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RESOURCE CONSENT IMPACT MONITORING

WAITARA MARINE OUTFALL TRACE METALS

MONITORING PROGRAMME

ANNUAL REPORT 1991/92

Technical Report 93-5

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EXECUTIVE SUMMARY

Under the terms of Coastal Permit TRK881205 held by the New Plymouth District Council, and Coastal Permit TRK83X821 held by New Zealand Synthetic Fuels Corporation, the effects of the discharge from the Waitara outfall has been monitored in a comprehensive manner. One element of the monitoring programme is the measurement of levels of heavy metals in mussels at various sites along the Waitara Coastline.

This report presents the results of the programme for the 1991-92 year. The monitoring programme has taken place for six years,with the aim of assessing any impacts that municipal and industrial (particularly from the petrochemical industry) discharges to the North Taranaki coast may be having on heavy metal accumulation in mussels.

Over the duration of this programme no evidence of adversely high levels of heavy metal tissue burden due to the Waitara marine outfall has been observed. While the results discussed in this report show significant increase in cadmium, these are less than 10% of the New Zealand permissible standards. Mercury levels are extremely low and this may in part be due to the storage time which elapsed before analysis took place. All other metals (chromium, copper, iron, lead, mercury, nickel and zinc) examined show a fairly constant tissue burden profile with fluctuations being within the likely natural perturbation levels.

It is recommended that the frequency and extent of the current heavy metal monitoring programme be reviewed.

1.0 INTRODUCTION

Metals are found in many discharges, particularly those associated with industries. The establishment of a petrochemical industry in North Taranaki in the mid 1980s raised public and Taranaki Regional Council concerns about discharge of contaminants to the coastal environment. Further concerns were held about the effects of the combined municipal/industrial discharge from Waitara marine outfall.

To assess the impact of these discharges baseline data were collected in 1981 before the commissioning of the petrochemical plants. Monitoring of trace metal in mussel tissue is one of several monitoring programmes initiated in 1985 in compliance with two consents to discharge wastewater from Waitara marine outfall. These were Coastal Permit TRK881205 held by North Taranaki District Council (now the New Plymouth District Council) and TRK83X821 held by New Zealand Synthetic Fuels Corporation Ltd.

In 1985 three surveys were carried out. Further surveys being carried out in 1986 (3), 1987 (2), 1988 and 1989. Sampling frequency has been reduced due to the establishment of a comprehensive database during the first few years, and to the consistently low levels of accumulation that have been recorded on each monitoring occasion. Results have been reported by the Taranaki Regional Council (see bibliography).

In July 1991 refurbishing of the Waitara outfall commenced. This resulted in temporary discharge of effluent to the Waitara River between July and November 1991. Coastal Permits TRK891205 and TRKX821 expired on the 12th March 1992 after the commissioning of the refurbished Waitara outfall. There are now four Coastal Permits these being TRK893397 New Plymouth District Council, TRK893398 AFFCO New Zealand, TRK893399 Methanex Waitara Valley and TRK893400 Methanex New Zealand Motunui Plant.

Perna canaliculus (green lipped mussel) is an important part of the local seafood resource and is traditional kaimoana of the local Iwi. Being filter feeders mussels are particularly useful in the monitoring of bioaccumulation of metals. Eight metals commonly associated with industrial discharge have been analysed over the duration of the monitoring programme. These are: cadmium, chromium, copper, iron, lead, mercury, nickel and zinc. Mercury and lead were dropped from the monitoring programme in 1988 because they had consistently been less than 10% of the permissible level. The food regulation give permissible levels of contamination for mercury, lead, copper, cadmium and zinc.

There are two aims to this programme:

1) to monitor levels of heavy metals in biota from the coastal environment of North Taranaki by examining spatial and temporal trends in levels of metal contaminants, with consideration for biological availability; and

2) the provision of information so that assessment of the degree of risk can be continually updated
a) from a human consumption standpoint;
b) with respect to the viability of the seafood resource; and
c) with respect to the marine ecosystem in the vicinity of the outfall.

In 1989 it was recommended that survey frequency should be reduced from annual to biannual because of the continuously low levels recorded in previous surveys, and that lead and mercury should be reintroduced to the monitoring programmes analyses. Problems with analytical equipment resulted in delayed analysis of the samples which was agreed to by consent holders. This report presents the results of a survey carried out on 22 and 23 November 1991.

2.0 METHOD

The sites and methodology of sampling were the same as has been used previously. Two sites located on each side of the Waitara outfall were sampled (Orapa Reef and West Beach to the west, and East Beach and Airedale Reef to the east); Epiha Reef and the Urenui Rivermouth are monitored as control locations on the basis of their isolation from known point sources of metal contamination. Locations are given in Figure 1.1.

The sample collection, preparation and analytical methodology have been described fully in previous reports (eg. Technical Report 89-7). Preparation of the mussels includes a depuration period to ensure removal of the gut content, necessary because iron and chromium are associated with the North Taranaki coastal sediment.

Statistical analysis was carried out using SYSTAT, VAX computer package, (SYSTAT, INC 1988). The Newman-Kuels test was carried out to assess differences between sites. This test is more powerful than the previously used Scheffe test but is simpler to use.

