Environmental Quality of Ohiwa Harbour - 2005

Prepared by Stephen Park, Senior Environmental Scientist

Environment Bay of Plenty
Environmental Publication 2005/05
April 2005

5 Quay Street
P O Box 364
Whakatane
NEW ZEALAND

ISSN 1175 - 9372

Acknowledgements

There are a wide number of staff that have assisted in the creation of this document in some way. That includes students that have worked here during the summer holidays, laboratory staff in respect of sample gathering and analysis and word processors with the final formatting of the document. All are gratefully thanked for their assistance.

Cover Photo: Ohiwa Harbour, taken by Daniel Wells, July 2002.

Executive Summary

This report brings together the results from a number of Environment Bay of Plenty's environmental monitoring programs. It provides a more comprehensive look at the environmental quality of Ohiwa Harbour and gives a better representation of the holistic nature of the monitoring conducted within the harbour and catchment.

Harbour water quality is very good on average. Most guidelines for the quality of bathing or shellfish gathering waters are easily met. The only water quality parameter to have shown any change over time has been one of the bacterial indicators (Enterococci) with a increase at the Ruatuna Road site.

Shellfish bacterial quality guidelines have been exceeded at times. However, this is usually after periods of bad weather and if shellfish are gathered at least five days after such events, there are generally no problems.

The harbour entrance is a very dynamic physical system and beach volume recording sites either side of the entrance reflect this. Further up the harbour where there is little energy the harbour sediments are very muddy due to settlement of catchment derived material. A lot of the sedimentation will have been historic. A large number of sediment sampling sites and survey transects will now provide accurate baseline measurements against which future change can be assessed.

Long term changes in seagrass and mangrove extent are occurring in the harbour. Mangroves are extending in response to sedimentation while seagrass extent has been reduced. Since 1990, monitoring of benthic macrofauna on the sandflats shows little if any change of species richness has occurred.

Monitoring of the Nukuhou showed it to have the second lowest water quality ranking of all rivers assessed in the Bay of Plenty. Water quality parameters contributing to the low ranking include clarity, suspended solids, nutrients and bacteria. Over the period (1990-2003) in which the river has been monitored it has been relatively stable. The only parameters to show any change have been a slight increase in temperature and a decrease in ammonium-nitrogen levels. Ammonium-nitrogen levels may be declining in response to improvements in dairy shed effluent disposal. Over the summer bathing season, the E.coli levels measured in the Nukuhou River do not meet the guidelines required for safe bathing.

Contents

List of Tables

List of Figures

Chapter 1: Introduction

1.1 Scope

Environment Bay of Plenty monitors a range of water quality data throughout the Bay of Plenty as part of it's resource management responsibilities. This includes a number sites within Ohiwa Harbour and catchment. Usually monitoring data is presented bay wide for specific components such as estuarine, river, shellfish or bathing quality. Previously a report has been produced covering all the monitoring conducted in Ohiwa Harbour and catchment (McIntosh & Park, 1997). The aim of that report was to give a more integrated presentation of data that would better reflect the holistic nature of the monitoring program carried out by Environment Bay of Plenty.

This report is intended to provide an update of monitoring data collected in Ohiwa Harbour since 1996. Data is not as comprehensive as previously reported, as this report is essentially presenting the same content as the background supporting material for the "Integrated Management Strategy for Ohiwa Harbour and Catchment", currently being developed by Environment Bay of Plenty along with all other stakeholders.

1.2 Ohiwa Harbour and Catchment

1.2.1 Ohiwa Harbour

Ohiwa Harbour is a 26.4 km^2 estuarine lagoon enclosed by the Ohope and Ohiwa barrier spits. It is shallow with 83% of its area being exposed sand and mudflats at low tide. The harbour has a very low volume compared to the spring tidal compartment and is dominated by tidal currents. Residence time of water in the harbour is low and estimated to be 1-2 tidal cycles.

The harbour is a valley system drowned by the post-glacial rise in sea level between 6,500 and 18,000 years ago to form an open embayment. From 6,500 to 2,000 years ago the bay was enclosed by the Ohope and Ohiwa spits. The largest changes occurred over the last 2,000 years with the drift of sand around Whakatane heads to the east. Over this period the Ohope spit accreted laterally eastwards at an average rate of about 3 m y^{-1}. Ohiwa spit at the same time has eroded, and there has been an accelerated infilling of Ohiwa Harbour. The tidal compartment being reduced by 36% between 1878 and 1976 (Gibb 1977).

Most estuaries have limited geological life spans and tend to continually infill over time. As described above Ohiwa Harbour is rapidly changing and infilling. These processes have been dominated by the open coastal supply of sediment. Particularly in the entrance of Ohiwa harbour, rapid change in channel morphology continues to take place. In the shallow upper reaches of the harbour, sediments derived from land start to dominate infill rates and changes the nature of the habitat. A full overview of the harbour's geological nature, hydrology and ecology is provided by Park (1991).

Ohiwa Harbour is documented by the Operative Bay of Plenty Regional Coastal Environment Plan as an area of significant conservation value with significant ecological, biological, wildlife, scenic, landscape, historic and cultural values. Extensive shellfish beds have important Maori cultural and resource values.

Part of the estuarine margins and several islands in the harbour are protected by legislation. Tern Island is a wildlife management reserve, Pataua Island a scientific reserve, Uretara Island a scenic reserve, Motuotu Island a nature reserve and the salt marsh area at the mouth of the Nukuhou River is the Nukuhou Conservation Area. In addition several other areas are zoned as wetland protection areas under various District plans. The harbour is classified as an outstanding Site of Special Wildlife Value (SSWI) due to the range of rare or endangered species found there (Rasch 1989) and identified by Owen (1991, 1994) as a wetland of international importance, especially for wading birds.

1.2.2 Catchment

Ohiwa catchment covers an area of 171 km^2 and drains into Ohiwa Harbour, which is the most prominent feature of the catchment. The main source of fresh water inflow into Ohiwa Harbour is the Nukuhou River with a small portion of the total contributed from Awaraptuna, Pukehoko, Waiotane, Wainui, Te Awawairoa, Kutarere and Te Kaha streams.

Current land cover/use and changes within the Ohiwa catchment since 1975 are provided in Table 1 below. 1995 results are sourced from Environment BOP's assessment of land cover based on digital satellite (Spot) imagery and ground truthing. The greatest changes over the twenty year period from 1975 – 1995 has been the increase in production forestry (predominantly pine) with a corresponding decrease in exotic pasture. Decreases in the area of scrub appears to be the result of reclassification as indigenous forest as growth of the vegetation has taken place over the twenty year period. Overall, no further nett clearance of native vegetation appears to have taken place within the Ohiwa catchment. There is a considerable increase in urban areas within the catchment and a possible increase in small-scale horticultural use of land.

Table 1 Land cover/use in the Ohiwa catchment (ha) and changes between 1975 and 1995.

Land cover/use	1995	1975/76	Increase/decrease	% change
Production forest	3,318	293	3,025	1,032
Indigenous forest	4,022	2,777	1,245	45
Scrub	917	2,055	-1,245	55
Exotic pasture	8,552	11,724	-3,172	27
Horticulture	37	0	37	
Urban areas	168	0	168	

More detailed information on land use/cover and soil conservation issues etc for the Ohiwa Catchment is documented as part of the "Integrated Management Strategy for Ohiwa Harbour and Catchment" project. Previous assessments show that 13% (2,295 ha) of the catchment is flat to rolling topography with relatively low soil erosion potential. The majority of the catchment (57% - 9,784 ha) consists of moderately steep hills near sea level with higher erosion potential. 27% (4,657 ha) of the catchment is erosion prone experiencing severe soil and earth slip with moderate sheet and gully erosion. This area consists mainly of steep hills but also includes dune country with severe to extreme erosion potential in windy conditions.

