Environment B·O·P
Environmental Report 99/08
April 1999

SHELLFISH QUALITY ASSESSMENT

Prepared by John McIntosh, Manager Environmental Investigations

Environment B·O·P
Quay Street
P O Box 364
Whakatane
NEW ZEALAND

ISSN 1172 - 5850

Acknowledgements

Dave Bassett, Annette Munday and Pauline Marshall for rigorous laboratory analyses. Many staff for collecting samples. Harry van Enckevort of ESR for smooth operation of the contract for analyses.

Cover Photo: Omokoroa Peninsula

Executive Summary

The Shellfish Quality Assessment (SQA) is part of the Environment B·O·P's Water Quality Monitoring (WQM) module of the Natural Environment Regional Monitoring Network (NERMN). Shellfish throughout the Bay of Plenty are sampled every three years for the presence of contaminants.

The coastal waters of the Bay of Plenty have been classified in the Regional Coastal Environment Plan. Clauses relevant to the classification are in the chapter on Coastal Discharges. It is stated that, "aquatic organisms shall not be rendered unsuitable for human consumption by the presence of contaminants." The Regional Plan also states in the Monitoring chapter that the NERMN monitoring, is one of a number of tools for monitoring the effectiveness of the Plan.

The SQA is designed to monitor the narrative classification standard above.

Examining the results in this report, there is an indication that the quality of shellfish in the Bay of Plenty is improving with respect to bacterial quality. This may be due to environmental policies implemented under the Resource Management Act or it may be an artefact of unusual climatic extremes or a result of both factors.

Shellfish in the Bay of Plenty have been shown to be uncontaminated when tested against a wide range of possible contaminants. Bay of Plenty shellfish contain a high total arsenic concentration. However, the Ministry of Health Food Regulations refer specifically to inorganic arsenic. Inorganic arsenic is about 10% of the total arsenic in shellfish. Therefore, the arsenic levels in Bay of Plenty shellfish are not a health hazard.

Contents

Executive Summary i

Chapter 1: Introduction 1

Chapter 2: Method 3

Chapter 3: Results 5

3.1 Bacterial Results 5

3.2 Pollutant Results 7

3.2.1 Polycyclic Aromatic Hydrocarbons 7

3.2.2 Metals 8

3.2.3 Tri-butyl Tin 10

3.2.4 Pesticide Scan 12

Chapter 4: Discussion 13

4.1 Bacteria 13

4.2 Polycyclic Aromatic Hydrocarbons 13

4.3 Metals 14

4.4 Tri-butyl Tin 15

4.5 Other Contaminants 15

4.6 Conclusion 15

References 17

Appendices 19

Chapter 1: Introduction

The Shellfish Quality Assessment (SQA) is part of the Environment B·O·P's Water Quality Monitoring (WQM) module of the Natural Environment Regional Monitoring Network (NERMN). Shellfish throughout the Bay of Plenty are sampled every three years for the presence of contaminants.

Several objectives are met by this survey. Shellfish filter a large quantity of water to extract particulate matter for food. The contaminants associated with the particulate matter can accumulate in the flesh of the shellfish. Bacterial contaminants eventually die off or are excreted but the levels in the shellfish will relate to the general level of cleanliness or contamination of the waters that the shellfish is feeding in, integrated over a period of time. Other chemical contaminants may be excreted or stored in the fatty tissue. Monitoring of contaminant levels serves the purpose of:

(i) Alerting people to possible health hazards.

(ii) Monitoring the effects of land-use in the catchment.

(iii) Monitoring compliance with the water classification standards.

The shellfish result provides a wider view of the prevailing levels of contamination than a water sample can. A water sample shows a single point in time, whereas the shellfish analysis integrates a longer period of time.

The coastal waters of the Bay of Plenty have been classified in the Regional Coastal Environment Plan. Clauses relevant to the classification are in the chapter on Coastal Discharges. It is stated that, "aquatic organisms shall not be rendered unsuitable for human consumption by the presence of contaminants." The Regional Plan also states in the Monitoring chapter that the NERMN monitoring, is one of a number of tools for monitoring the effectiveness of the Plan.