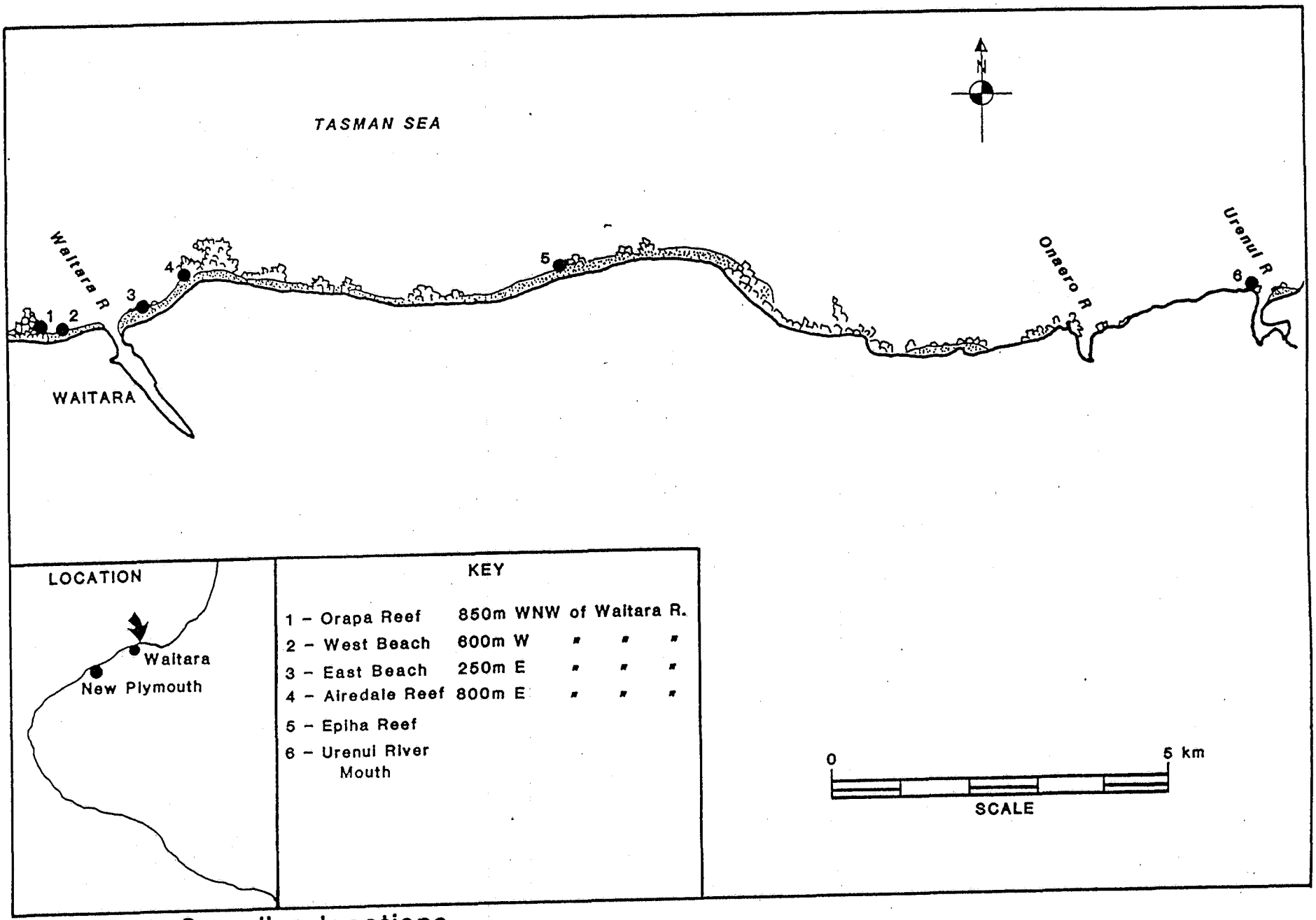

Figure 1.1: Sampling locations

3.0 RESULTS

3.1 METAL LEVELS IN MUSSELS

Data on the metal concentrations found in mussel samples is attached to this report as Appendix I. Table 2.1 presents a summary of results, together with corresponding information from 1989.

Table 2.1: DESCRIPTIVE STATISTICS FOR METAL LEVELS IN MUSSELS, NOVEMBER 1991: GEOMETRIC MEANS AND 95% CONFIDENCE INTERVALS; ug/g WET WEIGHT

Site		Orapa Reef	West Beach	East Beach	Airedale Reef	Epiha Beach[3]	Urenui River
Cadmium	91	0.04 0.02-0.09	0.05 0.03-0.08	0.06 0.05-0.07	0.07 0.05-0.10	0.05 0.02-0.20	0.03 0.02-0.06
	89	0.02 0.01-0.2	0.011 0.01-0.02	0.02 0.01-0.02	0.02 0.02-0.03	0.03 0.03-0.04	0.04 0.03-0.04
Chromium	91	0.05 0.03-0.06	0.05 0.03-0.07	0.03 0.01-0.10	0.09 0.05-0.10	0.02 0.03-0.07	0.02 0.01-0.04
	89	0.06[2] 0.04-0.07	0.07[2] 0.05-0.09	0.03[2] 0.01-0.06	0.05[2] 0.01-0.09	0.02 0.02-0.02	0.02 0.02-0.02
Copper	91	0.63 0.58-0.72	0.57 0.47-0.69	0.65 0.50-1.18	0.79 0.68-1.18	0.64 0.56-0.74	0.60 0.51-0.70
	89	0.43 0.36-0.51	0.31 0.30-0.31	0.32 0.28-0.35	0.44 0.41-0.47	0.53 0.49-0.58	0.53 0.48-0.58
Iron	91	15.6 10.0-24.0	13.4 10.1-17.8	14.5 11.7-18.6	70.0 44.7-112.2	10.5 7.2-13.8	12.1 8.9-16.2
	89	87.1[2] 73.8-102.7	72.3[2] 65.9-79.3	67.6[2] 57.0-80.1	97.5[2] 89.8-105.9	22.6 15.2-33.4	21.5 15.2-29.4
Lead	91	0.04 0.01-0.13	0.07 0.03-0.16	0.08 0.04-0.14	0.13 0.08-0.22	0.06 0.03-0.16	0.02 0.01-0.03
(4)	89						
Mercury	91	0.006 0.004-0.008	0.006 0.005-0.007	0.006 0.005-0.007	0.006 0.004-0.008	0.004 0.003-0.008	0.004 0.002-0.005
(4)	89						
Nickel	90	0.23 0.14-0.40	0.19 0.09-0.39	0.17 0.06-0.48	0.03 0.17-0.50	0.29 0.15-0.55	0.20 0.13-0.30
	89	0.17 0.12-0.22	0.17 0.15-0.20	0.16 0.13-0.20	0.29 0.17-0.42	0.24 0.20-0.27	0.20 0.16-0.24
Zinc	90	7.2 6.3-7.9	6.5 5.1-8.3	7.1 5.9-8.5	8.0 7.1-8.9	8.4 6.8-10.7	7.0 5.5-8.7
	89	5.0 4.2-6.0	4.1 3.9-4.3	4.2 3.6-4.9	6.0 5.4-6.6	7.4 7.1-7.8	7.5 6.6-8.6

NOTE:
1. First figure is geometric mean of results listed in Table A1; Second and third figures give the upper and lower levels at 95% confidence level.
2. Inhibited depuration noted during sample preparation.
3. Mussels of small size collected from this site.
4. Not analysed for in 1989.