1.3 Purpose for Monitoring

The purpose of the Resource Management Act (1991) as defined in Part II, (Purpose and Principals) (section 5) is to promote the sustainable management of natural and physical resources while also safeguarding the life-supporting capacity of air, water, soil and ecosystems; and to avoid, remedy, or mitigate any adverse effects of activities on the environment.

The consideration of ecosystems within the RMA includes aspects of, or constituent parts which have intrinsic values in their own right. This includes their biological and genetic diversity, integrity, form, functioning, and resilience.

Environmental monitoring is a specific requirement of the Act. Part IV, section 35 (1&2a) directs Regional Councils to "gather such information, and or undertake or commission such research, and monitor the state of the whole or any part of the environment of its region or district to the extent that is appropriate, as is necessary to carry out effectively its functions under the Act". These functions include in Part IV, section 30 (1)(a) "The establishment, implementation and review of objectives, policies, and methods to achieve integrated management of the natural and physical resources of the region".

Integrated management of these resources requires a holistic approach to data gathering and interpretation. To this end, the Natural Environment Regional Monitoring Network is designed to investigate the important physical, chemical, and biological characteristics of the Bay of Plenty region. Such information allows managers to assess the present and potential impacts of consent related activities and provides baseline environmental data. Additionally, long term trend detection using baseline environmental data will enable Council to assess the effectiveness of its own policies and plans in maintaining or enhancing the environment and in meeting its statutory obligations under the Resource Management Act.

Chapter 2: Environmental Monitoring Results

2.1 Harbour Sediments

Ohiwa Harbour is dominated by soft sediments with very little hard substrate present in the form of wave-cut sandstone ledges and upper shore banks. Sediments are predominantly sandy with very little gravel present. In the upper quieter areas of the harbour there are higher levels of silt and clay which dominated some areas as shown in Figure 1.

The rates of sedimentation and the changes that have occurred recently throughout the harbour are difficult to quantify. In a paper by Paul (1966) there is a summary of a number of reports of sedimentation events over the sand flats. These are all linked to flood events carrying silts into the harbour from the surrounding catchment. The depth of deposition and permanence appears to have varied greatly but records exist of silt layers 5cm depth being deposited from single events over the shellfish beds.

A number of measures have been undertaken by Environment Bay of Plenty to assess future changes. A large number of sediment samples were collected from 2002 – 2003 for particle size analysis. The location of these sites is shown on Figure 1 and formed the basis of the mud distribution interpretation. A comparison to the earlier sediment work of Richmond (1977) was attempted but the site location accuracy of this study proved to be too low to produce a conclusive picture of change between the two surveys. This was mainly due to the high variation in sediments over short distances. The recent survey is accurate enough to create a baseline against which change can be monitored and assessed over time.

In addition Environment Bay of Plenty has a number of survey cross sections on the sand flats of Ohiwa Harbour that were set up in 2002. These are in areas of the harbour where any sedimentation is more likely to reflect catchment inputs. They will allow sedimentation rates to be accurately followed over time periods as short as five to ten years. From this an assessment of catchment input trends can be followed and addressed if necessary.

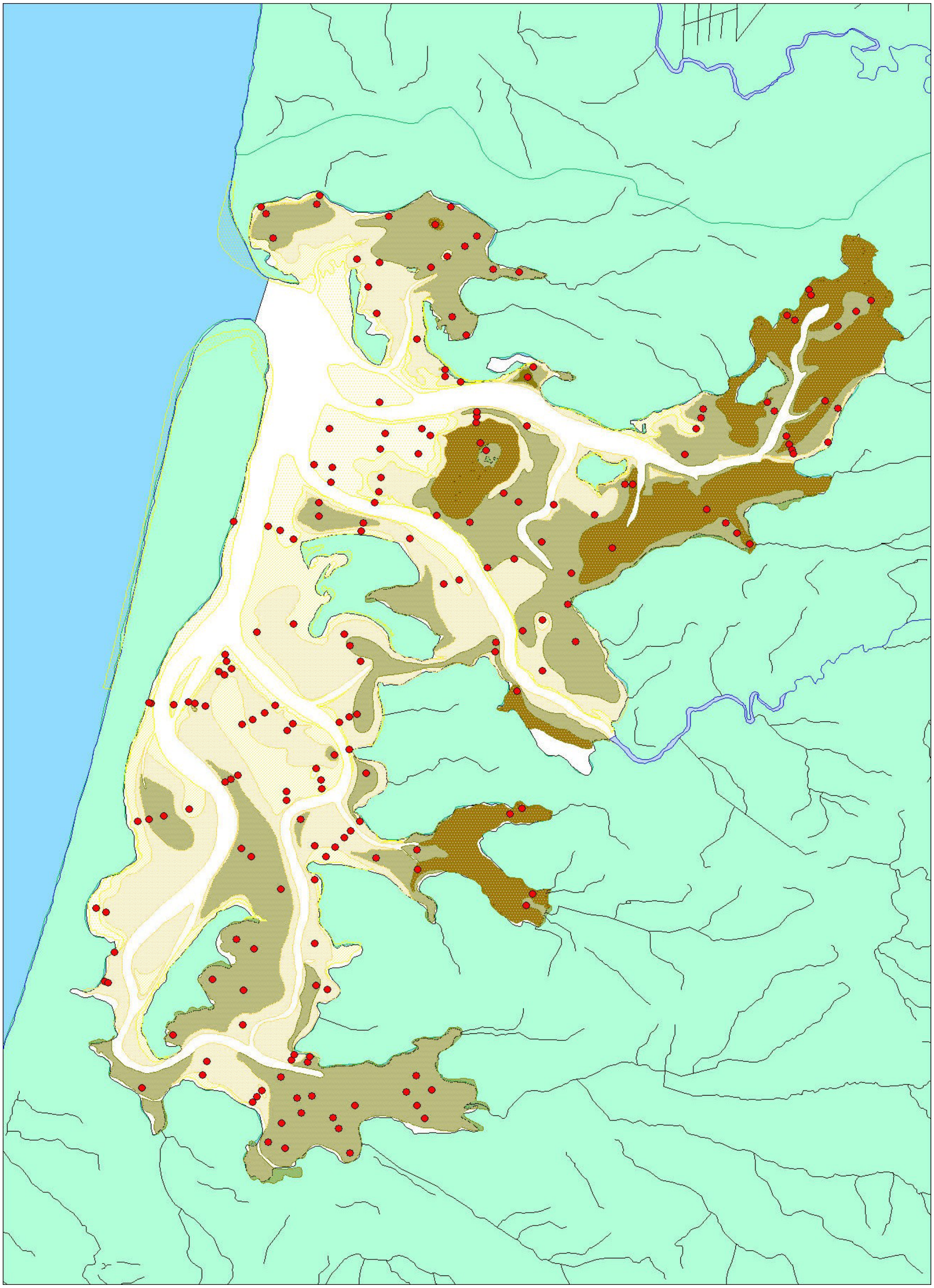

Figure 1 The amount of mud (clay and silt) present as a % of the sediment in the following classes (light to dark) 0-5, 5-10, 10-20, 20-50 & 50-100%.

