and current monitoring design is described as follows.

1.3.2 Background

The Waitara Marine Ecology Monitoring Programme was implemented in 1985 for the purpose of monitoring Discharge Permit 1205 held by Waitara Borough, and the Synthetic Fuels Plant (Effluent Disposal) Empowering Act 1983 (Discharge Permit X821). Both the discharge permit and Empowering Act contained conditions designed to protect the marine environment around the outfall.

In 1985 and 1986, comprehensive monitoring programmes were carried out to assess both the general ecology and seafood (mussels) resource in the intertidal zone of the embayment. Assessment of trace metals levels in mussels, bacteriological monitoring programmes and regular beach inspections were also undertaken.

The marine ecology programme was initiated in response to public concerns due to the imminent discharge of wastewater under the Empowering Act. This programme was continued until October 1986, a year after the synthetic petrol plant commenced discharging through Waitara outfall late in 1985.

In 1987, the intensity of the marine ecological programme was reduced. A new programme called the Waitara Intertidal Inspection Programme (WIIP) replaced the Marine Ecology and Beach Inspection Programmes. The WIIP programme consisted of a fortnightly semi-quantitative survey of selected species in three habitat types. The WIIP programme was continued for three years until 1990.

The marine ecological monitoring programme was reviewed in 1990 in light of the proposed upgrade of the outfall and construction of a municipal waste treatment plant. It was decided to return to a quantitative assessment programme similar to the programme undertaken from 1985 to 1986.

From September 1990 to November 1992 sampling was undertaken on four occasions per year with two spring surveys and two late summer or early autumn surveys per year. The surveys were programmed in this way to allow comparisons to be made between surveys undertaken within the same year and season, between different seasons within the same year, and between years. The three potential impact sites were surveyed on each occasion. The two control sites were generally surveyed once per year in conjunction with one of the early autumn surveys. From April 1993 the sampling frequency was changed to two per year with one spring survey and one autumn survey per year. In conjunction with decreasing the frequency of surveys, the control sites were sampled on both occasions per year rather than once per year.

The thrust of the programme was to gather quantitative data for each monitoring site over several years, in order to obtain a measure of natural fluctuations or trends. Trends measured for individual sites can then be compared to determine impacts.

The WOMB expressed concern about the interpretation of results from the new programme before an adequate body of data had been collected for analysis of changes through time, and suggested that three year's data be collected before interpretation was attempted. This report includes data from over thirteen years of monitoring since the programme was reviewed in 1990, as well as quantitative data collected in 1985 and 1986.

During the 1998 monitoring period the level of monitoring was reduced from two annual surveys per year to one spring survey per year according to the recommendation of the 1997 annual report. Given the long-term data available in relation to the Waitara marine outfall, the closure of the AFFCO meatworks and having been approached by WOMB regarding the scope and scale of the monitoring programme in place, it was considered reasonable to reduce the level of monitoring. However, it was also recommended that should the monitoring programme indicate any adverse ecological effects then the level of monitoring would return to that of two annual surveys.

1.3.3 Marine ecological monitoring methods

1.3.3.1 Field work

The surveys were conducted at five sites. The potential impact sites are Orapa B approximately 1.5 km south west of the outfall (SEA 901043), Orapa A approximately 1.1 km south west of the outfall (SEA 901040), and Airedale Reef approximately 1.1 km north east of the outfall (SEA 901030). See Figure 1 for the location of the three potential impact sites relative to the Waitara outfall. The two control sites are at Turangi Reef approximately 7.25 km north east of the outfall (SEA 900095) and Greenwood Road (SEA 903070) approximately 32.5 km south west of the outfall (Figure 2).

At each site a 50 metre transect is laid out. This transect is used to establish five 5 metre x 3 metre blocks. Within each block 5 random 0.25 m^2 quadrats are laid giving a total of 25 random quadrats where the percentage cover of algae and encrusting animal species is estimated using a grid. For all other animal species, individuals larger than 3 mm are counted. Under boulder biota is counted where rocks and cobbles are easily overturned. The percentage sand coverage per quadrat is also estimated using a grid.

The surveys were conducted between 29 September and 16 December 2004.

1.3.3.2 Data analysis

For the data collected during the 2004 survey the following data analysis was undertaken.

The mean and standard deviation was calculated for the number of algae, animal species and the total (algae and animals) number of species per quadrat data at each site. Shannon-Weiner diversity indices were also calculated for each quadrat and a mean Shannon-Weiner index for algae, animals and total species at each site. Graphical summaries of the total number of species per quadrat and Shannon-Weiner indices at each site were made using box and whisker plots. Assumptions of normality were tested using the Lilliefors test. One-way analysis of variance (ANOVA) tests were carried out on total number of species per quadrat data and Shannon-Weiner indices for total species. The non-parametric Kruskal-Wallis test is carried out in addition to the ANOVA test when sites failed the Lilliefors test. The Tukey multiple comparison test was used to determine where differences occurred when a significant difference result was obtained using the ANOVA test.

The results obtained during 2004 were then graphically compared with previous spring monitoring results.

When analysing ecological data it must be noted that natural environmental variation can occur both between different locations and between different sampling occasions. It is the aim of this programme to endeavour to sample habitat types which are as similar as possible and to avoid seasonal variation by sampling at the same time of year every year. Despite these efforts some variation which is unrelated to the presence of the Waitara outfall will still be present and these factors will be evident within survey results. For this reason it is important to examine both differences between sites

and variation over time to gain an overall understanding of the effect of the presence of the Waitara outfall.

1.3.4 Other Waitara monitoring programmes

The Waitara marine ecological monitoring programme is one of two 'impact' monitoring programmes carried out in relation to discharges from Waitara outfall. The other programme monitors shoreline bacteriological water quality in the Waitara embayment.

The major effluents contributing to the Waitara outfall discharge are each monitored at source in 'compliance' monitoring programmes. Annual reports are also produced on these programmes.

Figure 1 Location of potential impact sites relative to the Waitara outfall
Note Aerial photographs were taken at high tide so survey sites are under water.

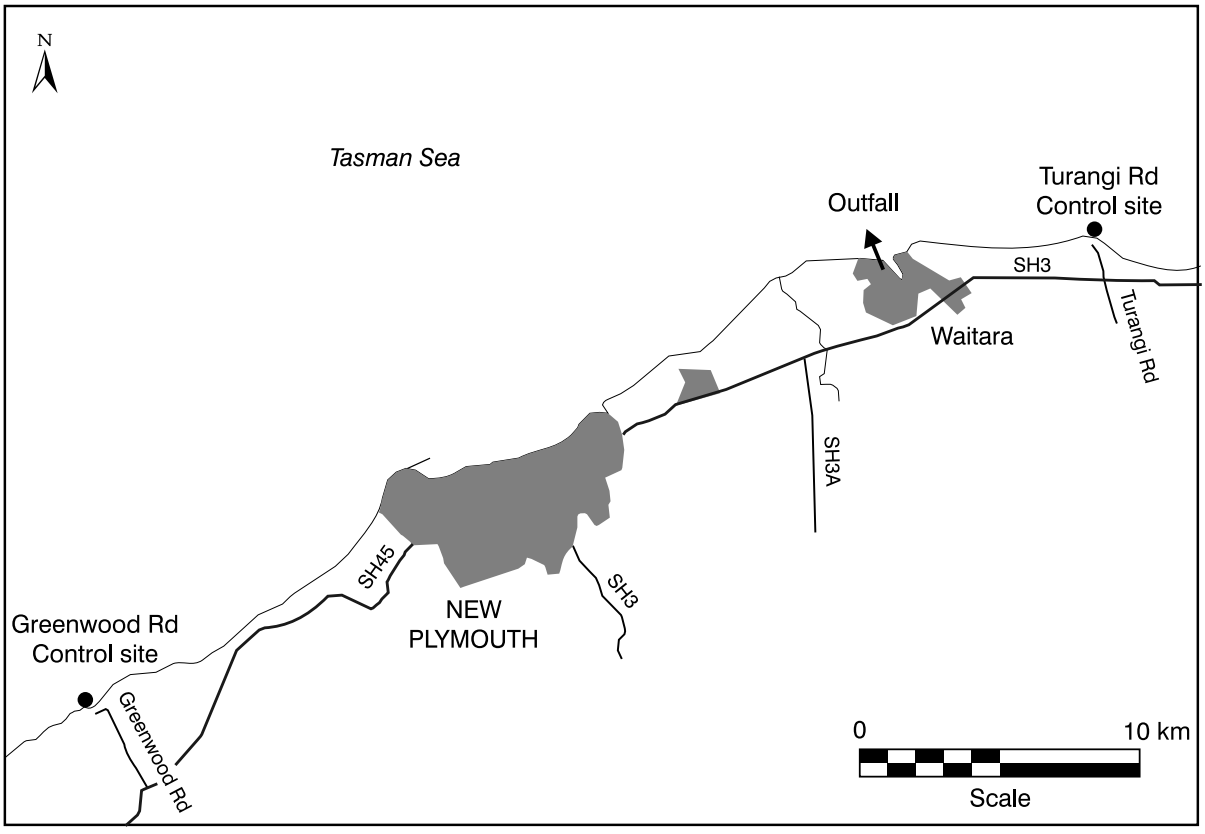

Figure 2 Location of control sites relative to the Waitara outfall

2. Results

2.1 Spring 2004 sample results

Summary statistics showing the mean number of algae, animal and total species (algae and animals) per quadrat and the mean Shannon-Weiner diversity index per quadrat for algae, animals and total species calculated from the data obtained during this survey are shown in Table 1.