Mussels collected from Epiha Reef were small (30-40 mm) with very few in the 60-70 mm size class specified for this type of analysis. Small mussels are known to have higher levels of metal accumulation (Technical Report 85-3). Therefore this site may have higher apparent levels of contamination than would have been the case if larger mussels had been available.

The difference in levels of iron may be at least partially due to the difficulties experienced in depuration of some mussels in 1989. This would have caused elevation of iron and chromium levels.

3.2 COMPLIANCE WITH STANDARDS FOR TRACE METALS IN SEAFOOD

All sites had levels of metal accumulation of <10% of New Zealand permissible levels (where these exist). These samples are likely to have lower levels of metal contamination than those prepared as food due to depuration prior to analysis. Mercury levels may be reduced due to storage of the mussels before analysis.

Table 2.2: COMPLIANCE OF RESULTS WITH NEW ZEALAND DEPARTMENT OF HEALTH REQUIREMENTS

Element	Permissible Level	Orapa Reef	West Beach	East Beach	Airedale Reef	Epiha Reef	Urenui River
Cadmium	1[4]	0.040	0.046	0.060	0.069	0.057	0.031
Chromium	NL[2]	0.046	0.048	0.036	0.092	<0.030	0.030
Copper	30[3]	0.636	0.572	0.650	0.800	0.644	0.596
Iron	NL[2]	15.78	13.48	14.52	71.02	10.12	12.22
Lead	2.0[3]	0.040	0.072	0.078	0.136	0.066	0.024
Mercury	0.5[3]	0.006	0.006	0.006	0.006	0.004	0.004
Nickel	NL[2]	0.236	0.198	0.178	0.300	0.294	0.204
Zinc	400[4]	7.16	6.50	7.10	8.02	8.44	6.98

NOTES:
1. All levels in ug/g wet weight
2. NL: no limit or guideline currently in force
3. Limit as listed in the First Table to Regulation 257 (Incidental Constituents), New Zealand Food Regulations 1984
4. The New Zealand Department of Health use 1 and 400 ug/g wet weight as guidelines for cadmium and zinc respectively, with the exception of cadmium in dredge oysters (Technical Report 90-19 pg 6).

3.3 DIFFERENCES BETWEEN SITES FOR 1991

Airedale Reef was found to have significantly higher levels of contamination (@ 95% Confidence Interval) than all other sites for chromium, iron and nickel. None of these metals has a set permissible level (see Tables A2-A9 in Appendix I).

Mussels collected from Airedale Reef had significantly higher (95% CI) levels of cadmium accumulation than Orapa Reef, West Beach and Urenui River. Mussels form East Beach had

levels of accumulation that were similar to Airedale Reef, but were significantly higher than Urenui River and Orapa Reef.

For Epiha Reef and Urenui River the levels of chromium were below detection levels for 9 of the 10 samples. This meant that there was insufficient variation for statistical analysis (ANOVA) to be carried out including these sites. With these sites excluded it was again found that Airedale Reef had significantly higher levels of accumulation and that there was no significant difference between Orapa Reef, East Beach and West Beach.

The 1991 copper tissue burdens recorded from Airedale Reef were the highest recorded over the duration of the monitoring programme. This site also had significantly higher accumulation of copper than all other sites in the 1991 survey.

Airedale Reef had significantly higher tissue burdens for iron. Iron levels for the remaining five sites (Orapa Reef, East Beach, West Beach, Epiha Reef and Urenui River) were tightly grouped (See Fig. 2.4).

Levels of lead accumulation were also significantly higher at Airedale Reef than at any other site, but this level was still less than 7% of the permissible standard. Orapa Reef and Urenui River had the lowest levels of lead accumulation. While East Beach, West Beach and Epiha Reef were not significantly different.

Epiha and Airedale Reef had significantly higher zinc tissue burdens than all other sites.

3.4 TEMPORAL DIFFERENCES IN LEVELS OF METALS IN TISSUE

Figures 2.1 to 2.6 give a graphical representation of levels of metals in tissue from 1985 to 1991. Mercury and lead are not shown temporally due to having an incomplete data base.

Temporal changes in metal levels in mussel tissue are seen for all metals. Nickel and zinc both appear to be at fairly stable levels. Cadmium levels for Airedale Reef, East Beach, Epiha Reef and Orapa Reef were significantly higher than levels found in the past (Fig 2.1). Copper levels for these sites were also significantly higher than in the 1989 survey.

Iron levels for the four impact sites (Orapa Reef, West Beach, East Beach and Airedale Reef), have been highly variable throughout the duration of the monitoring programme. While iron levels in mussels collected from Epiha Reef and Urenui River have shown little variation over time. In 1991 significantly lower levels of iron were present in tissue samples than in 1989. This could in part be due to the difficulty experienced in depuration of the mussels collected in 1989.