Cross Section Surveys - Estuaries and Lakes

Ohiwa Harbour Survey Sites

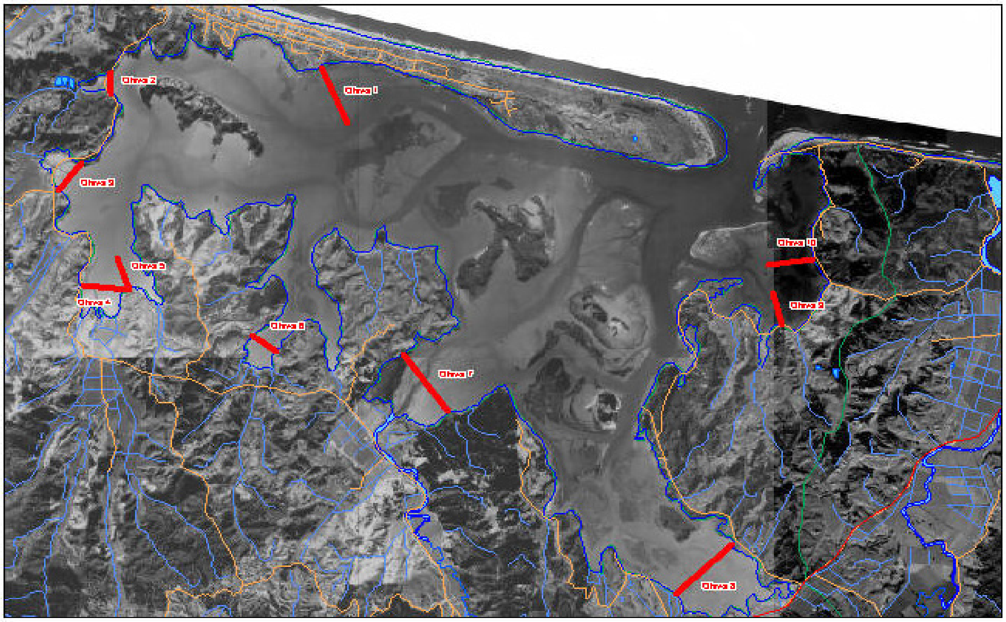

Figure 2 Survey cross sections in Ohiwa Harbour.

In 2004 a LIDAR survey was also made over the whole of Ohiwa Harbour at low tide. This has provided an accurate digital terrain model of the channel locations and intertidal flats. The horizontal accuracy of the data is ±15 cm which means that it will be good for following many of the larger morphological changes over time, especially near the entrance. However, it will only be useful at assessing lower sedimentation rates over a very long period of time.

Currently there is no sediment quality data in respect of possible impact of contaminants from stormwater and land runoff. It is expected that a number of sites will be investigated within the next few years as a monitoring programme is being set up by Environment Bay of Plenty.

In summary the data and historical reports show that following the extensive land clearance of the harbour catchment initiated in the late nineteenth century, the harbour has been impacted by sediment inputs from land. It would appear that the current situation for catchment derived sediment is reasonably stable (see Nukuhou River SS data) and that sedimentation may not be as bad as experienced in the past. There have been extensive land management works undertaken by Environment Bay of Plenty and its predecessors to mitigate sediment inputs.

The dynamic nature of the harbour entrance will continue to see marked changes occur there which are part of the natural coastal processes. There are a number of open coastal monitoring sites surveyed annually by Environment Bay of Plenty. One site (9) is located near the end of the Ohope Spit. At this location the beach has been slowly eroding over the period from 1990 – 2003 (Figure 3). On the opposite side of the entrance on Ohiwa Spit, Site 8 has been accreting as shown in Figure 4. An independent analysis beach change using LIDAR data from May 2000 and Oct 2003 (Halliday 2004) shows the same trends. This highlights the dynamic nature of the spit and harbour entrance.

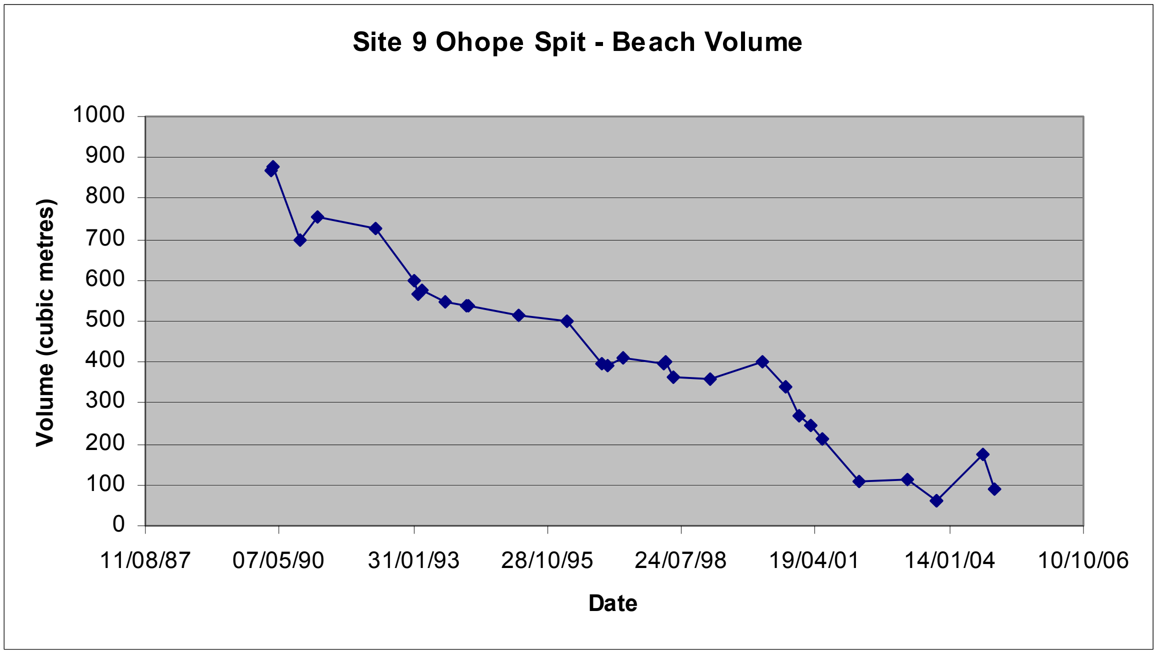

Figure 3 Beach volume measured at Site 9 on Ohope Spit from 1990 – 2004.

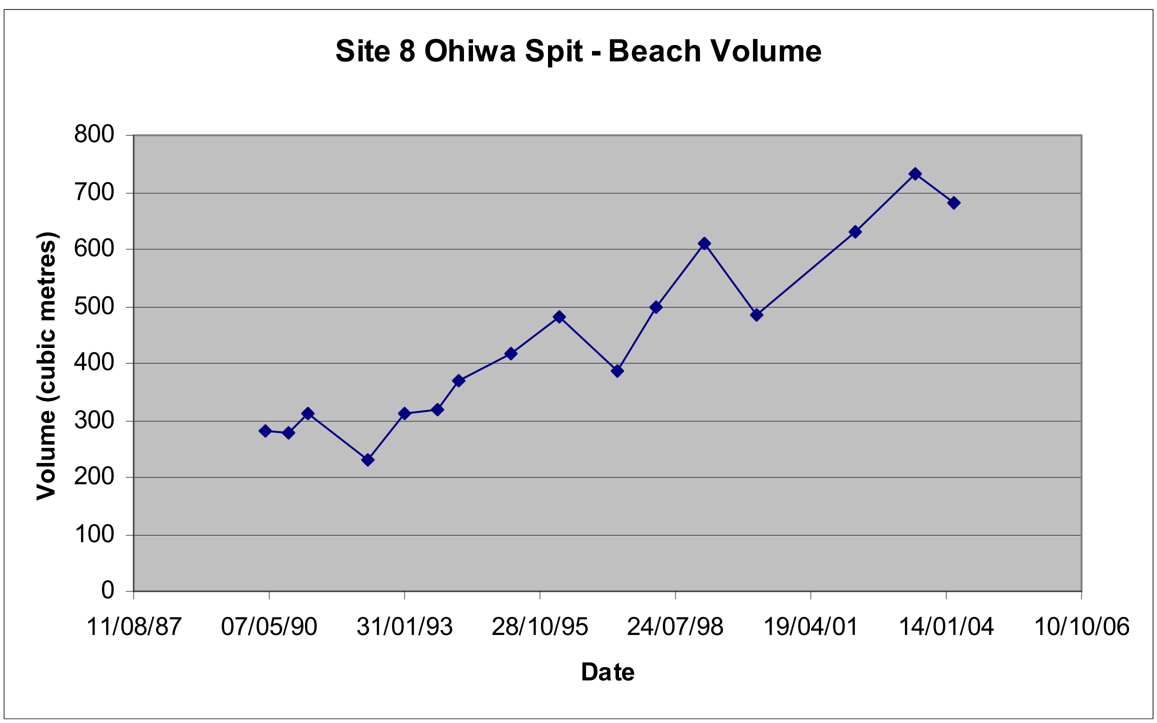

Figure 4 Beach volume measured at Site 8 on Ohiwa Spit from 1990 – 2004.