This is the fourth SQA to be carried out since Environment B·O·P came into being in 1989. The first three surveys involved analysis of bacterial contaminants only. However, a wide range of bacterial contaminants were analysed for including the normal indicator species, enterococci and faecal coliforms, and also pathogens such as *Vibrio* species, *Clostridium perfringens* and *Salmonella* species. When the previous report was presented to the Regional Council it was moved that shellfish should be analysed for a wider range of contaminants.

To achieve this objective, a selection of sites has been made and shellfish from these sites have been analysed for metal and organic contaminants. Indicator bacteria have been retained but the pathogen analysis has been dropped to maintain the costs at the previous level.

Fifty four sites were sampled across the estuaries and coastline of the Bay of Plenty between December 1998 and March 1999. The sites are shown in Figures 1.1 to 1.5.

Chapter 2: Method

Shellfish were collected by field parties, stored on ice and transported to Environment B·O·P's laboratory within six hours of collection. Processing of shellfish flesh was carried out in sterile conditions and analysis of faecal coliform and enterococci was carried out at Environment B·O·P's laboratory.

Shellfish flesh from selected sites was sent to the laboratories of the Institute of Environmental Science and Research (ESR) for analysis of selected metals, polycyclic aromatic hydrocarbons (PAH), pesticide residue screen, moisture and lipid content. ESR subcontracted Hill Laboratories of Hamilton to carry out butyl tin analyses.

Chapter 3: Results

3.1 Bacterial Results

Shellfish were analysed for faecal coliform and enterococci indicator bacteria. The results are set out in Table 3.1.

Environment B·O·P has set standards for shellfish quality in the Regional Coastal Environment Plan. The bacterial standard is based on the Ministry of Health's 'Microbiological Reference Criteria for Food' (1995). Standard 5.26(g) refers to the bacterial quality of shellfish for consumption as measured by the aerobic plate count, faecal coliforms and Salmonella. Faecal coliforms have been used as a measurement of quality in this survey. Enterococci bacteria have also been analysed for as they are the bacterial indicator of bathing water quality in marine waters.

To comply with the standard the median of five samples should be 230 faecal coliforms/100g shellfish flesh or less, and all samples should be less than 330 faecal coliforms/100g flesh.

Taken as a whole the median for the Bay of Plenty in Table 3.1 is 23 faecal coliforms/100g of shellfish flesh. The median for just Tauranga Harbour is also 23 faecal coliforms/100g.

Individual sites can be assessed against the single sample limit of 330 faecal coliforms/100g. Six of the fifty four sites exceed this limit.

In Tauranga Harbour, two samples from the Wainui Estuary, one from the Domain at Omokoroa and one from a side channel to the Wairoa River near Bay St, Bellevue, exceeded the single sample limit.

A pipi sample taken from Ohiwa during strong winds greatly exceeded the single sample limit, but a re-sampling a week later showed very low levels. The initial sampling may have taken the shellfish after they had filtered and stored re-suspended sediment and associated bacteria. In the intervening week before the re-sampling the pipi had cleansed themselves of this contamination.

The mussel site that exceeded the limit is on rocks at the mouth of the Whangaparaoa River and subject to the freshwater influence of the river.

Table 3.1 Bacterial results for Environment B·O·P's 1998/99 Shellfish Quality Assessment