The Shannon-Weiner diversity index ($H^{|}$) can give additional information to that provided by the number of species per quadrat data as this index also incorporates the abundance of individual species in addition to the number of species present.

Table 1 Summary statistics for Spring 2004 survey

Site	No. of quadrats		Mean number of species per quadrat			Mean Shannon Weiner Indices per quadrat		
			Algae	Animals	Total species (algae & animals)	Algae	Animals	Total species (algae & animals)
Greenwood Road	25	Mean Std Dev	7.84 1.95	8.00 2.54	15.84 3.60	0.724 0.111	0.621 0.199	0.907 0.185
Orapa B	25	Mean Std Dev	4.76 1.83	6.96 3.07	11.72 3.92	0.569 0.200	0.601 0.263	0.812 0.269
Orapa A	25	Mean Std Dev	5.08 1.57	10.40 2.10	15.48 2.78	0.539 0.119	0.797 0.174	0.958 0.144
Airedale Reef	25	Mean Std Dev	2.27 1.94	4.48 2.34	6.76 3.56	0.309 0.278	0.309 0.220	0.434 0.262
Turangi Reef	25	Mean Std Dev	4.80 1.50	9.48 3.15	14.28 4.08	0.519 0.158	0.738 0.285	0.888 0.285

2.1.1 Number of species per quadrat data

Graphical summaries of the total number of species per quadrat data at each site are shown as box and whisker plots in Figure 3. The notched area of the box represents the median plus and minus the 95% confidence interval. This form of graphical representation allows a quick comparison to be made between sites. Generally, if the notched areas of the boxes for the different sites do not overlap you would expect to obtain a significantly different result when an ANOVA test was carried out.

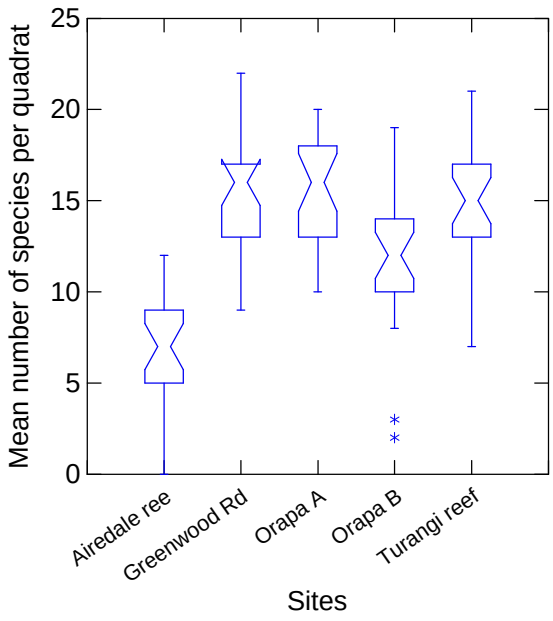

Figure 3 Box and whisker plots of total number of species per quadrat

A Lilliefors test indicated that there was no significant deviation from a normal distribution at a 95% confidence level for the Orapa A, Orapa B, Greenwood Road and Turangi Reef sites. The Airedale Reef site did however significantly deviate from a normal distribution due to the sand inundation that was present at the time of sampling. This can be seen above in the box and whisker graph. The ANOVA test is considered to be relatively robust even when assumptions of normality are not met, and as four of the five sites showed no significant deviation from a normal distribution it was considered appropriate to continue with an ANOVA test.

The ANOVA test carried out on the mean number of total species per quadrat for the five sites revealed a statistically significant difference between the sites (F = 26.838, P = 0.000) at a 95% confidence level. A Tukey multiple comparison test was used to indicate which sites had significantly different means. Table 2 shows which combinations of sites were significantly different at a 95% confidence level.

Table 2 Results of Tukey multiple comparison test of total number of species per quadrat

Site	Greenwood Rd	Orapa B	Orapa A	Airedale Reef	Turangi Reef
Greenwood Rd	-				
Orapa B	NS	-			
Orapa A	NS	NS	-		
Airedale Reef	SIG	SIG	SIG	-	
Turangi Reef	NS	NS	NS	SIG	-

Key - SIG = significant difference at 95% confidence level
NS = no significant difference at 95% confidence level

The analysis for total number of species per quadrat from the present survey showed the highest mean number of species per quadrat occurred at the Greenwood Road, Orapa A and Turangi Road site and the lowest was at the Airedale Reef site. The low species richness at Airedale Reef was due to the sand inundation that occurred during the sampling period in spring. It is shown above in Table 2 that Airedale Reef and Orapa B are significantly different due to the lower species richness compared to the other three sites.

2.1.2 Shannon-Weiner diversity index data

Graphical summaries of the Shannon-Weiner index data at each site are shown as box and whisker plots in Figure 4.

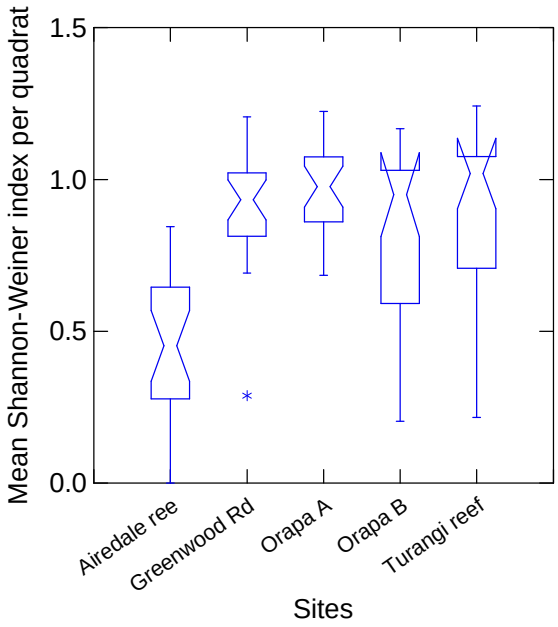

Figure 4 Box and whisker plots of mean Shannon-Weiner indices per quadrat

A Lilliefors test indicated that there was a significant deviation from a normal distribution at a 95% confidence level at Orapa B and Turangi Reef sites. The ANOVA test is considered to be robust even when assumptions of normality are not met, and as only two sites significantly deviated from a normal distribution it was considered appropriate to continue with an ANOVA test.

The ANOVA test carried out on the Shannon-Weiner index data for the five sites revealed a statistically significant difference between the sites ($F = 19.980$, $P = 0.000$) at a 95% confidence level.

A Tukey multiple comparison test was used to indicate which sites had significantly different means. Table 3 shows which combinations of sites were significantly different at a 95% confidence level.

Table 3 Results of Tukey multiple comparison test for Shannon-Weiner index per quadrat

Site	Greenwood Rd	Orapa B	Orapa A	Airedale Reef	Turangi Reef
Greenwood Rd	-				
Orapa B	NS	-			
Orapa A	NS	NS	-		
Airedale Reef	SIG	SIG	SIG	-	
Turangi Reef	NS	NS	NS	SIG	-

Key - SIG = significant difference at 95% confidence level
NS = no significant difference at 95% confidence level

As for the species richness data, analysis of Shannon-Weiner index per quadrat showed that the highest diversity occurred at the Orapa A site followed by Greenwood Road, Turangi Reef, Orapa B and the Airedale Reef site. The lowest diversity was recorded at the Airedale Reef site and this was significantly lower than the other four sites due to the sand inundation.