2.2 Harbour Water Quality

2.2.1 Water

Water quality has been regularly monitored by Environment Bay of Plenty at two sites in Ohiwa harbour since 1990. These sites are located at the boat ramp at Ruatuna Road opposite Hokianga Island and at the Port Ohope wharf (Figure 6). As shown in Table 2 there is very little freshwater influence at these sites, particularly as samples are taken around the time of high tide. The overall water quality results shown are good for the type of estuarine environment. They are comparable to average values for similar sites elsewhere in the Bay of Plenty. Chlorophyll-a levels are low on average and indicate a relatively low nutrient environment.

Table2 Mean concentration of nutrients (g/m^3), Suspended solids, chlorophyll a and salinity recorded from 1990 – 2004 in Ohiwa harbour.

Site	TP	DRP	TN	NO_x-N	NH_4-N	SS	Chla mg/m^3	Saln
Ruatuna Rd	0.024	0.008	0.126	0.026	0.019	16	0.9	32
Port Ohope	0.024	0.008	0.125	0.025	0.015	15	1.4	33

An analysis of trends over time shows that most of the measured water quality parameters are stable, neither consistently increasing or decreasing over time. There are some parameters that showed variation over the monitoring period such as suspended solids. The clearest change of any parameter was enterococci numbers measured at Ruatuna Road. In Figure 5 log-ten transformed data shows that since around the year 2000 numbers have been consistently higher (regression prob. = >0.000).

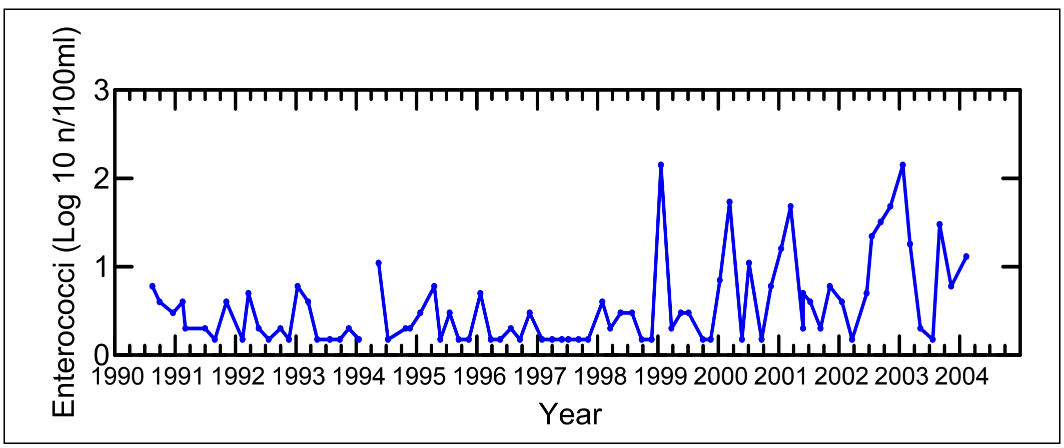

Figure 5 Log ten transformed Enterococci numbers recorded at Ruatuna Road site in Ohiwa Harbour from 1990 – 2004.

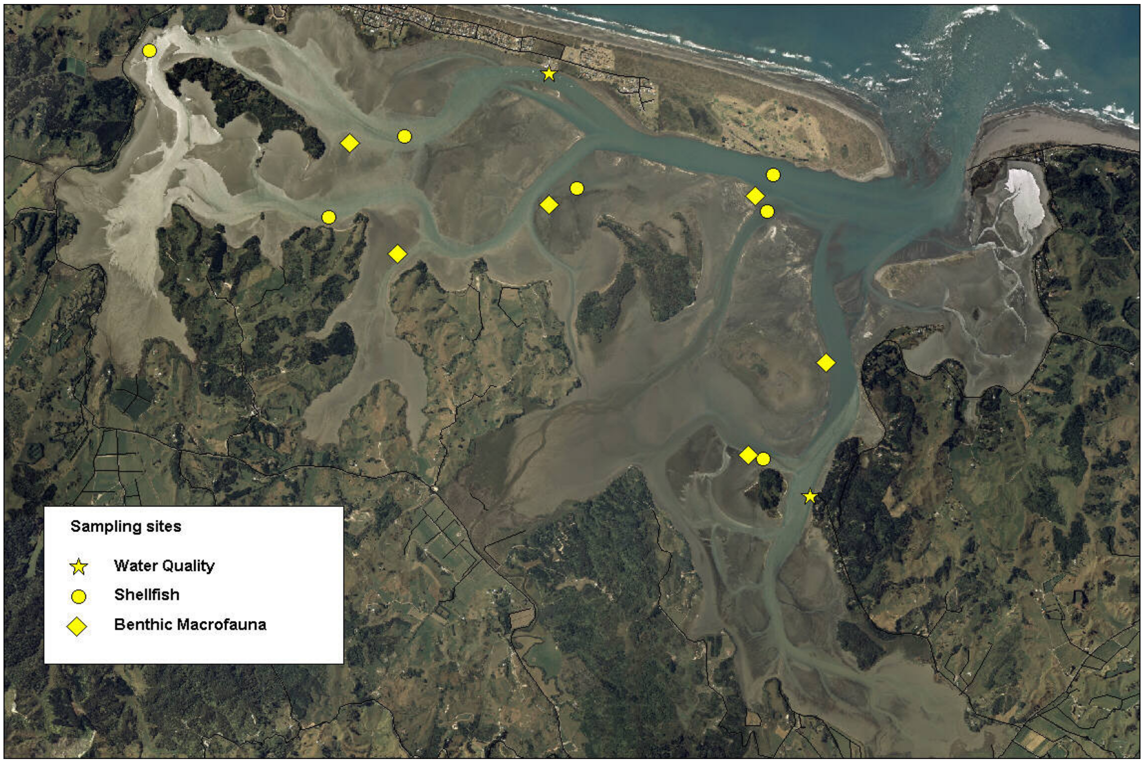

Figure 6 Location of water quality, shellfish quality and benthic macrofauna sampling sites in Ohiwa Harbour.

Table 3 Median number of bacteria recorded from 1990 – 2004 in Ohiwa harbour. Sample numbers range from 74-81 and results are numbers/100ml.

Site	Enterococci	Faecal coliforms	Escherichia coli
Ruatahuna Rd	1	4	1
Port Ohope	1	2	1

There are several bacterial water quality guidelines applicable to Ohiwa Harbour. Ministry for the Environment sets out swimming guidelines for marine waters based on enterococci bacteria. These set out different levels with acceptable “green” mode criteria that no single sample has greater than 140 enterococci/100 mL. Above this is an “Alert mode” and if two consecutive samples exceed 280 enterococci/100 mL then it is classified into the “Action mode”. As seen in Table 3 the median numbers of bacteria have been low over the whole period for which data is available.

The Ruatuna Road site has at times come close to being in the “Alert mode” as there have been two maximum recorded values of 140 enterococci/100 mL. The maximum value at the Ohope Wharf site throughout the period of monitoring is 46. This is a very good overall result as both sites have remained within the “green mode” classification for swimming water quality.