Site	Site No.	Sample	Date	Shellfish type	Faecal coliforms n/100g	Enterococci n/100g
Waihi Beach 3 Mile Creek	BOP900077	990533	15/03/99	tuatua	27	11
Tauranga Harbour Bowentown	BOP900092	990355	11/02/99	mussel	34	300
Tauranga Harbour Pio's Beach	BOP900048	990356	11/02/99	cockle	4	23
Tauranga Harbour Pio's Beach Yellow Point	BOP900020	990357	11/02/99	pipi	19	350
Tauranga Harbour Central Sand Bar	BOP900050	990360	11/02/99	cockle	27	170
Tauranga Harbour Tuapiro Estuary	BOP900022	990358	11/02/99	mussel	300	300
Tauranga Harbour Tanner's Point	BOP900091	990359	11/02/99	pipi	2	14
Tauranga Harbour Katikati	BOP900071	990032	11/01/99	mactra	23	130
Tauranga Harbour Wainui Estuary A	BOP900001	990403	17/02/99	mactra	900	630
Tauranga Harbour Wainui Estuary C	BOP900003	990404	17/02/99	mactra	300	1300
	BOP900003	990405	17/02/99	oyster	1100	280
Tauranga Harbour Omokoroa Domain	BOP900018	990288	28/01/99	pipi	1400	500
Tauranga Harbour Omokoroa	BOP900074	990289	28/01/99	pipi	7	110
Tauranga Harbour Te Puna Estuary	BOP900035	990059	13/01/99	oyster	130	300
Tauranga Harbour Matakana Pt Channel	BOP900044	990169	21/01/99	scallop	2	23
Tauranga Harbour Wairoa River	BOP900046	990465	17/02/99	pipi	13	11
Tauranga Harbour Tilby Point	BOP900032	990058	13/01/99	cockle	30	240
Tauranga Harbour Bay Street	BOP900067	990033	11/01/99	cockle	900	300
Tauranga Harbour Otumoetai	BOP900030	990057	13/01/99	cockle	8	240
Tauranga Harbour Waikareao	BOP900025	990045	12/01/99	pipi	23	50
Tauranga Harbour Rangiwaea Iswland	BOP900031	990170	21/01/99	scallop	13	30
Tauranga Harbour Hunter's Creek	BOP900029	990171	21/01/99	cockle	4	23
Tauranga Harbour Matapihi cockle	BOP900036	990047	13/01/99	cockle	23	90000
Tauranga Harbour Matapihi oyster	BOP900095	990048	13/01/99	oyster	23	900
Tauranga Harbour Port	BOP900045	990172	21/01/99	mussel	13	900
Omanu Beach Surf Club	BOP900096	990280	27/01/99	tuatua	4	17
Omanu Beach Yale Street	BOP900097	990281	27/01/99	tuatua	4	110
Maketu Estuary Mid Estuary	BOP980001	982966	14/12/98	cockle	80	300
	BOP980001	982967	14/12/98	pipi	13	8
	BOP980001	990334	09/02/99	pipi	17	17
	BOP980001	990335	09/02/99	cockle	80	30
Maketu Estuary Site 2	BOP980002	990336	09/02/99	cockle	14	110
Maketu Newdick's Beach	BOP900087	982964	14/12/98	mussel	4	23
	BOP900087	982965	14/12/98	tuatua	2	22
Little Waihi Estuary Shallow Bay near houses	BOP900014	990027	11/01/99	cockle	110	300
Little Waihi Main Channel	BOP900015	990028	11/01/99	cockle	130	130
	BOP900015	990029	11/01/99	pipi	30	33
Piripai Beach Ohuirehe Rd	BOP900093	990287	28/01/99	tuatua	110	50
Whakatane Heads Oceanside, Boat Ramp	BOP160013	990006	05/01/99	oyster	50	70
Whakatane Harbour Whakatane Heads	BOP900090	990007	05/01/99	mussel	13	22
Ohope Beach Moana Rd	BOP900094	990036	12/01/99	tuatua	17	80
Otarawairere Bay	BOP900101	990008	05/01/99	mussel	2	80
Ohiwa Harbour Oyster Site 1	BOP900054	982971	15/12/98	oyster	80	80
	BOP900054	982972	15/12/98	oyster	80	80
Ohiwa Harbour Paparoa Pt	BOP900040	983001	16/12/98	oyster	2	17
Ohiwa Harbour Hokianga Island	BOP900026	990244	25/01/99	cockle	80	500
Ohiwa Harbour Ohakana NW Channel	BOP900027	990307	03/02/99	scallop	4	30
Ohiwa Harbour Uretara Channel	BOP900028	982893	08/12/98	pipi	13000	240000
	BOP900028	983002	16/12/98	pipi	17	13
Ohiwa Harbour Main Channel	BOP900042	990308	03/02/99	scallop	8	22
Waiotahi Beach Estuary	BOP160008	982970	15/12/98	pipi	50	110
Opape at Point	BOP900099	990476	02/03/99	mussel	4	23
	BOP900099	990477	02/03/99	tuatua	17	80
Whangaparaoa River East Cape river mouth	BOP900098	990535	15/03/99	mussel	900	1100