2.1.3 Sand coverage

In addition to the number of algae and animals in each quadrat, the percentage coverage of sand is also recorded. This has been included in the sample design of all quadrat surveys as high sand levels (of greater than 30% coverage per quadrat) can significantly impact marine communities.

The mean percent coverage per quadrat at each site is presented in Table 4 below. In addition, the number of quadrats which sand occurred in out of the 25 quadrats sampled at each site is also given. This provides an indication of the distribution and extent of sand coverage across the sampling site.

Table 4 Mean percent coverage of sand per quadrat

Site	Mean % sand coverage per quadrat	Number of quadrats sand occurred
Greenwood Road	0.00	0/25
Orapa B	3.00	7/25
Orapa A	2.40	4/25
Airedale Reef	59.80	24/25
Turangi Reef	0.80	1/25

During this 2004 survey sand was recorded in nearly all quadrats at the Airedale Reef sites. The Airedale Reef site has had almost complete sand inundation now for the past couple of years, resulting in low species diversity for both animals and algae. All other sites experienced low sand levels, which you would expect to have no effect on the ecological diversity on the reef. Orapa B has high levels of the colonial worm *Sabellaria kaiparaensis* present which prevent any other species from growing on either the substrate or the worm cases.

2.2 Comparison of 2004 results with previous spring surveys

In this section the results obtained during the survey performed in Spring 2004 are compared with the results obtained from previous spring surveys performed at the same sites.

A summary of results obtained during previous spring surveys since 1985 is contained in Table 5. This table shows the mean, median and range of results for the mean number of algae, animals and total species (algae and animals) per quadrat and the mean Shannon-Weiner index per quadrat for algae, animals and total species at each site for spring surveys undertaken between 1985 and 2003. Also shown in this table are the results obtained during the spring 2004 survey for each of these measures of ecological diversity to allow a comparison with previous results.

Table 5 Summary of spring Waitara outfall ecological surveys 1985-2004

Site	Parameter (mean per quadrat)	Mean	Median	Range	October 2002 mean
Greenwood Road	No algae	4.70	4.83	3.6-5.64	7.84
(No. of surveys = 10)	No animals	12.10	12.76	5.04-16.04	8.00
	No total species	16.80	17.35	9.48-21.36	15.84
	SW index: algae	0.520	0.513	0.33-0.680	0.724
	SW index: animals	0.842	0.878	0.395-0.964	0.621
	SW index: total species	0.972	1.008	0.649-1.110	0.907
Orapa B	No algae	4.93	5.04	3.72-6.16	4.76
(No. of surveys = 16)	No animals	12.11	12.42	8.84-15.40	6.96
	No total species	17.04	16.88	13.40-21.04	11.72
	SW index: algae	0.563	0.569	0.426-0.695	0.569
	SW index: animals	0.846	0.850	0.701-0.979	0.601
	SW index: total species	0.985	0.975	0.885-1.112	0.812
Orapa A	No algae	4.53	4.90	0.00-6.24	5.08
(No. of surveys = 16)	No animals	11.97	12.66	0.00-15.64	10.40
	No total species	16.50	17.02	0.00-21.76	15.48
	SW index: algae	0.527	0.526	0.00-0.792	0.539
	SW index: animals	0.806	0.847	0.00-0.989	0.797
	SW index: total species	0.928	0.967	0.00-1.119	0.958
Airedale Reef	No algae	3.39	3.30	0.52-4.88	2.27
(No. of surveys = 16)	No animals	9.19	8.86	1.00-16.08	4.48
	No total species	12.57	12.74	1.52-20.68	6.76
	SW index: algae	0.417	0.431	0.067-0.591	0.309
	SW index: animals	0.675	0.676	0.063-1.025	0.309
	SW index: total species	0.802	0.832	0.093-1.131	0.434
Turangi Reef	No algae	4.90	4.80	3.68-6.62	4.80
(No. of surveys = 11)	No animals	11.67	12.05	9.40-13.92	9.48
	No total species	16.57	17.00	13.28-18.68	14.28
	SW index: algae	0.520	0.493	0.405-0.748	0.519
	SW index: animals	0.814	0.802	0.677-0.931	0.738
	SW index: total species	0.945	0.940	0.820-1.093	0.888

The results obtained at each of the sites between 1985 and 2004 are shown graphically in Figures 5 to 9. There are two graphs for each site; one graph shows the mean number of algae, animals and total species (algae and animals) per quadrat and the second graph shows the mean Shannon-Weiner index per quadrat for algae, animals and total species.

Comparisons between sites for mean number of species per quadrat and mean Shannon-Weiner indices per quadrat for total species for all spring surveys since 1985 are shown in Figure 10. Figure 10(a) shows the mean number of species per quadrat, and Figure 10(b) shows the mean Shannon-Weiner index per quadrat.

GREENWOOD ROAD

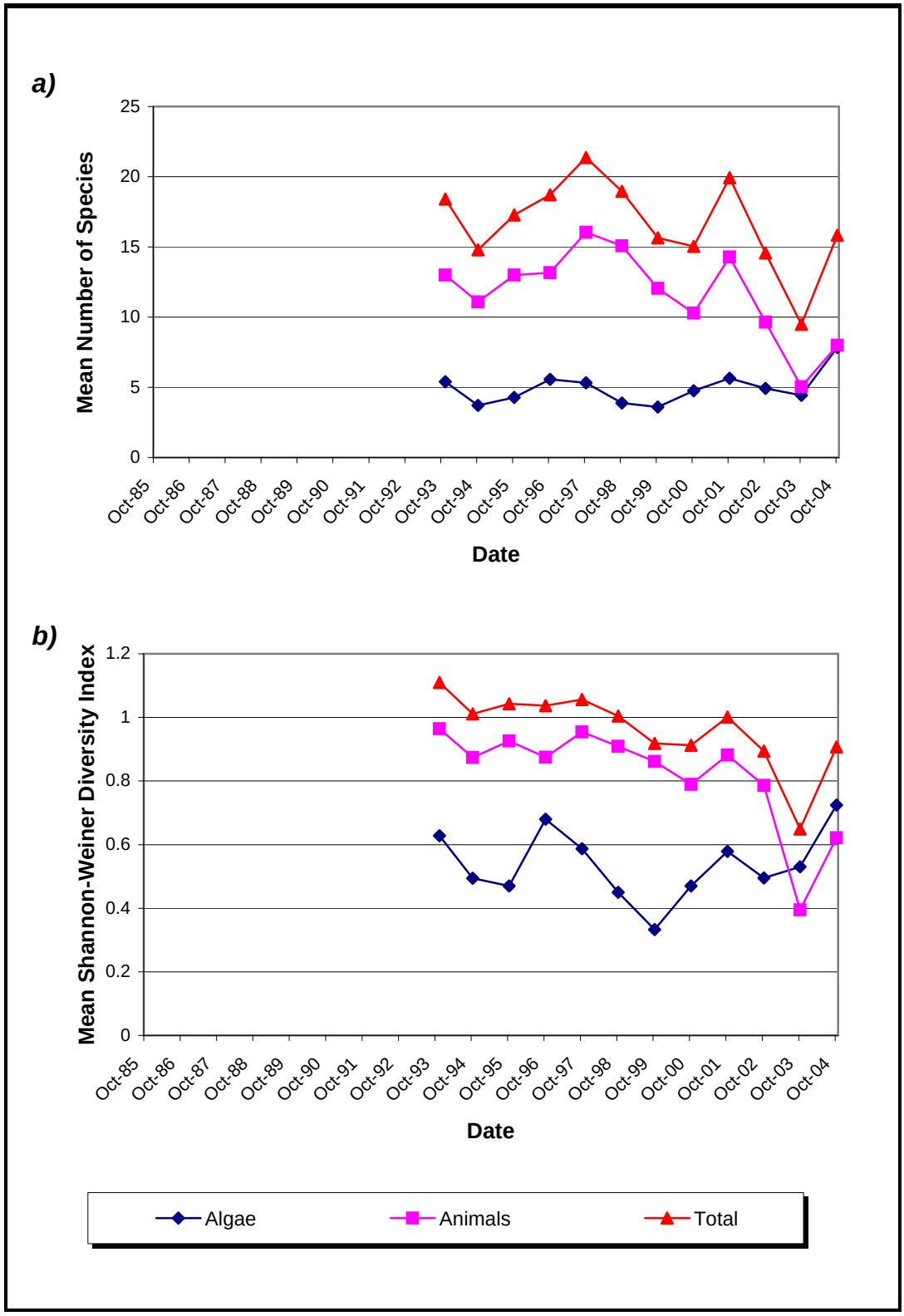

Figure 5 Greenwood Road a) mean number of species per quadrat and b) mean Shannon-Weiner diversity index per quadrat