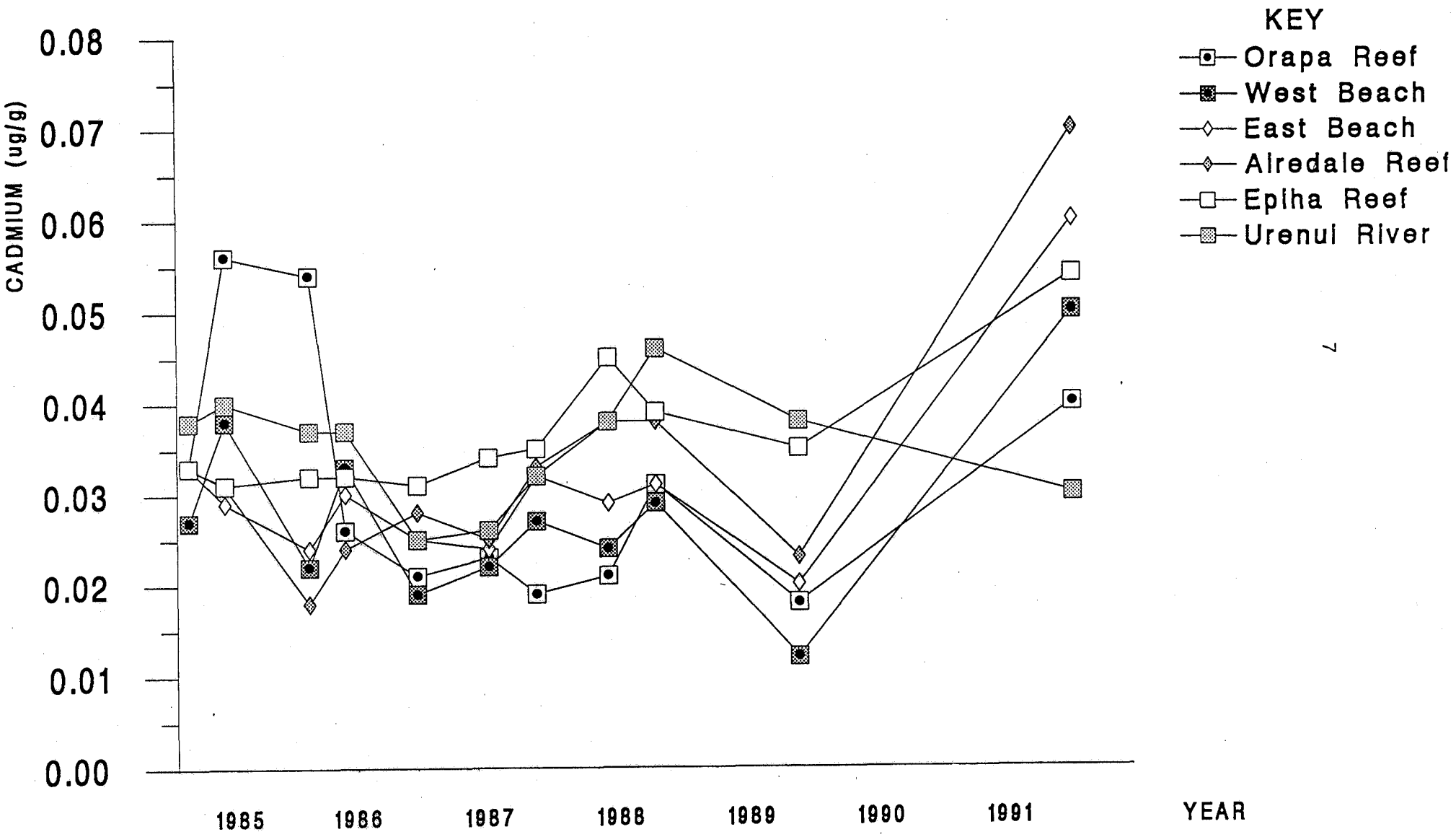

Figure2.1: Temporal fluctuatuions in Cadmium levels in mussel tissue

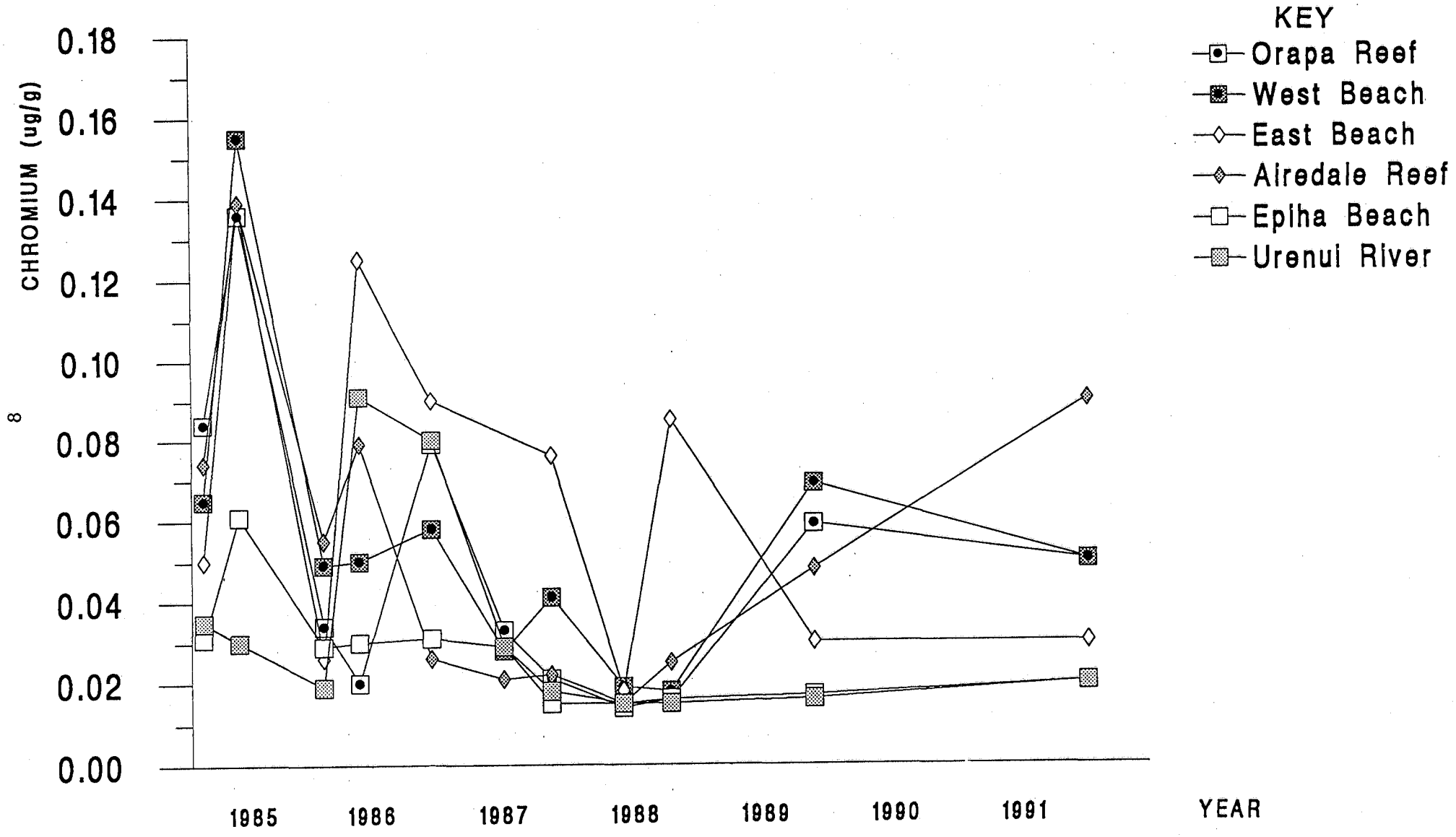

Figure 2.2: Temporal fluctuations in Chromium levels in mussel tissue

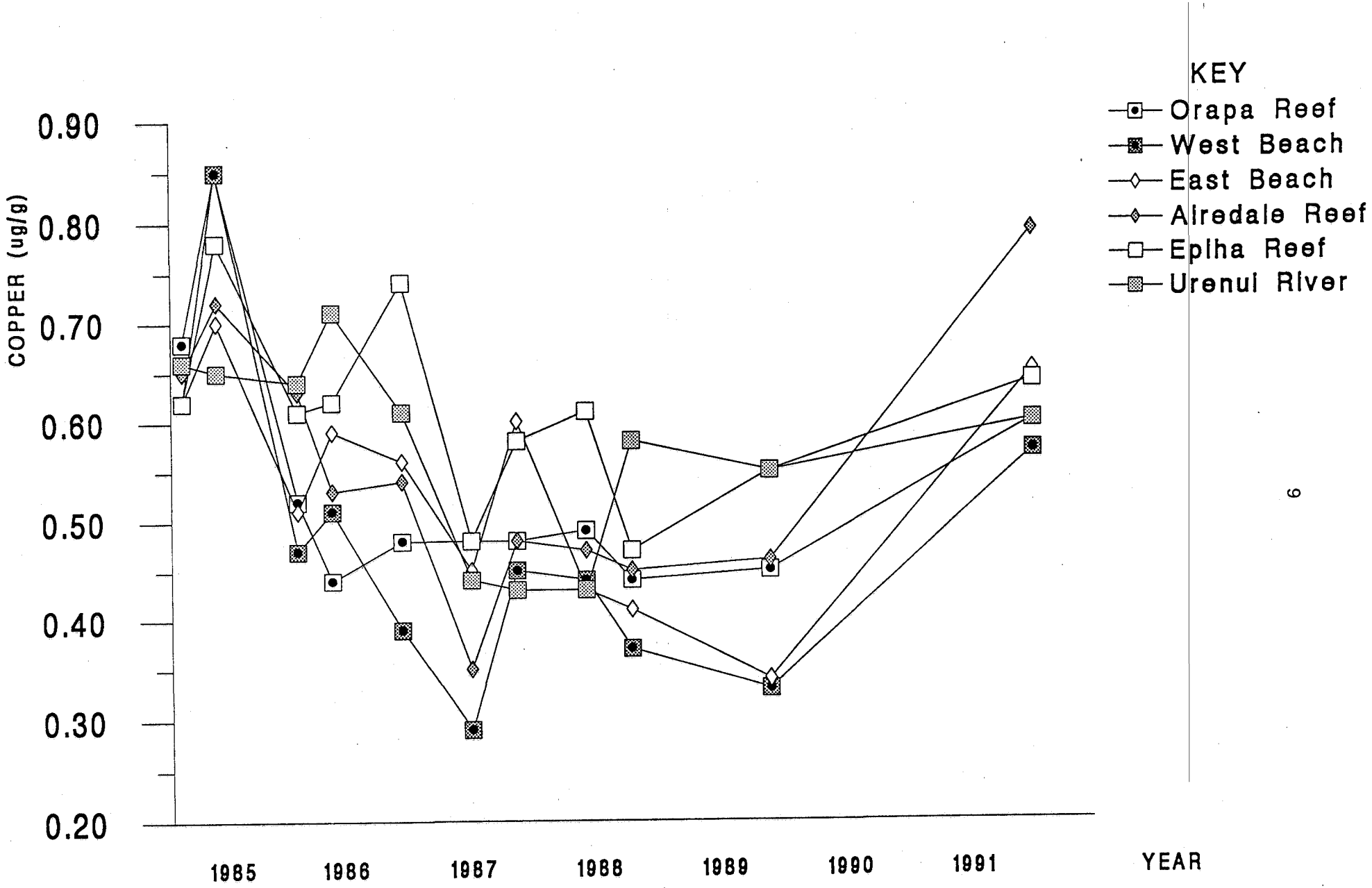

Figure 2.3: Temporal fluctuations in Copper levels in mussel tissue

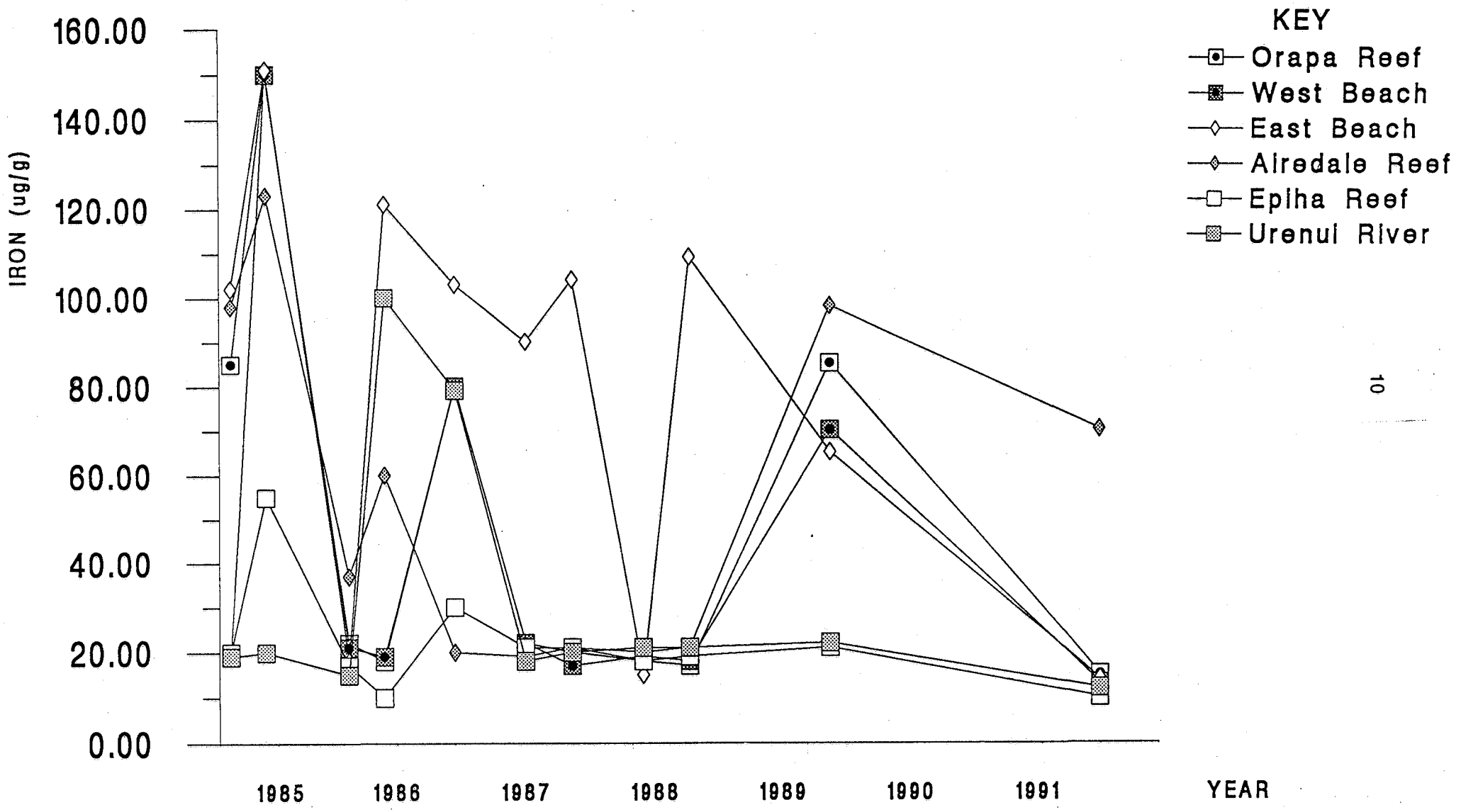

Figure 2.4: Temporal fluctuations in iron levels in mussel tissue

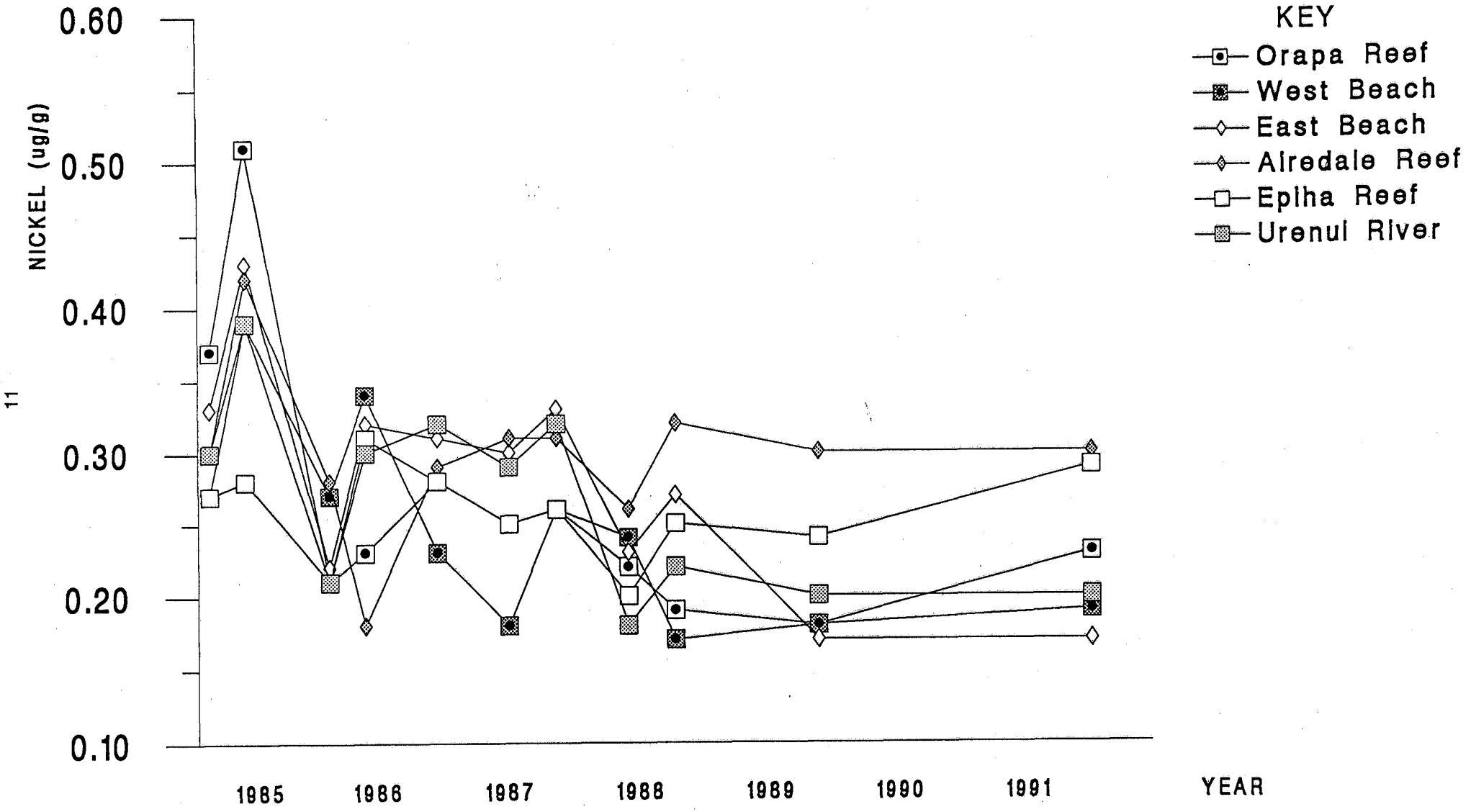

Figure 2.5: Temporal fluctuations in Nickel levels in mussel tissue

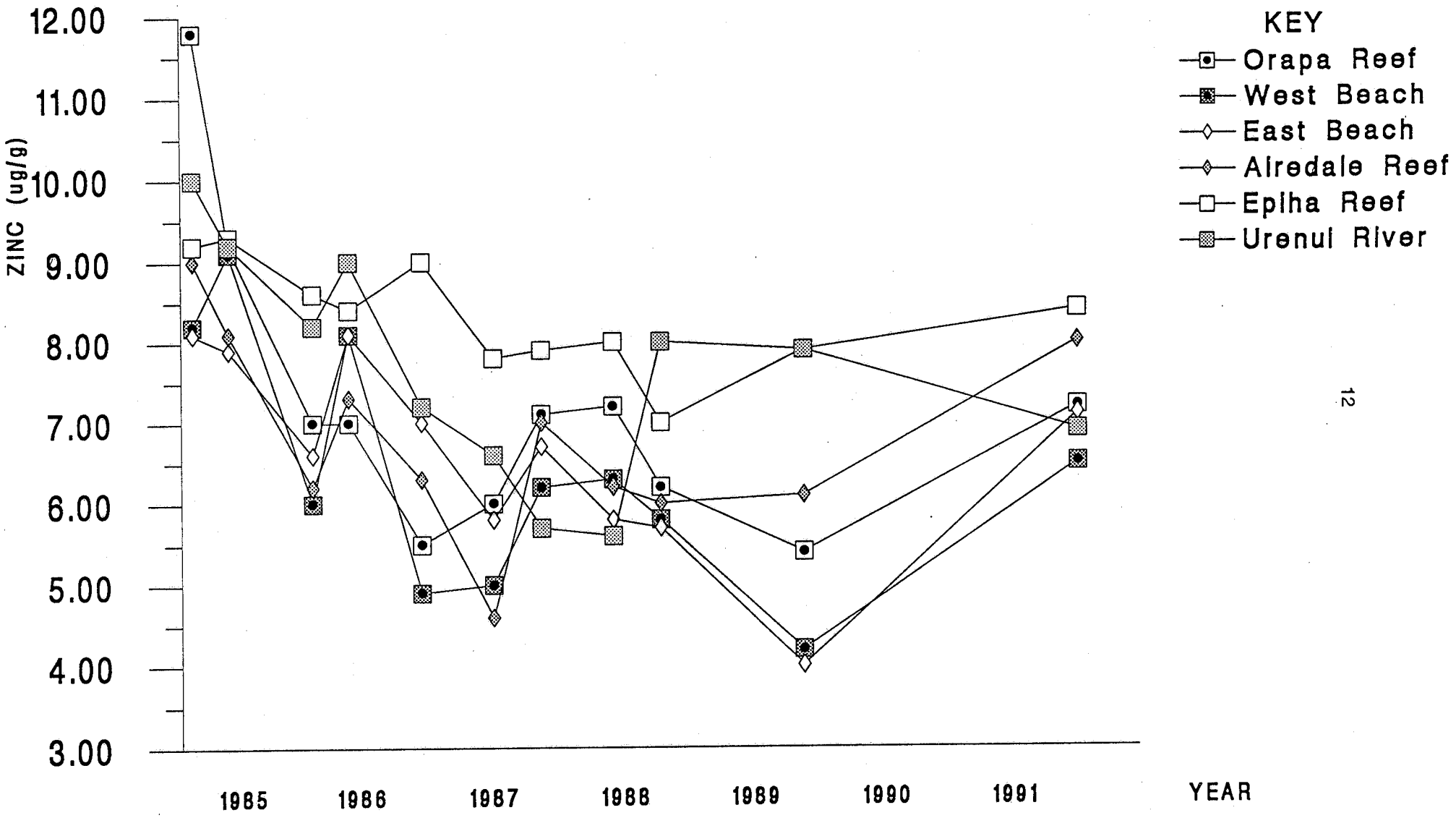

Figure 2.6: Temporal fluctuations in Zinc levels in mussel tissue

4.0 DISCUSSION

Accumulation of metals in mussel tissue is dependent on a number of factors. These include levels in sediment, amount of metals present in effluent, proximity to a river mouth, flood events (which lift and distribute sediment), storms and coastal currents.

The results for 1991 are within the likely natural perturbation of metal contaminants in the coastal environment. While these perturbations may be accentuated by the presence of metals in effluent, the level of accumulation in mussel tissue is well within the New Zealand Food Standards permissible levels (where these exist).