3.2 Pollutant Results

Ten sites were selected for a wide range of pollutant analyses. Nine of these sites are listed in Table 3.2 below. The other site was a freshwater mussel site by the Rotorua City lakefront.

Table 3.2 Shellfish sites for monitoring of metal, pesticide and organic pollutants.

Shellfish Type	Site location (Environment B·O·P laboratory site number)		
Pipi	Tauranga (900025) Waikareao (moorings)	Tauranga (900046) Wairoa (Tilby Pt)	Ohiwa (900028) Uretara Channel
Cockle	Tauranga (900030) Otumoetai (channel)	Tauranga (900029) Hunter's Creek	Ohiwa (900026) Hokianga Island
Mussel	Tauranga (900045) Port	Tauranga (900092) Bowentown	Whakatane (900090) Whakatane Heads

3.2.1 Polycyclic Aromatic Hydrocarbons

Exposure to Polycyclic Aromatic Hydrocarbons (PAHs) has long been identified as of environmental concern. Over 120 PAH have been identified as pollutants, and are produced by the combustion of organic matter, by forest fires and volcanic eruptions. Increased urban concentrations from anthropogenic sources are of particular concern because many PAHs show carcinogenic and mutagenic properties. With the increased use of diesel vehicles (a primary source) as a cheaper and in some respects more environmentally friendly means of private transport, there is some concern that urban levels of PAHs could increase to unacceptable levels.

There is a threat to the quality of shellfish where hydrocarbons can accumulate such as around urban areas. The results of PAH analyses are shown in Table 3.3 below.

Raw data for Table 3.3 is contained in Appendix II. Data has been corrected for moisture content and converted to a dry weight basis to be consistent with international mussel watch projects.

The detection limits for each sample were specific to that sample depending on analytical interferences. The sample from Lake Rotorua had a very high limit of detection because the baseline to the analytical trace was poor. Results in the next section may indicate why that occurred.

Marine samples from the Bay of Plenty were in the range of the US Mussel Watch median.

Table 3.3 Polycyclic Aromatic Hydrocarbons in Bay of Plenty shellfish

Site	**Total of 16 USEPA Priority Pollutant Polycyclic Aromatic Hydrocarbons ng/g dry weight**
Pipi Waikareao	< 205
Pipi Tilby Pt	< 202
Pipi Ohiwa	< 135
Cockle Otumoetai	< 222
Cockle Hunters Creek	< 233
Cockle Ohiwa	< 253
Mussel Port Tauranga	< 172
Mussel Bowentown	< 116
Mussel Whakatane	< 176
Mussel Lake Rotorua	< 1055
US Mussel Watch Median 1989 – 1995	237
US Mussel Watch High value	1100

3.2.2 Metals

Shellfish are not equal in their ability to concentrate metals. The US and World wide Mussel Watch Programmes have used mussels and oysters for analysis and report species differences. Cockle, pipi and mussel used in the Bay of Plenty survey also show species peculiarities. In 1990, oysters from Ohiwa Harbour were used as sentinel shellfish in Tauranga Harbour to analyse for a range of contaminants (Power, 1994). The results of that survey are also included here.

Results of metal analyses are presented in Table 3.4. The result sheets supplied by ESR are displayed in Appendix II. The concentrations have been converted to a dry weight basis using the moisture content data also supplied by ESR.

The US Mussel Watch project has 274 sites that are intended to represent large areas rather than hot spots around the coast of the US and the Great Lakes. Median values are unlikely to be from contaminated sites.