ORAPA B

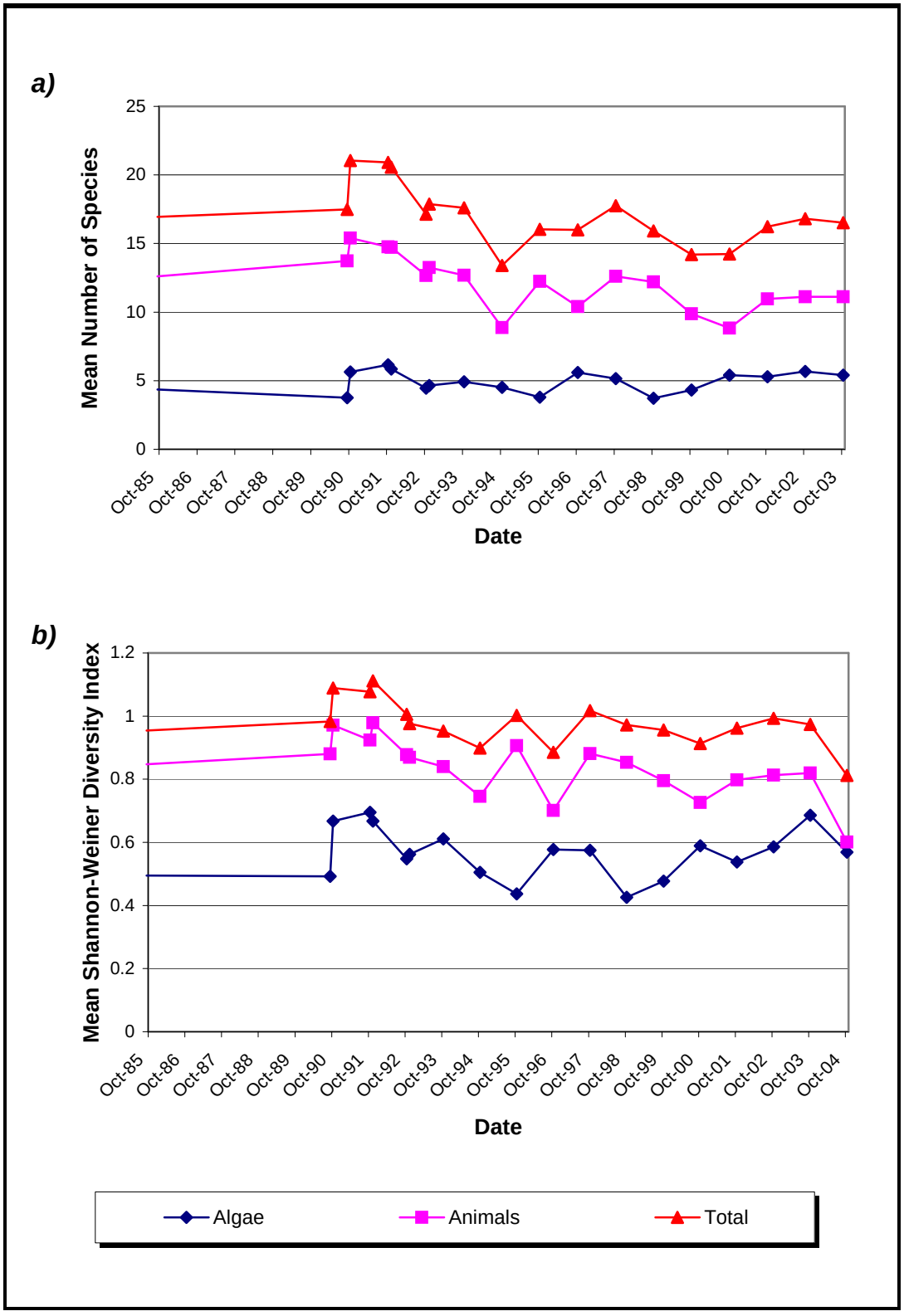

Figure 6 Orapa B a) mean number of species per quadrat and b) mean Shannon-Weiner diversity index per quadrat

ORAPA A

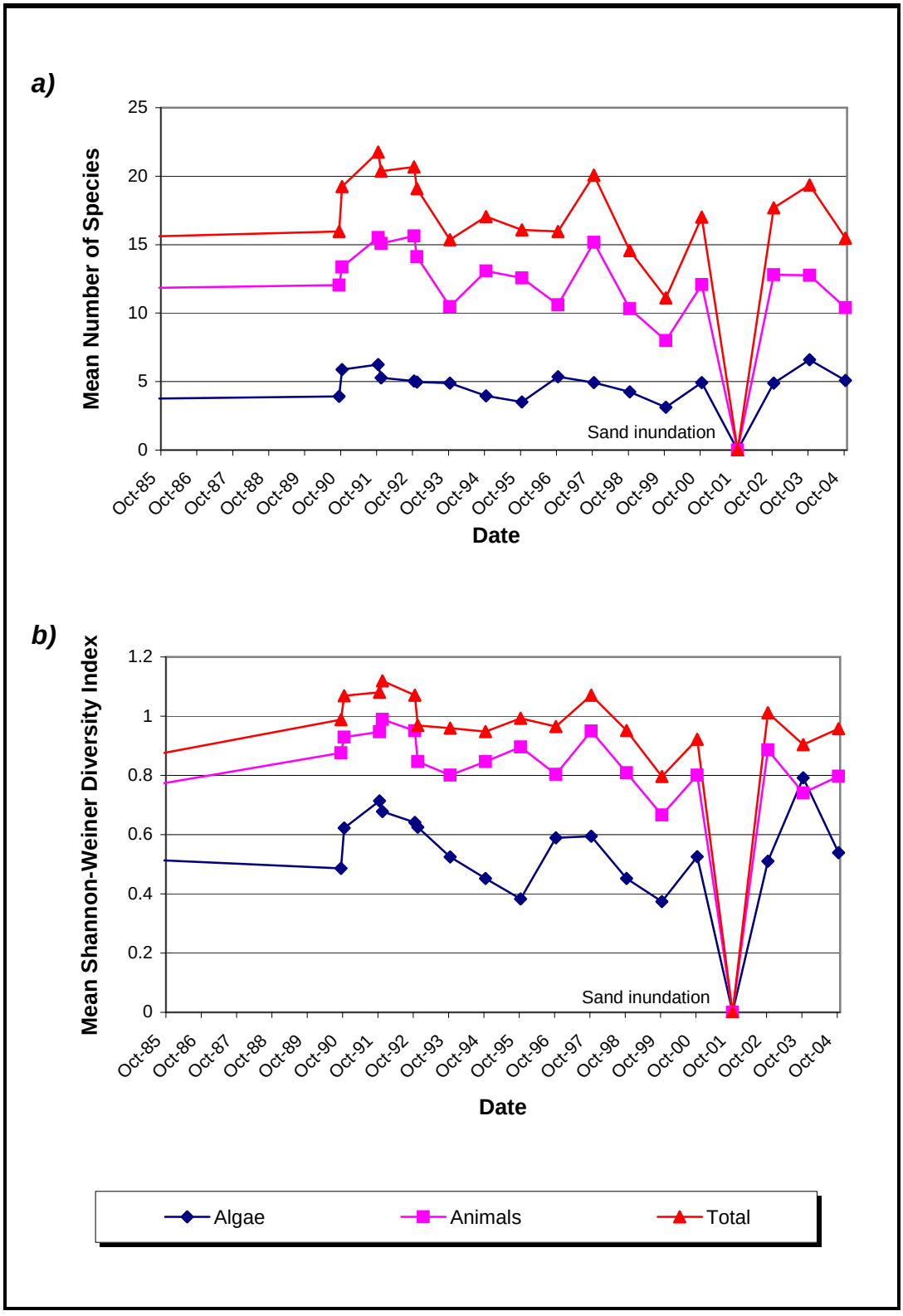

Figure 7 Orapa A a) mean number of species per quadrat and b) mean Shannon-Weiner diversity index per quadrat