For shellfish gathering waters there is a guideline requiring the median faecal coliform content of water samples taken over a shellfish gathering season not to exceed14/100 mL, and not more than 10% of samples should exceed 43/100 mL. Both the Ruatuna and Ohope sites easily meet these guidelines. Ohope Wharf has slightly better results and has only 1 sample out of 80 (1.3%) that exceed 43/100 mL, while Ruatuna Road site has 3/83 (3.6%).

2.2.2 Shellfish

Shellfish have been sampled at a number of sites within Ohiwa Harbour since 1992 (Figure 6). Most sampling has been for the purposes of checking bacterial numbers in shellfish. Faecal coliform and Enterococci numbers are measured as indicators of the possible presence of disease causing bacteria or virus but do not cause sickness themselves. The faecal coliform bacteria are used to test compliance against a national standard. To comply the median of five samples (usually over a season) should be 230 faecal coliforms/100g shellfish flesh or less, and all samples should be less than 330 faecal coliforms/100g flesh.

In Table 4 below the median values and sample number from each site is shown. Three of the sites do not have at least five samples but the median value for faecal coliform bacteria does meet the standard and none of the samples exceeded the single sample limit as shown by the maximum number recorded for any sample in the last column. Out of the four sites with at least five samples all have failed the single sample limit at some stage. The Nukuhou/main channel pipi bed site opposite the boat ramp is also the only site that fails the median standard of 230 faecal coliforms/100g shellfish flesh. The maximum number of 13,000 faecal coliforms/100g shellfish flesh was recorded shortly after an unsettled period of weather with strong winds. Re-sampling the same pipi a week later resulted in very low numbers of bacteria.

Table 4 Enterococci (Ent) and faecal coliform (FC) bacterial numbers (median) recorded in shellfish flesh from sites in Ohiwa Harbour from 1992 - 2000.

Site	Species	N	Ent	FC	FC (max)
NW Uretara Is	Cockles	3	200	80	300
Hokianga Is	Cockles	5	140	110	3000
Main channel/Ohakana Is	scallops	5	80	40	900
Ohiwa oyster farm	Oyster	6	95	100	800
Paparoa Pt.	Oyster	4	335	105	200
Nukuhou/main channel	Pipi	6	85	320	13000
Main channel	Mussel	4	21	10	10

Sampling shellfish bacterial numbers in Ohiwa Harbour has shown that in general there are often poor results after periods of heavy rain. As shown later in this chapter, the Nukuhou River which flows into the middle of the harbour has poor water quality specifically in respect of bacterial numbers. This includes high numbers of faecal coliform bacteria. It also appears that strong winds in the harbour may also raise bacterial numbers by re-suspending sediment and associated bacteria. Overall it is clear that shellfish quality can be marginal at some sites around the harbour after periods of strong wind or heavy rain. It is advisable that any one wanting to collect shellfish should do so at least five days or more after these events.

Two sites in Ohiwa Harbour have results for analysis of metal contamination of shellfish flesh. Cockles from just northwest of Hokianga Island and pipi from the bed opposite the boat ramp where the Nukuhou channel ends were sampled. Results are shown in Table 5 below.

Table 5 Metal concentrations in shellfish flesh from Ohiwa Harbour (mg/kg wet weight).

	Guideline	Cockles	Pipi
Arsenic	1.0	2.4	2.9
Cadmium	2.0	0.05	0.18
Chromium	1.5	0.31	0.68
Copper	70	0.71	1.2
Lead	2.5	0.02	0.18
Zinc	1000	6.7	11.1

The guideline for arsenic (Table 5) is in terms of inorganic arsenic while the results presented are totals. Results from Maketu Estuary have previously shown that inorganic arsenic is around a tenth of the total. All results meet the guidelines for consumption of shellfish.

By world standards arsenic and chromium are elevated in most shellfish in the Bay of Plenty. Arsenic is clearly sourced from geothermal inputs and the same may be true for chromium.

2.3 Benthic Communities

2.3.1 Seagrass

Seagrass beds are reasonably common in Ohiwa Harbour as they are else where in New Zealand estuaries. They have been shown to support distinct benthic assemblages of animals compared to the surrounding sand flats. Seagrass beds are very productive and help stabilise substrate.

The areas of seagrass in Ohiwa Harbour have been mapped based on aerial photography from 1945 and 1992. Seagrass appears to be sensitive to sedimentation in Harbours. In both Tauranga and Ohiwa harbours the pattern of seagrass loss is mainly from the sheltered estuarine areas with significant modified and erodible catchment. The mechanism of loss is through direct burial, coating of leaf surfaces with silt which reduces light penetration, reducing water clarity and light penetration. Sediment inputs are often associated with nutrients which promote both water column and epiphytic algal growth which in turn reduces light available for seagrass growth.

In 1945 there was 121 hectares of seagrass in Ohiwa Harbour and in 1992 it had reduced to 88 hectares. This is a loss of 27% over a period of 47 years. It is very likely that considerable loss had also occurred before 1945. It is also possible that the rate of loss has now slowed or stopped altogether. Environment Bay of Plenty will resurvey the seagrass beds in the near future which will help to show the current trend.

2.3.2 Mangroves

Mangroves or mangals as they are sometimes called, are literally trees in the tide. In New Zealand there is only one species of mangrove tree with the scientific name of *Avicennia marina var. australasica*. The mangrove is limited to northern areas of New Zealand as it is intolerant of hard frost. It grows best in the more northern zones where it commonly reaches a height of 7-9 m and forms mangrove forests. In its more southern range such as Ohiwa and Tauranga Harbours it tends to form shrublands with plants rarely exceeding 2 m in height. Ohiwa Harbour on the east coast and Kawhia Harbour on the west coast generally represent the southern limit of mangroves.

In economic and cultural terms mangroves can provide additional shellfish resources, lichens for dyeing flax and wool, honey, erosion protection and water quality improvement. In ecological terms they are valuable as they enhance species diversity, increase habitat complexity and extend and provide habitat for a number of rare bird species. However, there are aspects of mangroves which need to be considered to balance the overall picture. In general mangroves achieve many of the apparent ecological benefits by accelerating the succession from marine to terrestrial ecosystems resulting in a decline of some marine components.

Mangroves have been spreading rapidly in most harbours and estuaries in which they occur. It has been recognised that this spread is part of a natural response to increased sediment runoff since clearance of native bush took place in the catchments. Rates of spread may also have been accelerated by global warming.

In Ohiwa Harbour mapping of distribution in 1945 and 1992 has shown marked increases. In 1945 there were 20.6 canopy ha and by 1992 this had increased to 91.1. This is an increase of 442% over 47 years.

In some areas of the harbour mangrove spread has markedly reduced open water areas. Although this can have some ecological advantages and disadvantages, many people view it as detrimental. Environment Bay of Plenty has sought to address the cause of mangrove spread. That is the sedimentation issues. There are a wide range of policy and associated works around the harbour aimed at reducing sediment inputs. Many of the harbours natural mechanisms preventing sediment inputs have been lost. The freshwater wetlands that used to exist in most of the valleys leading to the harbour have been drained and lost. In 1840 it is estimated that there were 557 ha compared to only 64 in 1992.

2.3.3 Macrofauna

Most of the animals found around our soft-shores and harbours live either on or in the sediments. They tend to be small and include bivalves such as cockles, crabs, anemones, snails and worms. These animals form benthic communities which are monitored annually at a number of sites throughout the Bay of Plenty. Records of abundance of all the animals and some details of the habitat allow trends showing improvement or decline to be followed over time.

There are a total of 6 sites that have been monitored in Ohiwa Harbour. Four of these sites have proved to be very stable physically and hence sampling is currently conducted annually. Species richness which is the mean number of species found in samples taken from each site, is a good indicator of biodiversity or the health of these communities. Results of testing whether species richness is changing over time shows that two sites in Ohiwa Harbour show very slight increases while two remained stable. Overall the results are encouraging as the benthic communities point toward no degradation of the habitat quality over the period 1990-2003.