The World wide Mussel Watch (Cantillo, 1998) data comes from more then 300 references and most reported results come from data sets of about 1000 results or more. Many different species of mussels and oysters make up this data set.

Table 3.4 Metal results from the 1999 sampling of Bay of Plenty shellfish compared to 1990 results of Tauranga Harbour sentinel oysters and the median and high results of the US and World wide Mussel Watch Programmes.

Sample	**Arsenic**	**Cadmium**	**Chromium**	**Copper**	**Iron**	**Mercury**	**Lead**	**Zinc**
	mg/kg dry weight							
Pipi Waikareao	23.3	0.5	3.3	10.8	1000	0.10	0.7	83.3
Pipi Tilby Pt	20.8	1.2	3.2	8.3	1333	0.06	0.7	91.6
Pipi Ohiwa	20.7	1.3	4.9	8.6	2142	0.11	1.3	78.5
Cockle Otumoetai	35.6	0.6	3.6	13.3	122	0.11	0.3	111.1
Cockle Hunters Cr	38.9	0.6	4.8	7.9	189	0.09	0.4	108
Cockle Ohiwa	30.0	0.6	3.9	8.9	288	0.15	0.3	83.8
Mussel Port Tauranga	14.3	0.6	2.4	9.3	614	0.09	1.2	78.5
Mussel Bowentown	18.0	0.5	2.1	4.5	519	0.05	0.5	66.6
Mussel Whakatane	12.5	1.1	2.4	4.8	766	0.13	0.5	75.0
Mussel Lake Rotorua	50.0	2.8	4.0	38.0	12200	14.0	62.0	480
Oyster 1990 Waikareao	0.61	1.2	1.3	155.3	253	0.08	1.1	874
Oyster 1990 Port	0.84	1.3	0.4	66.8	205	0.04	0.9	560
Oyster 1990 south	0.66	0.79	0.5	50.3	227	0.05	0.69	485
Oyster 1990 north	0.74	1.40	0.4	37.4	221	0.05	0.68	380
US Mussel Watch 1995 (median)	9.6	2.2	1.8	9.1 (oyster 120)		0.12	1.8 (oyster 0.47)	130 (oyster 2100)
US Mussel Watch (high value)	15	4.8	3.1	12 (oyster 280)		0.26	5.1 (oyster 0.85)	190 (oyster 4300)
World wide Mussel Watch (median)	7.1 (oyster 5.7)	2.0 (oyster 4.1)	1.6 (oyster 2.5)	7.9 (oyster 160		0.32 (oyster 0.27)	5.0 (oyster 2.5)	130 (oyster 1600)
World wide Mussel Watch (high value)	16 (oyster 14)	7.5 (oyster 21)	6.5 (oyster 10)	21 (oyster 680)		0.99 (oyster 0.70)	20.0 (oyster 0.86)	260 (oyster 4500)

World wide and United States Mussel Watch data from Cantillo (1998).

Cantillo (1998) used the data to set a level of metal concentration that indicated that contamination was occurring. Table 3. Shows how Bay of Plenty shellfish compare to that scale.

Table 3.5 Summary of Bay of Plenty shellfish data compared to contamination indicator level of world wide data (Cantillo, 1998).

Metal	Indicator level of elevated metal content (mg/kg dry wt)	Bay of Plenty shellfish elevated?
Arsenic	16.0	Y
Cadmium	3.7	N
Chromium	2.5	Y
Copper	10.0	N
Mercury	0.23	N
Lead	3.2	N
Zinc	200.0	N

The Lake Rotorua freshwater mussel greatly exceeds the levels indicated by Cantillo (1998) as being contaminated. The major influence on the metal levels in the Lake Rotorua mussel is geothermal. However this site is also within the influence of the Rotorua city stormwater inflows so anthropogenic sources could also affect metal levels.

Arsenic and chromium are elevated in Bay of Plenty shellfish. Geothermal arsenic is undoubtedly the cause of the elevated arsenic levels but the reason for chromium to be elevated is less clear. Geothermal sources cannot be ruled out given that the effect is so widespread across the Bay of Plenty.