AIREDALE REEF

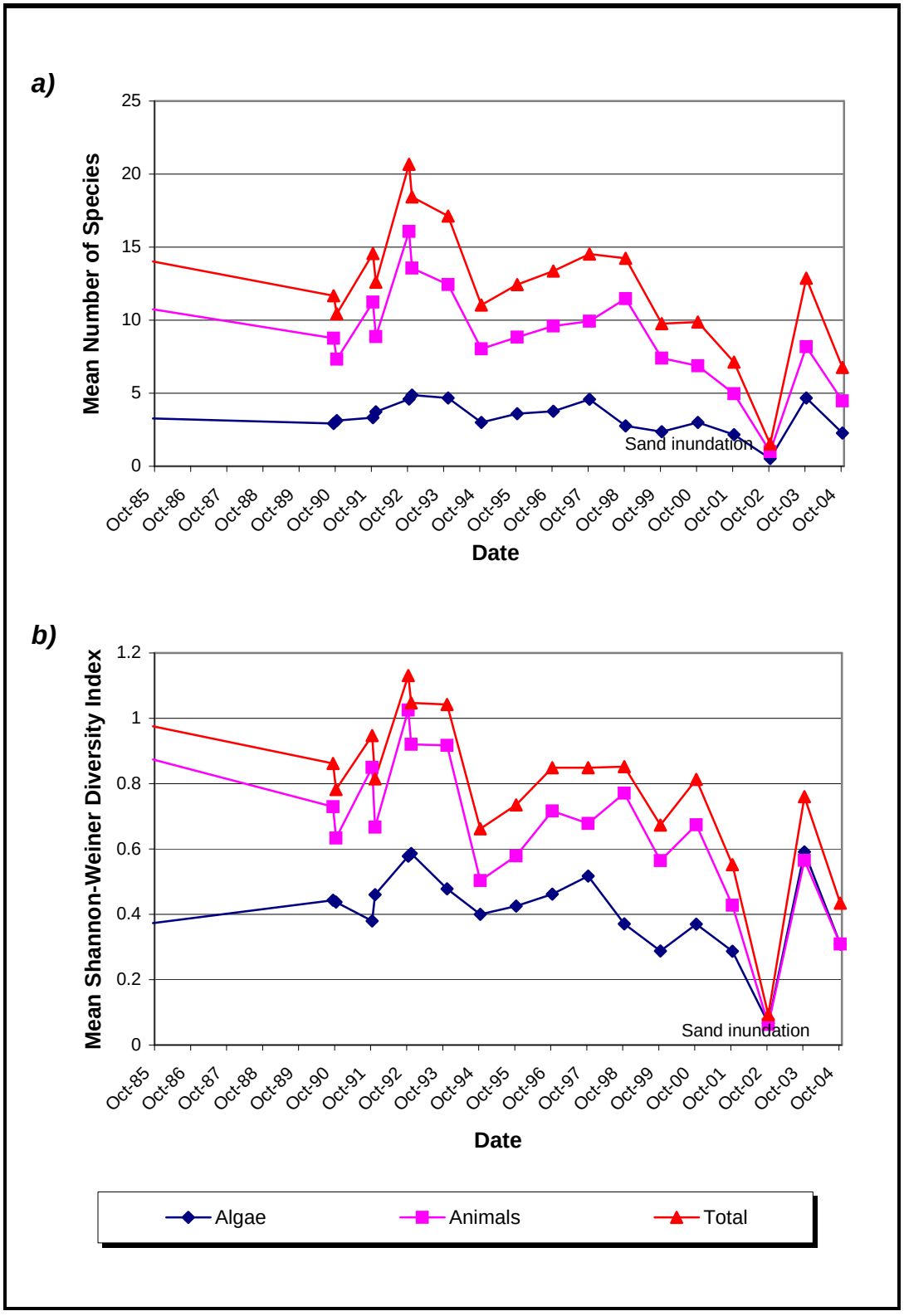

Figure 8 Airedale Reef a) mean number of species per quadrat and b) mean Shannon-Weiner diversity index per quadrat

TURANGI REEF

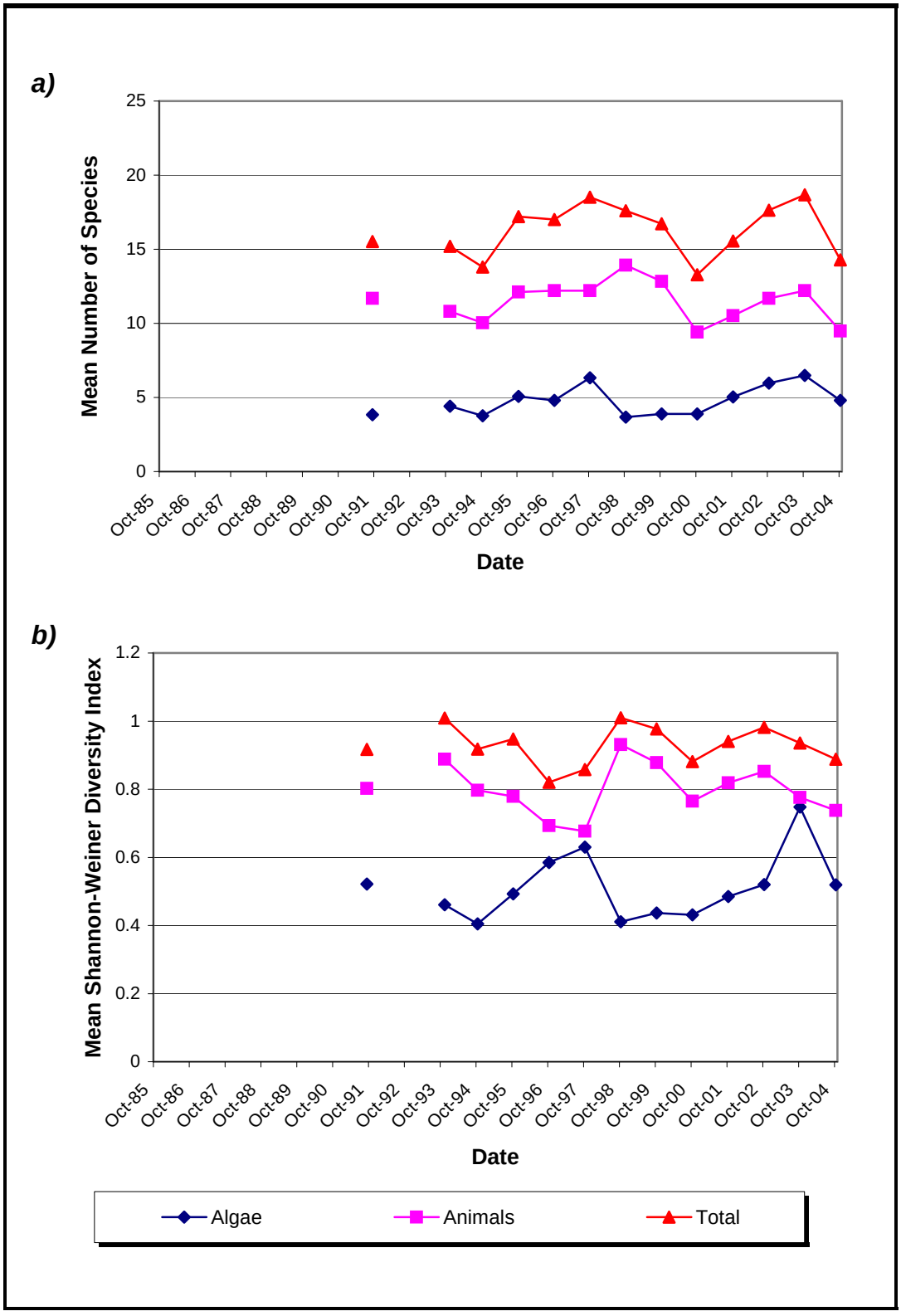

Figure 9 Turangi Reef a) mean number of species per quadrat and b) mean Shannon-Weiner diversity index per quadrat