The location of Airedale Reef makes this area susceptible to sediment from the Waitara River and effluent from the discharge. Since the 1989 sampling two major flood events have occurred. In both cases an increase in sediment loading of the river could be expected. Coastal currents are likely to have pushed these sediments onto Airedale Reef, resulting in higher levels of metal accumulation for most metals at this site.

While the database now available shows little need for concern about trace metal accumulation in organisms of the coastal marine area, it is important that monitoring programmes such as this continue. Not only does it act as assurance for the public, but it also helps enable a comprehensive assessment of the condition of the North Taranaki coast.

5.0 CONCLUSIONS AND RECOMMENDATION

Over the duration of the heavy metal monitoring programme no impact on the coastal marine environment of North Taranaki could be directly attributed to the discharge of municipal and industrial wastewater.

It is now appropriate to review this programme in terms of monitoring sites and frequency of sampling. The possibility of incorporating some of the control site monitoring into an appropriate regional monitoring programme needs to be assessed. The number of control sites could also be reduced. Permit holders would remain responsible for the cost of surveying individual impact sites (via the Special Order Monitoring Programme).

The frequency of monitoring has been gradually reduced over time. It is suggested the next monitoring survey be completed in the 1995/96 (four years after the last survey) monitoring period. The design of the programme should otherwise remain the same, which will ensure that temporal comparison can be made.

6.0 BIBLIOGRAPHY

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APPENDIX I

Table A1: Results of analysis of metals in mussel tissue. Samples collected 22 and 23 November 1991. All levels expressed in ug/g wet weight.

Site/Element	Cadmium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Zinc
Orapa Reef	0.037	0.04	0.64	16.1	0.04	0.006	0.24	7.0
	0.049	0.04	0.66	13.9	0.05	0.006	0.18	7.2
	0.051	0.05	0.67	20.0	0.04	0.007	0.31	7.6
	0.042	0.05	0.62	12.9	0.05	0.006	0.23	7.3