Examining the data carefully shows that mussels from the Bay of Plenty are marginally below the level suggested by Cantillo (1998) to be contaminated. Cockle and pipi were not included in the US or World wide studies so it is assumed that these shellfish accumulate chromium to higher levels than either mussels or oysters. Oysters from the 1990 survey had very low chromium levels.

3.2.3 Tri-butyl Tin

These compounds are very effective biocides and have been used to kill organisms that settle on boat hulls. The tin compounds were much more effective and longer lasting than the copper compounds they replaced. However, the toxic effects spread beyond the bounds of the boat hulls and affected marine life particularly around marinas.

There has been an enforced move away from using organo tin compounds as anti-foulants on boats over the last twenty years. On July 1989, in New Zealand, a partial ban was placed on the sale and use of organotin-based anti- foulants for craft less than 25 metres in length (except of aluminium construction).

The reason for the concern was the effect of this chemical in inducing deformity in marine benthic organisms. Human health concerns were also an issue. Power (1994) discusses these effects in detail.

The results of the organo tin analyses of shellfish from the 1998/99 SQA are presented in Table 3.6.

Table 3.6 Organo tin results from the Bay of Plenty shellfish of the 1998/99 Shellfish Quality Assessment (SQA).

Sample	**Monobutyl tin (as Sn) mg/kg dry wt**	**Dibutyl tin (as Sn) mg/kg dry wt**	**Tri butyl Tin (as Sn) mg/kg dry wt**	**Triphenyl tin (as Sn) mg/kg dry wt**
Pipi Waikareao	< 0.0005	0.011	0.013	< 0.0003
Pipi Tilby Pt	< 0.0006	0.008	0.011	> 0.0003
Pipi Ohiwa	< 0.007	< 0.0005	< 0.0004	< 0.0003
Cockle Otumoetai	< 0.0007	< 0.0005	0.009	< 0.0003
Cockle Hunters Creek	< 0.0007	< 0.0005	< 0.0004	< 0.0003
Cockle Ohiwa	< 0.0007	< 0.0005	< 0.0004	< 0.0003
Mussel Port Tauranga	< 0.0007	0.022	0.014	< 0.0003
Mussel Bowentown	< 0.0007	< 0.0005	< 0.0004	< 0.0003
Mussel Whakatane	< 0.0007	< 0.0005	< 0.0004	< 0.0003
Mussel Lake Rotorua	< 0.0007	< 0.0005	< 0.0004	< 0.0003

Where organo tin compounds have been detected the levels are very low, but the locations are where detection was most likely e.g. near the Port of Tauranga, in the associated channels and near moorings. Table 3.7 compares the results of the recent survey with the 1990 results of Power (1994).

Table 3.7 Total butyl tin levels in shellfish from the 1998/99 SQA compared to the 1990 sentinel shellfish survey of Tauranga Harbour.

Site	**Total butyltin mg/kg dry weight (as Sn)**	
	Median 1990 oyster	**1999**
Port Tauranga Harbour	0.090	0.036 (mussel)
Waikareao Estuary Tauranga Harbour	0.048	0.024 (pipi)

Given the differences with which shellfish species concentrate chemicals compounds it is difficult to say whether the reduction is real. However, the trend is in the right direction. Table 3.8 outlines the reductions in total butyl tin levels that have been recorded in the United States.

US Mussel Watch results have shown a dramatic decrease in total butyl tin from a median of 0.106 mg/kg dry weight in 1989 to 0.015 mg/kg dry weight in 1995. Compared to the 'high' value of 0.3 mg/kg dry weight for the US Mussel Watch project, the levels in Tauranga Harbour are low.

Table 3.8 US Mussel Watch results for the total butyl tin concentration of mussels in 1989 and 1995.

	Total butyltin mg/kg dry weight (as Sn)	
	1989	**1995**
US Mussel Watch	0.106	0.015

3.2.4 Pesticide Scan

These results are in Appendix II. Pesticides were undetected in all samples at the level of detection shown for the 86 pesticides tested.