Within this period there have been events which have occurred which are either natural or cyclical. On one occasion around 1998 most of the scallops disappeared from the harbour as a result of high freshwater inputs. In 2000/2001 there was extensive mass mortality of cockles in the harbour. It was never confirmed whether this was the result of a pathogen or linked to climatic factors. Sea lettuce also bloomed within the harbour during the periods 1991-94 & 97-98. Research indicates that these blooms were most likely the result of nutrient up-welling on the coast rather than catchment derived nutrient. Events of this type serve to highlight some of the natural changes that take place, but in the longer term have no lasting effect on the state of the harbour ecosystem.

Some of the shellfish resources of the harbour are coming under increasing pressure and show changes in response to high fishing effort. The best example is the mussel beds near the boat ramp. Due to the sandy mobile substrate they cover, virtual total removal of these beds from some areas could lead to a loss for a substantial period of time. Currently there is a Rahui (ban) on the taking of the mussels from these beds to allow them to recover. Environment Bay of Plenty has no direct responsibility for the management of fisheries such as these.

2.4 Nukuhou River

2.4.1 Water Quality

The total catchment of Ohiwa Harbour is 171 km^2. Of this the Nukuhou River catchment is 103 km^2 or 60% of the total. Mean flow of the Nukuhou River based on data from 1990-2000 is around 2.786 m^3 s^{-1}. Total freshwater inflow to the harbour is around 4.146 m^3 s^{-1} with small flows contributed from each of the Awaraptuna, Pukehoko, Waiotane, Wainui, Te Awawairoa, Kutarere and Te Kaha streams. There is a monitoring site on the Nukuhou River at which water quality data has been collected since 1990. Data from this site has been analysed for trends and overall water quality status.

Table 6 provides the medium values of each of the measured water quality parameters. The water quality grade is based on the scoring system set out by McBride & Davies-Colley (1999) to assess ecosystem health. In this case it was derived from ranking of 7 key parameters from 44 river sites within the region. A full description of methods and set of results is available in Taylor and Park (2001).

Nukuhou River on the basis of Water Quality scores, ranked second lowest in the region with only the Tarawera River receiving a lower score. In Table 6 below the individual scores are shown for each of the seven graded parameters. It was the clarity, suspended solids, nutrients and bacterial components of water quality which were poor in this river. The overall score or water quality grade of the Nukuhou meant that it received an “action” classification, indicating a need to investigate and remedy water quality.

Table 6 Water quality statistics and grading score for parameters measured over the period 1990 –2003 and ANZECC default trigger values for lowland rivers.

	Minimum	Maximum	Median	WQ grade	ANZECC
Clarity (black disc - m)	0.08	2.75	0.94	degraded	0.8
Turbidity (NTU)	3.2	66	6.6		5.6
Suspended Solids (g/m^3)	2.9	160	11.6	poor	
Colour (abs coeff 440nm)	0.46	5.53	1.84		
pH	6.4	7.8	7.1	excellent	7.2 – 7.8
Conductivity (mS/m @ 25 C)	7.7	13.3	10.2	excellent	
Temperature (^{o}C)	6.1	21.6	14.3		
Dissolved oxygen (% satn)	63	110	91	good	>98

Biological oxygen demand	0.3	8.1	1		
DRP (g/m^3)	0.008	0.229	0.038		0.001
TP (g/m^3)	0.015	0.286	0.074		0.033
NH4-N (g/m^3)	0.002	0.384	0.054	poor	0.021
NO_x (g/m^3)	0.1	1.42	0.532		0.444
TN (g/m^3)	0.325	2.153	1.036		0.614
Escherichia coli (n/100ml)	3	99,000	620	poor	
Enterococci (n/100ml)	7	3,900	190		
Faecal coliforms (n/100ml)	60	94,000	800		

ANZECC (2000) guidelines only provide a set of default trigger values for undisturbed or slightly disturbed lowland river systems while the Nukuhou River would be considered to be moderately disturbed. In the Regional Water and Land Plan it has a classification of “aquatic ecosystem”. The default trigger values are shown in Table 6 and provide a comparative guideline as to what values should be in a more pristine lowland river. The trigger values are only intended to provide a guide as to the need for investigation if a parameter is being exceeded in any water body.

To assess long-term trends over time in the Nukuhou River, data was first analysed to remove any significant factors which add variability. Removal of this variability helps to detect any changes in the residual data. Flow is usually a major factor causing data variability and analysis showed strong correlations with suspended solids, turbidity, black disc clarity measurements and conductivity. The following all showed strong seasonal effects; temperature, dissolved oxygen, Escherichia coli, Enterococci and Faecal coliform bacteria, ammonium-nitrogen, colour, conductivity, dissolved reactive phosphorus, total phosphorus, nitrate/nitrite nitrogen and total nitrogen.

Results using de-seasonalised and flow adjusted data showed that only temperature and ammonium-nitrogen have shown any consistent upward or downward change over the period 1990 – 2003. Residual temperature data had a weak but significant regression ($p=0.026$) and appears to be increasing at a rate of about 0.1 ^{o}C per year. This change could be due to a number of factors such as tree clearance, climate cycles and climatic warming. Whatever the cause such a trend in temperature will place additional stress on the aquatic ecosystem. In Figure 7 both the raw seasonal trend and the residual data are shown.