	0.023	0.05	0.59	16.0	<0.03	0.005	0.22	6.7
West Beach	0.048	0.05	0.54	15.2	0.08	0.007	0.15	6.0
	0.032	0.04	0.60	14.0	0.04	0.006	0.22	6.6
	0.048	0.05	0.63	12.4	0.04	0.006	0.18	7.1
	0.056	0.06	0.56	14.1	0.08	0.006	0.15	7.0
	0.048	0.04	0.53	11.7	0.08	0.006	0.29	5.8
East Beach	0.061	0.04	0.59	13.0	0.08	0.006	0.19	7.0
	0.063	0.03	0.72	14.1	0.08	0.006	0.23	7.3
	0.055	0.04	0.73	15.7	0.05	0.006	0.08	7.7
	0.061	0.05	0.61	15.7	0.09	0.006	0.19	6.9
	0.058	<0.03	0.60	14.1	0.09	0.005	0.20	6.6
Airedale Reef	0.066	0.09	0.76	81.6	0.12	0.006	0.33	7.4
	0.060	0.10	0.80	66.8	0.14	0.007	0.31	8.1
	0.084	0.12	0.95	88.3	0.18	0.006	0.21	8.0
	0.074	0.08	0.86	58.7	0.12	0.005	0.34	8.5
	0.059	0.07	0.63	59.7	0.12	0.005	0.31	8.1
Epiha Reef	0.052	<0.03	0.64	11.2	0.06	0.004	0.30	9.4
	0.026	<0.03	0.59	11.6	0.04	0.003	0.20	8.0
	0.072	<0.03	0.68	9.8	0.08	0.005	0.27	7.4
	0.069	<0.03	0.65	8.4	0.08	0.005	0.31	8.4
	0.067	<0.03	0.66	9.6	0.07	0.005	0.39	9.0
Urenui River	0.026	<0.03	0.59	12.9	<0.03	0.004	0.22	6.8
	0.045	0.03	0.54	14.3	0.04	0.004	0.17	6.0
	0.025	<0.03	0.60	11.7	<0.03	0.004	0.17	7.2
	0.026	<0.03	0.64	11.8	<0.03	0.003	0.25	7.4
	0.034	<0.03	0.61	10.4	<0.03	0.003	0.21	7.5