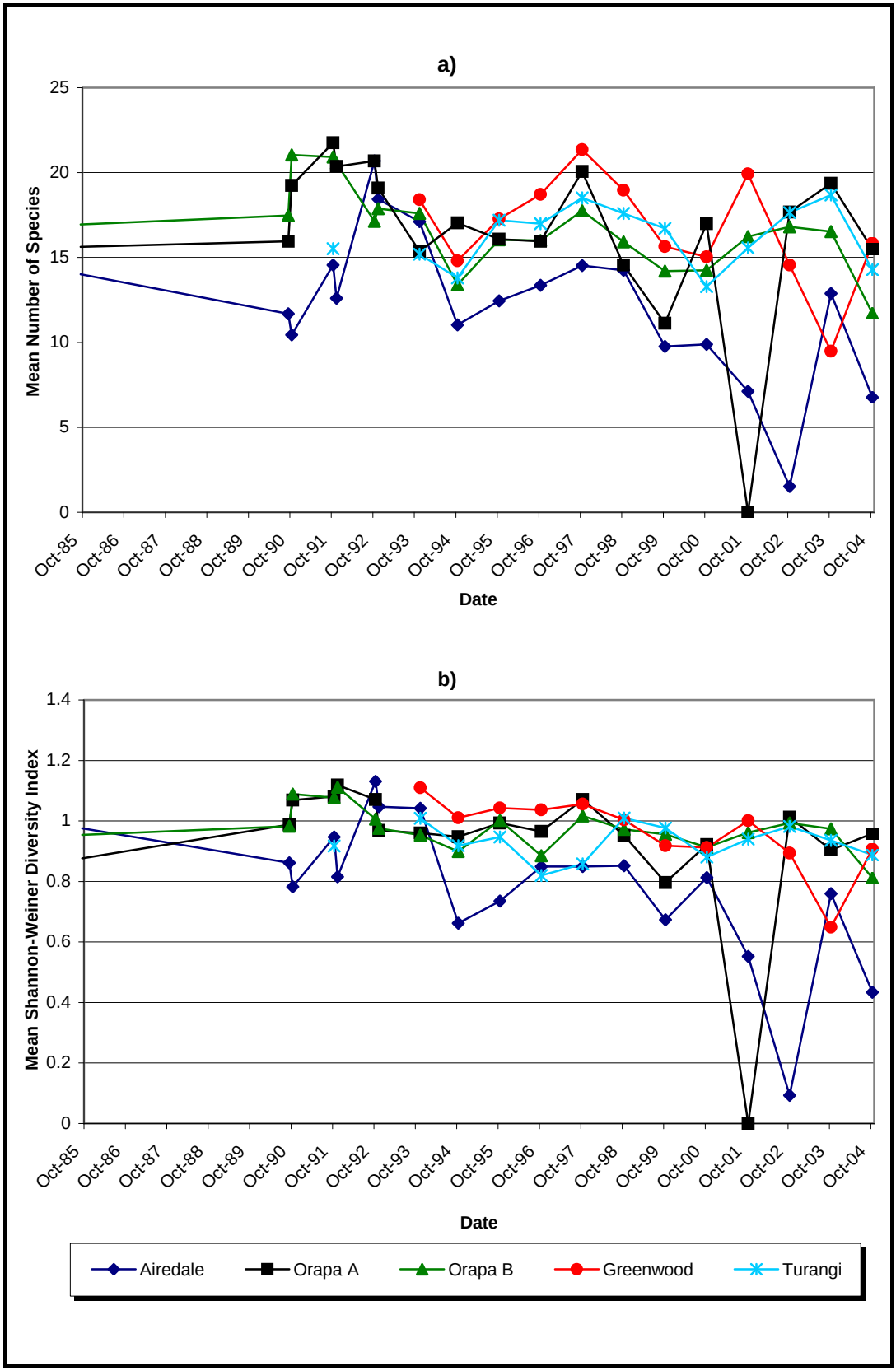

Figure 10 Comparison over time of a) mean number of species per quadrat and b) mean Shannon-Weiner diversity index per quadrat-spring 1985-2004

3. Discussion

3.1 The Resource Management Act (1991)

The Resource Management Act primarily addresses environmental `effects', which are defined as positive or adverse, temporary or permanent, past, present or future, or cumulative. Effects may arise in relation to:

(a) the neighbourhood or the wider community around a discharger, and may include cultural and socio-economic effects;
(b) physical effects on the locality, including landscape, amenity and visual effects;
(c) ecosystems, including effects on plants, animals, or habitats, whether aquatic or terrestrial;
(d) natural and physical resources having special significance (eg, recreational, cultural, or aesthetic);
(e) risks to the neighbourhood or environment.

In drafting and reviewing conditions on discharge permits, and in implementing monitoring programmes, the Taranaki Regional Council is recognising the comprehensive meaning of `effects' inasmuch as is appropriate for each discharge source. Monitoring programmes are therefore not only based on existing permit conditions, but also on the obligations of the Resource Management Act to assess the effects of the exercise of consents.

3.2 Discussion of marine ecological monitoring

The concept of ecological diversity consists of two basic components. These components are *species richness* or the number of different species present in an ecological community, and the *relative abundance* of the different species that are present. Two measures of ecological diversity are used in this report to assess the effect of the Waitara marine outfall discharge on the local intertidal marine community. The first measure is the mean number of species per quadrat at each site and this is essentially a measure of species richness. This statistic is calculated for algae and animals individually and also for the combined number of algae and animals (total species) per quadrat. The second measure of ecological diversity is the mean Shannon-Weiner diversity index per quadrat. This statistic incorporates both the number of different species present (species richness) and the relative abundance of those species into one statistic. This statistic is also calculated for algae and animals individually and for algae and animals combined together (total species).

Although the comparison of results from potential impact sites and control sites within the same year provides useful information, from the beginning of the programme it was envisaged that the primary form of assessment would be the analysis of trends over time. Also the comparison of results obtained at a particular site with previous results obtained from that site during surveys undertaken at a comparable time of year would be assessed.

The data analysed in this report constitutes a fourteen year continuous data record from September 1990 to spring 2004. Data collected during 1985 and 1986 is also

included in statistical comparisons as this data was collected in the same manner as data collected since September 1990.

The results of the October 2004 survey showed the sites Orapa A (impact site), Greenwood Road and Turangi Reef (control site) as having the highest ecological diversity followed by Orapa B (impact site) and Airedale Reef (impact site). Airedale Reef decreased in ecological diversity due to sand inundation which has been occurring for the last couple of monitoring years with a general trend of decreasing ecological diversity, which has been occurring since October 1997.

Minor sand levels were recorded at all sites during the present survey with the exception of Airedale Reef. Monitoring across intertidal rocky reefs in Taranaki has indicated that the ecological diversity and abundance of marine communities can be adversely affected when sand levels exceed 30% coverage. It is considered that the high sand coverage across Airedale Reef (60% coverage) resulted in the significant decline in species richness during 2004. Airedale Reef has had a high sand coverage over the past few years where 31% per quadrat was recorded in the 2003 survey and 91% per quadrat was recorded in October 2002. These increased sand levels of recent years have resulted in a decreasing trend of species richness. The sites, Greenwood Road, Orapa A, Orapa B and Turangi Reef are considered to have been unaffected by sand levels.

Greenwood Road increased in species diversity after a decreasing trend over the last couple of years due to sand inundation. In the October 2003 survey it recorded the lowest ecological diversity among all sites, where it has now increased to have one of the highest diversity levels among the five sites. The sand inundation that was present at high levels at this site allowed no suitable habitat present on the reef for colonisation of marine species due to sand smothering the reef.

Table 5 shows that species richness (mean number per quadrat) levels recorded for 2004 were within the range of results collected during previous (1985-2003) surveys for Greenwood Road, Orapa A, Turangi road and Airedale Reef. Species richness levels for Orapa B were below the range of results collected during the previous surveys which may be a result of habitat alteration by tubeworms. Greenwood Road increased in the total number of algal species present during the 2004 survey to a level higher than the previous range of results.

The mean Shannon-Weiner diversity index data, which incorporates the relative abundance of each of the species present at the site as well as the number of species, generally showed the same result as for the species richness with the results within the range from previous surveys except Orapa B. The increase in algae for Greenwood Road also resulted in a larger diversity index.

The plots in Figures 5 to 9, and particularly Figure 10, show fluctuations in diversity at each of the sites over time. These plots show that up until October 2000 each site was undergoing a period of decreasing diversity (for both mean number of species and Shannon-Weiner diversity index).