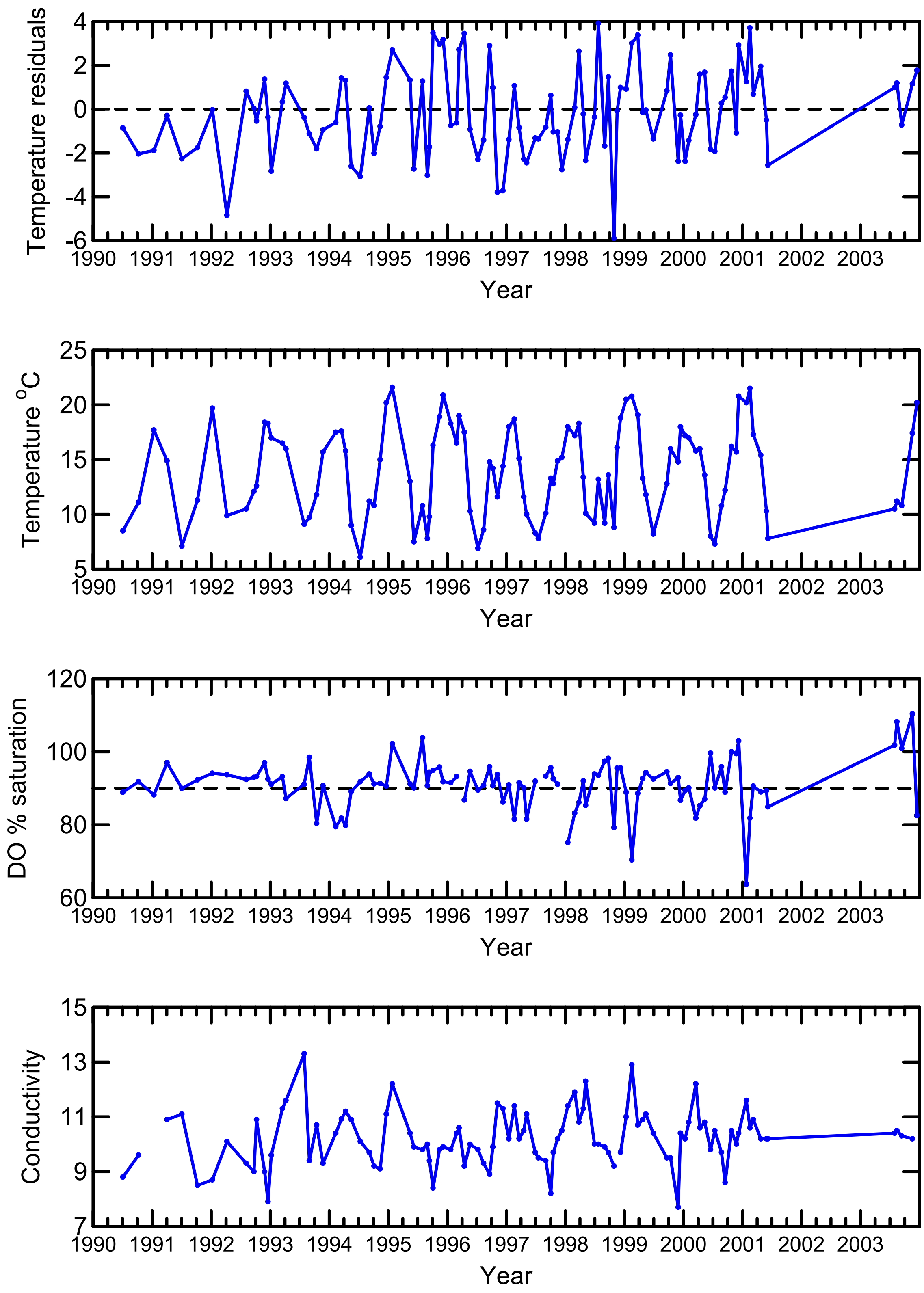

Figure 7 Graphs of Temperature, dissolved oxygen and Conductivity recorded in the Nukuhou River from 1990 to 2003.

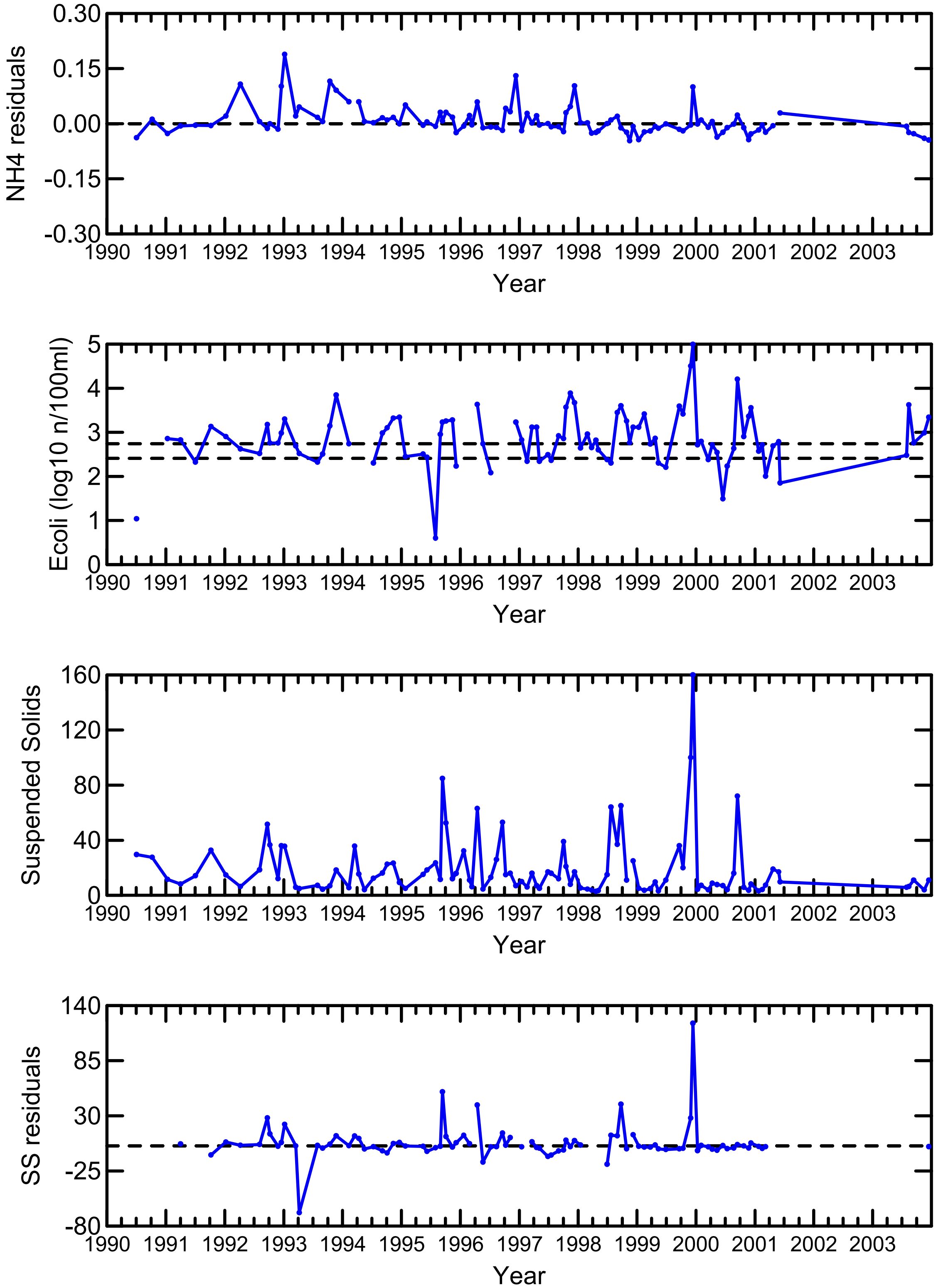

Figure 8 Graphs of Suspended solids, Ecoli bacteria and ammonium nitrogen recorded in the Nukuhou River from 1990 to 2003.

Residual ammonium-nitrogen data displayed a reasonably strong regression (p=0.000) with a decline of 0.005 gm^3 per year. This change is positive and will help improve the health and overall state of the aquatic ecosystem. Historically the lower Nukuhou River was thought to have been impacted by dairy farming. A number of changes in disposal of dairy shed waste have occurred over the years and in particular there is no longer any discharges directly to water. It is possible that these changes account for the change seen. Residual ammonium-nitrogen data is shown in Figure 8.

Most of the water quality parameters in the Nukuhou River show no linear trends over time. This means that there has been little change in water quality over the last decade in which it has been monitored by Environment Bay of Plenty apart from the two parameters highlighted above.

Although dissolved oxygen levels show no overall increase or decrease over time there has been an increase in overall range which can be seen in Figure 6. The increasingly lower DO levels recorded over time indicates a possible lowering of water quality.

Conductivity results are also shown in Figure 7. The seasonal pattern is displayed quite clearly in the latter half of the monitoring period. In Figure 8 results for Ecoli (log transformed data) are shown and the seasonal trend is also apparent from 1998-2001. The faecal coliform and Enterococci bacterial numbers show very similar seasonal trends to Ecoli.

Suspended solids data are shown in Figure 8 with both the raw data and the flow adjusted residuals graphed. The residual data clearly shows that no long-term trend is occurring.

2.4.2 Bathing water guidelines

Escherichia coli is currently considered the most appropriate indicator for freshwater and is applied during the bathing season. It is only an indicator bacteria which shows the possibility that disease causing bacteria or virus may be present. It does not cause any sickness itself. Current Ministry for the Environment guidelines require that “no single sample is greater than 260 *E. coli* / 100mL” for “Acceptable” waters. The “Alert mode” classification applies for samples >260 and <550 *E. coli* / 100mL. Waters with samples above 550 *E. coli* / 100mL are classified into the “Action mode”.

In the graph of *E. coli* numbers over time in Figure 8 the “Alert” and “Action” modes are indicated by the dashed lines. As shown in this graph, acceptable water quality only occurs outside the bathing season in winter. During summer the water is nearly always within the “action” mode indicating that it is unsuitable for bathing.

Chapter 3: Summary

3.1 Harbour Water Quality

Most of the water quality parameters measured at the two monitoring sites in Ohiwa Harbour since 1990 have remained reasonably stable without change over that period. Also levels recorded for water quality parameters are generally good for an estuarine environment. Nutrient levels are low along with indicators of productivity such as chlorophyll-a.