The level of detection was higher than was used for the 1990 sentinel shellfish survey (Power, 1994). That survey found detectable but very low levels of chlordane (0.003 mg/kg dry weight), total DDT (0.03 mg/kg dry weight) and dieldrin (0.002 mg/kg dry weight) in Waikareao Estuary shellfish. At the level of detection of the current survey, DDT at 0.03 mg/kg would have been detected. It was considered that the cost of performing the analyses to the lower detection limit outweighed the advantage of confirming the low result.

Chapter 4: Discussion

4.1 Bacteria

Table 4.1 below shows an analysis of the bacterial results for the four Shellfish Quality Assessments carried out since 1991. The result for the current survey is the best of the four carried out since the inception of Environment B·O·P.

It is difficult to link cause and effect with bacterial numbers. Environment B·O·P has implemented policies to reduce bacterial contamination in the environment. This could be part of the reason for the reduction of bacteria in shellfish. However, climate extremes of the last couple of years have produced unexpected environmental effects so the reduction could also be linked to this phenomenon.

Table 4.1 Median faecal coliform and enterococci results for each SQA since 1991/92.

Year of survey	Median Faecal coliform/100g	Median Enterococci/100g	Number of samples where FC are greater than 330/100g	Number of samples in survey
1991/92	140	500	21	57
1993/94	75	500	14	58
1995/96	110	170	18	61
1998/99	23	80	6	55

4.2 Polycyclic Aromatic Hydrocarbons

The nine marine sites tested were about the level of the median for the US Mussel Watch project. This is treating the non-detect result in a conservative manner by implying that the real result could be as high as the limit of detection used in the test. To test to a lower limit of detection involves a greater cost. The results indicate that it is not worth going to that extra expense to show a low result because the risk to the health of consumers is low.

4.3 Metals

Peake (1992) refers to the NZ fish and shellfish Food Regulations (1984). Table 4.2 sets out the permitted levels of metals from that reference.

Table 4.2 Comparison of metals in Bay of Plenty shellfish with the permitted levels of the (1984) Food Regulations.

Metal	Permitted levels (wet weight) Food Regulations (1984)	Wet weight Bay of Plenty shellfish metal levels mg/kg
Arsenic	2 (inorganic)	1.5 – 3.5 (organic)*
Cadmium	1**	0.05 – 0.14
Chromium	-	
Copper	30	0.6 – 1.3 (Rotorua 1.9)
Mercury	0.5	– 0.02 (Rotorua 0.17)
Lead	2	0.04 – 0.18 (Rotorua 3.1)
Zinc	40	7 – 11 (Rotorua 24)

* *inorganic arsenic is approx. 10% of organic for shellfish* ** *no limit set for shellfish*

Arsenic levels were high in all the shellfish compared to the median for the US and Worldwide mussel watch projects. This demonstrates the effects of geothermal activity in the Bay of Plenty on the wider marine environment.

The Ministry of Health, Food Regulations (1984) refer specifically to inorganic arsenic. The analytical laboratory could not perform this analysis, but indicated that inorganic arsenic is approximately 10 % of total arsenic in shellfish flesh.

This is consistent with the findings of analysis of Maketu Estuary shellfish in 1991 (Park., 1992). In this study total arsenic levels varied between 1.4 and 4.4 mg/kg wet weight, while inorganic arsenic varied between 0.16 and 0.24 mg/kg wet weight. Arsenic, although elevated in Bay of Plenty shellfish is well within the requirements of the Food Regulations.

Metal levels in the Lake Rotorua freshwater mussel sample were very high. This site is a high impact site with major inputs of geothermal waters and stormwater from Rotorua City.

Gifford (1993) sampled mussels in Lake Rotorua in the main body of the lake. He found similar arsenic, cadmium and zinc levels in freshwater mussels. However, mussels from the main body of the lake had lower chromium, copper, mercury and lead levels than the mussels of this survey from the lake front at the city.