In the 2004 survey the mean number of species found at all sites decreased apart from Greenwood Road which increased after recovering from sand inundation in 2003. Greenwood Road, Orapa A and Turangi road have the highest mean number of species per quadrat followed by Orapa B and Airedale Reef.

The diversity index only increased at Greenwood Road and Orapa A which has the two highest species diversity indexes for the 2004 survey, followed closely by Turangi road. Orapa B and Airedale Reef are significantly lower which can be attributed to environmental factors.

3.3 Evaluation of performance

An intertidal marine ecological survey was carried out between September to December 2004 at five sites to assess the effects of the Waitara marine outfall discharge on the intertidal marine community. These surveys included three potential impact sites within the Waitara embayment and two control sites, north and south of the outfall.

Any adverse effects of the Waitara marine outfall discharge on the intertidal community would be indicated by a significant decline in ecological diversity at the potential impact sites. During this 2004 survey, it was clearly evident that high sand levels caused a significant decline in the ecological diversity at Airedale Reef. Greenwood Road, which is one of the two control sites, was significantly affected by sand inundation in October 2003, but is now starting to recover back to levels of similar species diversity it had prior to the inundation.

Orapa A (potential impact), and Greenwood Road (control) each showed an increase in ecological diversity in comparison to October 2003, whereas Orapa B (potential impact) and Turangi road (control) decreased in ecological diversity. In the 2001 survey Orapa A was completely inundated with sand allowing no ecological surveys to be carried out, but in 2004 the area of reef has recovered to levels higher than all other sites, both potential impact and control sites.

All sites decreased in ecological diversity except Greenwood Road and Orapa A during the 2004 survey. Orapa A has an ecological diversity similar to the Turangi Road and Greenwood Road control sites. The other impact site of Airedale Reef is still recovering from sand inundation, while Orapa B also had a decrease in ecological diversity due to habitat colonising worms. So it is concluded that the Waitara marine outfall discharge was not having any adverse effect on the intertidal reef communities in the Waitara embayment.

During the year, the consent holders demonstrated a high level of environmental performance and compliance with the resource consents in relation to the discharge via the Waitara marine outfall.

3.4 Recommendations from 2003 Annual Report

Based on the results of the Waitara marine outfall monitoring programme conducted during 2003, it was recommended:

1) THAT the Waitara marine outfall monitoring programme continues during the 2004 year in a similar manner to the 2003 monitoring programme

2) THAT should any adverse ecological effect arise as a result of the Waitara marine outfall as indicated by the monitoring programme, the level of monitoring shall return to that of two annual surveys

These recommendations were complied with by the completion of the 2004 monitoring programme for the Waitara marine outfall marine ecological monitoring programme.

3.5 Alterations to monitoring programmes for 2005

In designing and implementing the monitoring programmes for water discharges in the region, the Taranaki Regional Council has taken into account the extent of information made available by previous authorities, its relevance under the Resource Management Act, the obligations of the Act in terms of monitoring discharges and effects, and subsequently reporting to the regional community, the scope of assessments required at the time of renewal of permits, and the need to maintain a sound understanding of industrial processes within Taranaki discharging to the environment.

In the case of the Waitara marine outfall, the programme for 2004 was not altered from that for 2003 on the grounds that no adverse marine ecological effects arose as a result of the wastewater discharge. In is considered that for the 2005 year, the programme should continue at its current residual level. A recommendation to this effect is presented in the next section.

4. Recommendations

Based on the results of the Waitara outfall marine ecological monitoring programme conducted during 2004, it is recommended:

1. THAT the Waitara outfall marine ecological monitoring programme continues during the 2005 year in a similar manner to the 2004 monitoring programme

2. THAT should any adverse ecological effect arise as a result of the Waitara outfall as indicated by the monitoring programme, the level of monitoring shall return to that of two annual surveys

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Appendix I

Consent 3397
Consent 3398
Consent 3399
Consent 3400

Appendix II

Summary of spring survey results
1985-2004

Greenwood Road	No. of Quadrats	No. algae	No. animals	No. total species	SW index: algae	SW index: animals	SW index: total species	Sand % cover
September 1985	40	4.90	12.52	17.42	0.537	0.895	1.030	-
November 1993	10	5.40	13.00	18.40	0.628	0.964	1.110	-
October 1994	25	3.72	11.08	14.80	0.494	0.874	1.011	-
October 1995	25	4.28	13.00	17.27	0.470	0.926	1.043	-
October 1996	25	5.56	13.16	18.72	0.680	0.875	1.037	0.24
October 1997	25	5.32	16.04	21.36	0.587	0.954	1.056	0.20
October 1998	25	3.88	15.08	18.96	0.450	0.909	1.004	0.12
October 1999	25	3.60	12.04	15.64	0.333	0.861	0.920	0.52
October 2000	25	4.76	10.28	15.04	0.470	0.789	0.912	0.68
October 2001	25	5.64	14.28	19.92	0.579	0.881	1.001	0.80
October 2002	25	4.92	9.64	14.56	0.495	0.786	0.894	12.76
October 2003	25	4.44	5.04	9.48	0.53	0.395	0.649	61.04
October 2004	25	7.84	8	15.84	0.724	0.621	0.907	0

Orapa B	No. of Quadrats	No. algae	No. animals	No. total species	SW index: algae	SW index: animals	SW index: total species	Sand % cover
September 1985	40	4.35	12.60	16.95	0.495	0.847	0.954	-
September 1990	25	3.76	13.72	17.48	0.492	0.880	0.983	-
October 1990	25	5.64	15.40	21.04	0.667	0.971	1.089	-
October 1991	25	6.16	14.76	20.92	0.695	0.924	1.077	-
November 1991	25	5.84	14.72	20.56	0.667	0.979	1.112	-
October 1992	15	4.46	12.66	17.13	0.548	0.878	1.006	-
November 1992	25	4.64	13.24	17.88	0.562	0.869	0.976	-
October 1993	25	4.92	12.68	17.60	0.611	0.840	0.953	-
October 1994	25	4.52	8.87	13.40	0.505	0.746	0.899	3.08
October 1995	25	3.80	12.24	16.04	0.437	0.906	1.002	1.76
October 1996	25	5.60	10.40	16.00	0.577	0.701	0.885	4.56
October 1997	25	5.16	12.60	17.76	0.575	0.881	1.017	2.92
October 1998	25	3.72	12.20	15.92	0.426	0.853	0.972	4.20
October 1999	25	4.32	9.88	14.20	0.477	0.795	0.960	8.03
October 2000	25	5.40	8.84	14.24	0.589	0.726	0.913	3.12
October 2001	25	5.28	10.96	16.23	0.538	0.798	0.962	8.27
October 2002	25	5.68	11.12	16.8	0.586	0.813	0.993	5
October 2003	25	5.40	11.12	16.52	0.686	0.820	0.974	4.76
October 2004	25	4.76	6.96	11.72	0.569	0.601	0.812	3.0