Table A2: Inter-site comparison for Cadmium

ANOVA table for inter-site comparison of cadmium between all sites.

Source	Sum-of-Squares	df	Mean-Squares	f-ratio	P
Site	**0.104**	**5**	**0.021**	**2.205**	**0.087**
Error	**0.227**	**24**	**0.009**		

Newman-Kuels comparison for cadmium

	Orapa Reef	West Beach	East Beach	Airedale Reef	Epiha Reef
West Beach	NS				
East Beach	*	NS			
Airedale Reef	*	*	NS		
Epiha Reef	*	NS	NS	NS	
Urenui River	NS	NS	*	*	*

* Significant difference in levels observed at the 95% confidence interval.

Table A3: Inter-site comparison for Copper

ANOVA table for inter-site comparison of copper between all sites

Source	Sum-of-Squares	df	Mean-Squares	f-ratio	P
Site	**0.230**	**5**	**0.046**	**3.084**	**0.027**
Error	**0.357**	**24**	**0.015**		

Newman-Kuels comparison for copper

	Orapa Reef	West Beach	East Beach	Airedale Reef	Epiha Reef
West Beach	NS				
East Beach	NS	NS			
Airedale Reef	*	*	*		
Epiha Reef	NS	NS	NS	*	
Urenui River	NS	NS	NS	*	NS

Table A4: Inter-site comparison for Iron

ANOVA table for inter-site comparison of iron between all sites

Source	Sum-of-Squares	df	Mean-Squares	f-ratio	P
Site	**14012.846**	**5**	**2802.569**	**87.730**	**0.000**
Error	**766.688**	**24**	**31.945**		

Newman-Kuels comparison for copper

	Orapa Reef	West Beach	East Beach	Airedale Reef	Epiha Reef
West Beach	NS				
East Beach	NS	NS			
Airedale Reef	**	**	**		
Epiha Reef	NS	NS	NS	**	
Urenui River	NS	NS	NS	**	NS

** Significant difference in levels observed at the 99% confidence interval.

Table A5: Inter-site comparison for Lead

ANOVA table for inter-site comparison of lead between all sites

Source	Sum-of-Squares	df	Mean-Squares	f-ratio	P
Site	**0.039**	**5**	**0.008**	**25.173**	**0.000**
Error	**0.008**	**24**	**0.000**		

Newman-Kuels comparison for lead

	Orapa Reef	West Beach	East Beach	Airedale Reef	Epiha Reef
West Beach	*				
East Beach	*	NS			
Airedale Reef	**	**	**		
Epiha Reef	*	*	*	**	
Urenui River	NS	*	*	**	*

Table A6: Inter-site comparison for Nickel

ANOVA table for inter-site comparison of nickel between all sites

Source	Sum-of-Squares	df	Mean-Squares	f-ratio	P
Site	**0.066**	**5**	**0.013**	**4.534**	**0.005**
Error	**0.070**	**24**	**0.003**		

Newman-Kuels comparison for nickel

	Orapa Reef	West Beach	East Beach	Airedale Reef	Epiha Reef
West Beach	NS				
East Beach	NS	NS			
Airedale Reef	*	*	*		
Epiha Reef	NS	*	*	NS	
Urenui River	NS	NS	NS	*	*

Table A7: Inter-site comparison for Zinc

ANOVA Table for inter-site comparison of zinc

Source	Sum-of-Squares	df	Mean-Squares	f-ratio	P
Site	**12.967**	**5**	**2.593**	**8.717**	**0.000**
Error	**7.140**	**24**	**0.298**		

Newman-Kuels comparison for zinc

	Orapa Reef	West Beach	East Beach	Airedale Reef	Epiha Reef
West Beach	NS				
East Beach	NS				
Airedale Reef	*	*	*		
Epiha Reef	*	*	**	NS	
Urenui River	NS	NS	NS	*	*

Table A8: Inter-site comparison for Chromium

ANOVA Table for inter-site comparison of chromium between Orapa Reef, West Beach, East Beach and Airedale Reef.

Source	Sum-of-Squares	df	Mean-Squares	f-ratio	P
Site	**0.009**	**3**	**0.003**	**19.625**	**0.000**
Error	**0.003**	**16**	**0.000**		

Newman-Kuels comparison for chromium.

	Orapa Reef	West Beach	East Beach	Airedale Reef
West Beach	NS			
East Beach	NS	NS		
Airedale Reef	*	*	NS	

Table 9A: Inter-site comparison for mercury

ANOVA table for inter-site comparison of mercury between all sites

Source	Sum-of-Squares	df	Mean-Squares	f-ratio	P
Site	**0.001**	**5**	**0.000**	**1.152**	**0.361**
Error	**0.002**	**24**	**0.000**		

No significant difference between sites observed.

Table A10: Site information for sampling undertaken in November 1991

	Orapa Reef	West Beach	East Beach	Airedale Reef	Epiha Reef	Urenui River
Date	22.11.91	22.11.91	22.11.91	22.11.91	22.11.91	23.11.91
pH		8.6	8.4		16.3	8.2
Water Temp °C					8.0	17.3
Alkalinity to pH 4.5		114	64		116	101
Salinity at 15°C		35.2	17.5		36.2	30.2
Wind Strength	Strong Breeze					
Wind Direction	North West					
Sea Conditions	Moderate					
Turbidity	Mod/High					