Mercury is a metal of geothermal origin but the copper, chromium and lead levels may be elevated because of stormwater effects from anthropogenic sources.

4.4 Tri-butyl Tin

The levels of tri butyl tin in the Bay of Plenty shellfish were low. The Food Regulations (1984) set a tin (Sn) limit of 40 mg/kg, for human consumption of food. The current levels of tri butyl tin do not represent a threat to human health. The threat is to sensitive marine organisms. Page and Widdows (1991) found that at shellfish flesh concentrations exceeding 2 mg/kg dry weight, significant biological effects could be measured. Tri butyl tin levels were well below this at the sites where detectable levels were found.

4.5 Other Contaminants

Polycyclic aromatic hydrocarbons were below the level of detection used in this survey for the 10 shellfish sites tested. The level compared favourably with the median of the US Mussel Watch project and the conclusion can be drawn that the shellfish are uncontaminated with the 16 pollutants tested. PAHs are microbially biodegraded in the surface layers of soil and sediment so accumulation is not favoured.

The pesticide scan also showed no contamination. The level of detection for this scan was not the lowest possible but it enabled a wide range of chemicals to be tested.

4.6 Conclusion

There is an indication that the quality of shellfish in the Bay of Plenty is improving with respect to bacterial quality. This may be due to environmental policies implemented under the Resource Management Act or it may be an artefact of unusual climatic extremes.

Shellfish in the Bay of Plenty have been shown to be uncontaminated when tested against a wide range of possible contaminants. Bay of Plenty shellfish contain a high total arsenic concentration. However, the Ministry of Health Food Regulations refer specifically to inorganic arsenic. Inorganic arsenic is about 10% of the total arsenic in shellfish. Therefore, the arsenic levels in Bay of Plenty shellfish are not a health hazard.

References

Cantillo A Y (1998): Comparison of results of Mussel Watch Programs of the United States and France with Worldwide Mussel Watch Studies. Marine Pollution Bulletin Vol 36, No 9, 712 – 717.

Deeley J M and Ruff K L (1996): NERMN Shellfish Quality Assessment 1996. Environmental Report 96/7.

Gifford J S (1993): Assessment of chemical contaminants in the Lake Rotorua Catchment: Report prepared for Environment B·O·P: NZ Forest Research Institute.

McIntosh J J (1992): Shellfish Quality Assessment 1992. Technical Report 31.

McIntosh J J (1994): Shellfish Quality Assessment 1994. Environmental Report 94/19.

Page D S and Widdows J D (1991): Temporal and spatial variation in levels of alkyltins in mussel tissue: a toxicological interpretation of field data. Marine Environmental Research 2(3): 535-558.

Park S G (1992): Maketu Estuary Environmental Baseline Monitoring Project 1990/91. Technical Report 20. 15 June 1992.

Peake B M (1992): Aspects of Marine Pollution. Department of Chemistry and Marine Science University of Otago.

Power F M (1994): Environment B·O·P Environmental Report 94/9 Sentinel Shellfish.

Appendices

Appendix I	NERMN Shellfish Data 1992 – 1999
Appendix II	ESR Laboratory Results
Appendix III	Internet Notes on the US Mussel Watch Project
Appendix IV	Toi Te Ora Public Health Shellfish Results from Ohope and Otarawairere

Appendix I – NERMN Shellfish Data 1992 – 1999

Appendix II – ESR Laboratory Results

Appendix III – Internet Notes on the US Mussel Watch Project

Appendix IV

Toi Te Ora Public Health Shellfish Results from Ohope and Otarawairere

Results of sampling recreational shellfish for faecal coliform bacteria and Salmonella. No sample tested positive for Salmonella.

Faecal coliform numbers in shellfish taken from Ohope Beach and Otarawairere Bay, Whakatane (number MPN/100g).

Date	**Ohope Beach, Whakatane tuatua**	**Otarawairere Bay, Whakatane mussel**
October 1996	78	20
January 1997	20	20
17 August 1998	20	20
24 August 1998	68	40