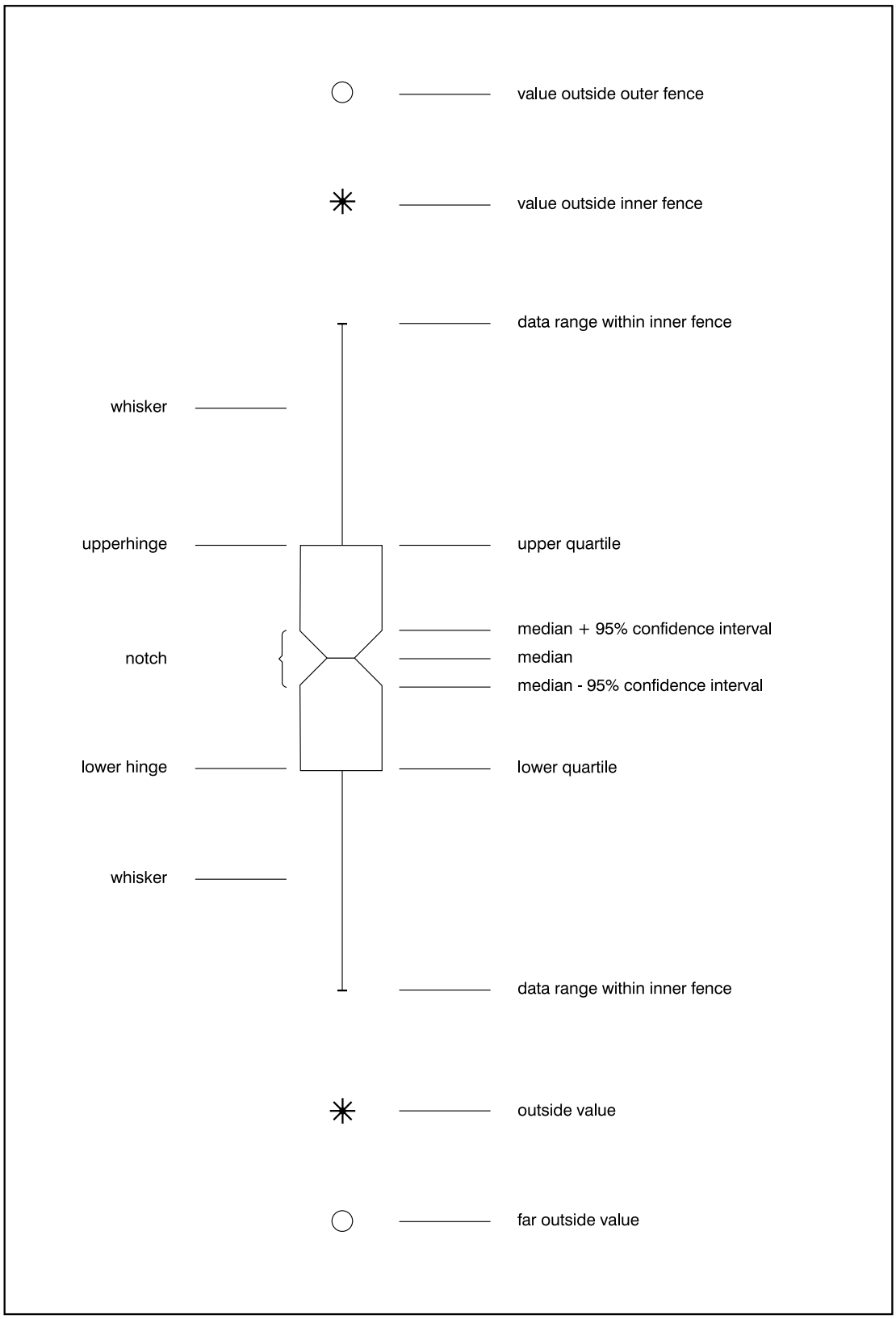
Orapa A	No. of Quadrats	No. algae	No. animals	No. total species	SW index: algae	SW index: animals	SW index: total species	Sand % cover
September 1985	40	3.77	11.85	15.62	0.513	0.774	0.876	0.52
September 1990	25	3.92	12.04	15.96	0.486	0.876	0.988	-
October 1990	25	5.88	13.36	19.24	0.622	0.929	1.069	-
October 1991	25	6.24	15.52	21.76	0.714	0.947	1.081	-
November 1991	25	5.28	15.08	20.36	0.678	0.989	1.119	-
October 1992	25	5.04	15.64	20.68	0.641	0.951	1.071	-
November 1992	25	4.96	14.12	19.08	0.625	0.847	0.969	-
October 1993	25	4.88	10.48	15.36	0.525	0.801	0.960	-
October 1994	25	3.96	13.08	17.04	0.452	0.847	0.948	1.00
October 1995	25	3.52	12.56	16.08	0.383	0.896	0.993	0.00
October 1996	25	5.36	10.60	15.96	0.589	0.804	0.965	0.04
October 1997	25	4.92	15.16	20.07	0.595	0.950	1.071	5.80
October 1998	25	4.24	10.32	14.56	0.452	0.809	0.952	1.96
October 1999	25	3.12	8.00	11.12	0.374	0.666	0.800	24.08
October 2000	25	4.92	12.08	17.00	0.526	0.801	0.922	0.76
October 2001	25	0	0	0	0	0	0	100
October 2002	25	4.88	12.8	17.68	0.51	0.886	1.012	0.88
October 2003	25	6.60	12.76	19.36	0.792	0.741	0.904	1.00
October 2004	25	5.08	10.4	15.48	0.539	0.797	0.958	2.40

Airedale Reef	No. of Quadrats	No. algae	No. animals	No. total species	SW index: algae	SW index: animals	SW index: total species	Sand % cover
September 1985	40	3.27	10.75	14.02	0.373	0.874	0.976	3.55
September 1990	25	2.92	8.76	11.68	0.443	0.729	0.862	-
October 1990	25	3.12	7.32	10.44	0.437	0.633	0.782	-
October 1991	25	3.32	11.24	14.56	0.380	0.850	0.947	-
November 1991	25	3.72	8.87	12.60	0.460	0.667	0.815	-
October 1992	25	4.60	16.08	20.68	0.578	1.025	1.131	-
November 1992	25	4.88	13.56	18.44	0.586	0.920	1.047	-
November 1993	25	4.68	12.44	17.12	0.478	0.917	1.042	-
October 1994	25	3.00	8.04	11.04	0.400	0.503	0.662	8.39
October 1995	25	3.60	8.84	12.44	0.425	0.579	0.735	8.96
October 1996	25	3.76	9.60	13.36	0.462	0.716	0.849	8.20
October 1997	25	4.59	9.92	14.52	0.517	0.678	0.849	19.68
October 1998	25	2.76	11.48	14.24	0.371	0.771	0.852	4.16
October 1999	25	2.36	7.40	9.76	0.288	0.564	0.670	20.68
October 2000	25	3.00	6.88	9.88	0.370	0.674	0.813	3.48
October 2001	25	2.16	4.96	7.12	0.287	0.428	0.552	55.88
October 2002	25	0.52	1	1.52	0.067	0.063	0.093	91.28
October 2003	25	4.68	8.19	12.88	0.591	0.565	0.760	31.24
October 2004	25	2.27	4.48	6.76	0.309	0.309	0.434	59.80

Turangi Road	No. of Quadrats	No. algae	No. animals	No. total species	SW index: algae	SW index: animals	SW index: total species	Sand % cover
September 1985	40	6.62	12.05	18.67	0.628	0.930	1.093	-
September 1991	25	3.84	11.68	15.52	0.522	0.802	0.917	-
November 1993	15	4.40	10.80	15.20	0.461	0.888	1.009	-
October 1994	25	3.76	10.04	13.80	0.405	0.797	0.918	0.84
October 1995	25	5.07	12.12	17.20	0.493	0.779	0.947	1.32
October 1996	25	4.80	12.20	17.00	0.585	0.693	0.820	1.40
October 1997	25	6.32	12.20	18.52	0.630	0.677	0.858	4.59
October 1998	25	3.68	13.92	17.60	0.411	0.931	1.010	2.48
October 1999	25	3.88	12.84	16.72	0.437	0.878	0.980	2.00
October 2000	25	3.88	9.40	13.28	0.431	0.765	0.881	0.96
October 2001	25	5.04	10.52	15.56	0.485	0.819	0.940	3.08
October 2002	25	5.96	11.68	17.64	0.52	0.852	0.982	7.52
October 2003	25	6.48	12.2	18.68	0.748	0.776	0.938	0.60
October 2004	25	4.8	9.48	14.28	0.519	0.738	0.888	0.8

Appendix III

Explanation of box and whisker plots



Box and whisker plots are a useful method of summarising data in a graphical form that allows rapid comparison of data groups. The data is represented as a box with a whisker protruding from each end.

The median (middle value of the sorted data; half of the data is either side of the median) is represented by the central horizontal line. The notch, symmetrically spread around the median represents the 95% confidence interval about the median. It is this feature that allows rapid statistical comparison between groups. If notches overlap, there is no significant difference between groups (at the 95% confidence level). If notches do not overlap, a statistical difference is implied.

The top and bottom of the box represent the upper and lower hinges respectively. The median splits the ordered group of numbers in half and the hinges split the remaining halves in half again. This means that 50% of the data lies within the box.

Hspread, comparable to the interquartile (25% to 75%) range is the difference between the values of the two hinges, ie, Upper hinge - Lower hinge = Hspread. The inner fences are defined as follows:

Lower fence = lower hinge - (1.5 x Hspread)
Upper fence = upper hinge + (1.5 x Hspread)

The outer fences are defined as follows:

Lower fence = lower hinge - (3 x Hspread)
Upper fence = upper hinge + (3 x Hspread)

The whiskers show the range of values that lie within the inner fences. Values outside the inner fence are plotted as asterisks (*). Values