One of the bacterial indicator species, Enterococci, has shown a significant increase at the Ruatuna Road site since 2000. However, both sites remain well within the Health Department guidelines for bathing water quality.

Both sites also meet the water quality bacterial (faecal coliforms) guideline requirements for shellfish. Several shellfish species have also been tested at various sites within the harbour for flesh quality. At most sites the guidelines for bacterial numbers are met. One exception has been pipi taken from the bed opposite the Ohope boat ramp. One set of results taken after bad weather exceeded the guidelines, but re-sampling a week produced a result within the guidelines. During bad weather both land runoff and re-suspension of sediments from the mud flats can elevate bacterial numbers making it advisable to wait for a period of 5 days or more before harvesting shellfish.

3.2 Harbour Sediments

Historically, Ohiwa Harbour has experienced an increased rate of sedimentation with a number of storm events depositing deep layers (up to 5cm) since the clearance of native bush from the catchment in the late 18th and early 19th centuries. Drainage of the harbours wetland areas exacerbated the problem of sediment being carried into the harbour.

Recent sediment surveys have mapped the harbour. The upper enclosed areas to the south show the highest impact from sediment deposition and are very muddy. The sediment survey data will provide an excellent baseline against which changes in the nature of the sediments can be monitored through time. In conjunction with a number of survey transects monitoring sediment height, it should be possible to identify problem areas in the catchment.

Environment Bay of Plenty has extensive and ongoing works to retire erosion prone areas of the catchment, stream and harbour margins where possible. These measures will assist in slowing the sedimentation rates and create a healthier harbour ecosystem.

The harbour entrance and spits are very dynamic coastal systems. Results from coastal beach monitoring sites and analysis of LIDAR data highlights the physical changes that are taking place.

3.3 Harbour Ecology

Monitoring of benthic macro fauna communities on the sandflats of Ohiwa Harbour indicates that very little change has occurred over the period from 1990 onwards.

On longer time scales the harbour ecology is showing a number of changes. These include a historic decline in the areas of seagrass and an increase in the extent of mangroves. Both these changes are very likely to be a direct response to the historic sedimentation that has occurred in the harbour. The mangroves in particular may have a lag period in responding to colonisation of additional habitat that has become available. The extent of seagrass beds on the other hand should stabilise if measures to reduce sediment input are successful.

3.4 Nukuhou River

Nukuhou River has the second lowest water quality ranking of all rivers assessed in the Bay of Plenty. The lowest scoring river was the Tarawera which has extensive geothermal and industrial discharges to it. Water quality parameters contributing to the low ranking include clarity, suspended solids, nutrients and bacteria. The grading of the Nukuhou Rivers indicates that it requires action to remedy water quality. There are a wide range of initiatives that are being undertaken to address water quality.

Over the period (1990-2003) in which the river has been monitored it has been relatively stable. The only parameters to show any change have been a slight increase in temperature and a decrease in ammonium-nitrogen levels. The temperature increase if sustained over time would be detrimental to overall water quality, while the decline in ammonium-nitrogen levels is beneficial. Ammonium-nitrogen levels may be declining in response to improvements in dairy shed effluent disposal.

Over the summer bathing season the E.coli levels measured in the Nukuhou River do not meet the guidelines required for safe bathing.

References

Beadel, S.M. 1993: The Coastal Environment Regional Plan. Ohiwa Harbour Indigenous Vegetation, Report prepared for Bay of Plenty Regional Council.

Beadel, S.M. 1994a: Significant Indigenous Vegetation of the Bay of Plenty coastal zone. Report prepared for Bay of Plenty Regional Council.

Beadel, S.M. 1994b: Hiwarau Road Wetland. Report prepared for Department of Conservation, Whakatane.

Beadel, S.M. 1994c: Botanical conservation values of Hiwarau C block. Report prepared for Department of Conservation, Rotorua.

Beadel, S.M. & Shaw, W.B. 1988: Taneatua Ecological District. Biological survey of reserves series, Report No.12. Department of Conservation.

Beadel, S.M., Townsend, A.J. & Shaw, W.B. 1996: Natural heritage of the Whakatane district. Report prepared for the Whakatane District Council.

Beadel, S.M., Shaw, W.B. & Gosling, D.S. 1996: Taneatua ecological district survey report for the protected natural areas programme. Report prepared for the Department of Conservation, Rotorua.

Bowers, L. & Jones, K. 1991: Tauwhare Pa archaeological investigation and site restoration. Department of Conservation, Rotorua. Technical Report series No.9.

Clarkson, B.R. & Regnier, C.E. 1989: West Gisborne. Biological survey of reserves Report No.16. Department of Conservation.

Cromarty, P. & Scott, D.A. 1996: A directory of wetlands in New Zealand. New Zealand Department of Conservation.

Deely, J. & Donald, R. 1995: Natural Environment Regional Monitoring Network. Water quality of the Bay of Plenty Rivers (1990-1994). Environment BOP Environmental Report 95/7.

Department of Conservation 1994a: Draft Conservation Management Strategy Volume I for the Bay of Plenty. Bay of Plenty Conservancy Management planning Series No. 6.

Department of Conservation 1994b: Draft Conservation Management Strategy Volume II for the Bay of Plenty. Bay of Plenty Conservancy Management planning Series No. 6.

Fletcher Challenge Forests 1996: Taneatua Forest - Application for a 10 year resource consent 1996-2006.

Gibb, J.G. 1977: Late Quaternary sedimentary processes at Ohiwa Harbour, eastern Bay of Plenty, with special reference to property loss on Ohiwa Spit. Ministry of Works, *Water and Soil Division Technical Publication* No.5.

Halliday, S. 2004: Mapping Coastal Change – Up close and in detail. AAMHatch Issue 26, April/May 2004, pg 1-3.

McIntosh , J., Park, S. 1997: Environmental quality of Ohiwa Harbour. Environment BOP, Environmental Report 97/17: 55 p.

Miskell, B. 1993: A landscape assessment of the Bay of Plenty coastal environment for Environment BOP.

Mitchell, C.P. 1990: Whitebait spawning grounds in the Bay of Plenty. Report to Department of Conservation. New Zealand Freshwater Fisheries Miscellaneous Report No. 40.

Owen, K.L. 1991: A preliminary directory of Bay of Plenty wetlands of international importance. Department of Conservation, Rotorua.

Owen, K.L. 1994: Marshbird habitat of Ohiwa Harbour. Technical report series No. 22. Department of Conservation, Rotorua.

Park, S.G. 1991: Coastal Overview Report. *Bay of Plenty Regional Council Technical Publication Number 3, August 1991*:109 p.

Park, S.G. 1995: Coastal and Estuarine Ecology Monitoring Programme 1994/95. Environment BOP, Environmental Report 95/20: 155 p.

Paul, L.J. 1966: Observations on past and present distributions of mollusc beds in Ohiwa Harbour, Bay of Plenty. New Zealand J. Science, 9: 30-40.

Rasch, G. 1989: Wildlife and wildlife habitat in the Bay of Plenty Region. Department of Conservation, Rotorua.

Richmond, B. 1977: Geomorphology and modern sediments of Ohiwa Harbour. Unpublished thesis, University of Waikato.

Richmond, B.M., Nelson, C.S., Healy, T.R. 1984: Sedimentology and evolution of Ohiwa Harbour, a barrier-impounded estuarine lagoon in the Bay of Plenty. New Zealand J. Mar. & Freshwater Res. 18: 461-478.

Tatton, K. 1994: Ohiwa Harbour archaeologoical survey. A report on archaeologoical sites w15/580 W15/581 W15/582. Department of Conservation, Rotorua.

Taylor, J., Park. S : 2001: Bay of Plenty Rivers' water quality (1989 – 2000). Environment BOP, Environmental Report 2001/12: 118 p