State of the Ohiwa Harbour and Catchment

Prepared by Heather MacKenzie, Environmental Data Officer - Ecology

Bay of Plenty Regional Council
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Cover Photo:
Ōhiwa Harbour Catchment

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Executive summary

This report collates monitoring results from a number of monitoring programmes, studies and reports for the Ōhiwa Harbour and its catchment. It aims to provide a comprehensive look at the ecological quality of the Ōhiwa Harbour Catchment.

Land cover changes occurring within the Ōhiwa Harbour Catchment have been minor. Complete fencing of the Ōhiwa Harbour margin has been achieved and 80% of major streams and rivers feeding into the Harbour have been fenced. A significant area (12%) of the Catchment has had forestry harvested since 2008, pressure is being placed on areas of that harvested forestry land to be converted to pasture.

There are numerous threatened flora and fauna, including marsh birds, bats and kiwi occurring within the Ōhiwa Harbour Catchment. Some plant species recorded were not previously known to occur within the Catchment. Increases in the abundance and distributions of native fauna includes Australasian bittern, North Island fern bird, weka, kiwi and variable oyster catcher have been recorded. Introduced pest plants and animals are controlled in numerous areas within the Catchment with a focus on those affecting the indigenous fauna and flora.

Harbour water quality is monitored at two sites and is rated good when compared to other eastern bay estuaries. However, suspended solid and wastewater related measures are showing increasing trends on the eastern side of the Harbour. Bathing water quality in the Harbour remains as one of the best in the Bay of Plenty.

Freshwater quality results in the Nukuhou River show some improvements (suspended solids and nitrogen) however, we are also seeing an increased temperature trend.

Streams feeding directly into Ōhiwa Harbour contain relatively diverse native freshwater fish populations. However, around 40% of streams have barriers to fish migration. This figure needs to be reduced to improve the potential habitat for native fish species.

Although the Ōhiwa tributary shows improvement, the overall macro invertebrate stream health has not changed in the Ōhiwa Harbour Catchment. Comparison of the Kutarere, and Wainui and Nukuhou sites to others in the region showed that they had similar macro invertebrate stream health as other pasture streams.

Marine sediment results are good with contaminants results well below guideline values. Benthic communities have maintained their species richness and diversity over time. Mussel beds in the Harbour have been reduced with simultaneous starfish population increases.

Mangrove extents were last mapped in 2009. An area of 11.7 ha has been cleared of seedlings and outlying plants over the last two years. Current mapping is being carried out and this will help indicate whether the rate of spread is being halted by removal. Sea grass extents are showing no changes over time.

Gains have been made within the Ōhiwa Harbour Catchment. With continued improvements to land use options and land management practices there are likely more gains to be made. It is important maintain the monitoring programme within the Ōhiwa Harbour and its Catchment.

Any revision of the Ōhiwa Harbour Strategy needs to focus on monitoring activity to ascertain the state of the Ōhiwa Harbour and its catchment's environment over time.

Contents

Tables and Figures

Part 1: Introduction

This State of Ōhiwa Harbour and Catchment report was prepared to address two (Health of the Harbour and Natural Areas, Plants and Animals) of the seven themes of the Ōhiwa Harbour Strategy. It also provides an assessment of progress against some of the actions contained in those two themes, in particular actions 7.3.1, 7.3.6, 12.3.3, 12.3.4 and 12.3.5. The report gives a snapshot of the current physical and ecological condition of the catchment and harbour as well as some trends for these parameters over time. The term Ōhiwa Harbour Catchment (referred hereafter as the Catchment) is used when discussing the entire catchment and Ōhiwa Harbour (referred hereafter as the Harbour) for the marine area.

This report considers the whole Ōhiwa Harbour Catchment, as the entire Catchment drives the health of rivers, streams and subsequently the Harbour. Five years has passed since the launch of the strategy.

1.1 Ōhiwa Harbour Catchment

The Ōhiwa Harbour Catchment covers an area of 171 km^2 (see Figure 1.1), and drains into the Ōhiwa Harbour. There are 16 major streams and one river (Nukuhou) draining the Catchment. The total length of major streams in the Catchment is approximately 171.4 km. Land use types of the Catchment are covered in section 2.

1.2 Ōhiwa Harbour

The Ōhiwa Harbour is a 26.4 km^2 estuarine lagoon enclosed by the Ōhope and Ōhiwa barrier spits and has 56 km of margin length. 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 (Park, 2005).

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

There are ten small islands within the Harbour, one of which (Ohakana Island) has permanent residents. Four of the islands cover less than 1 hectare and their names are not widely known. The remaining islands are Whangapikopiko Island (Tern Island) (Government Purpose Wildlife Refuge), Pataua Island (a Scientific Reserve), Uretara Island (Scenic Reserve), Motuotu Island (Nature Reserve). The Harbour is classified as an outstanding Site of Special Wildlife (Rasch, 1989a and 1989b) and as a wetland of international importance for wading birds (Owen, 1994).

Ōhiwa Harbour is an area of significant conservation value with significant ecological, biological, wildlife, scenic, landscape, historic and cultural values.

1.2.1 Ōhiwa Harbour Strategy

The Ōhiwa Harbour Strategy promotes integrated catchment management, and was published in June 2008. It identifies issues and concerns raised by local residents, Iwi and those agencies involved in various aspects of harbour management. The strategy also provides clear actions to be undertaken to address these issues. For specific information on the actions refer to the Ōhiwa Harbour Strategy, 2008. The implementation of these actions is overseen by the Ōhiwa Harbour Implementation Forum (OHIF) and managed by the Ōhiwa Harbour Strategy Co-ordination Group (OHSCG). Membership of these groups is comprised of representatives of:

- Upokorehe hapū,
- Ngati Awa,
- Whakatōhea,
- Ngai Tuhoe (Waimana Kaaku),
- Whakatane District Council,
- Opotiki District Council,
- Bay of Plenty Regional Council (BOPRC), and
- The Department of Conservation (DOC) is also represented on the OHSCG.

Part 2: Land

2.1 Land Cover/Use

Land use change in the Catchment has been calculated using the Land Cover Data Base 3 (LCDB3)[1]. This is a nationally recognised approach to monitoring land cover and land use over time to provide an indication of the change in the level of risk or vulnerability to the land. LCDB3 was used as it provided land cover type for 2001 and 2008, ensuring consistency between measures. The land cover for the Catchment in 2008 can be seen in Figure 1.1. Land cover classes used in Table 2.1, compared with those from LCDB3 can be viewed in Appendix 1.

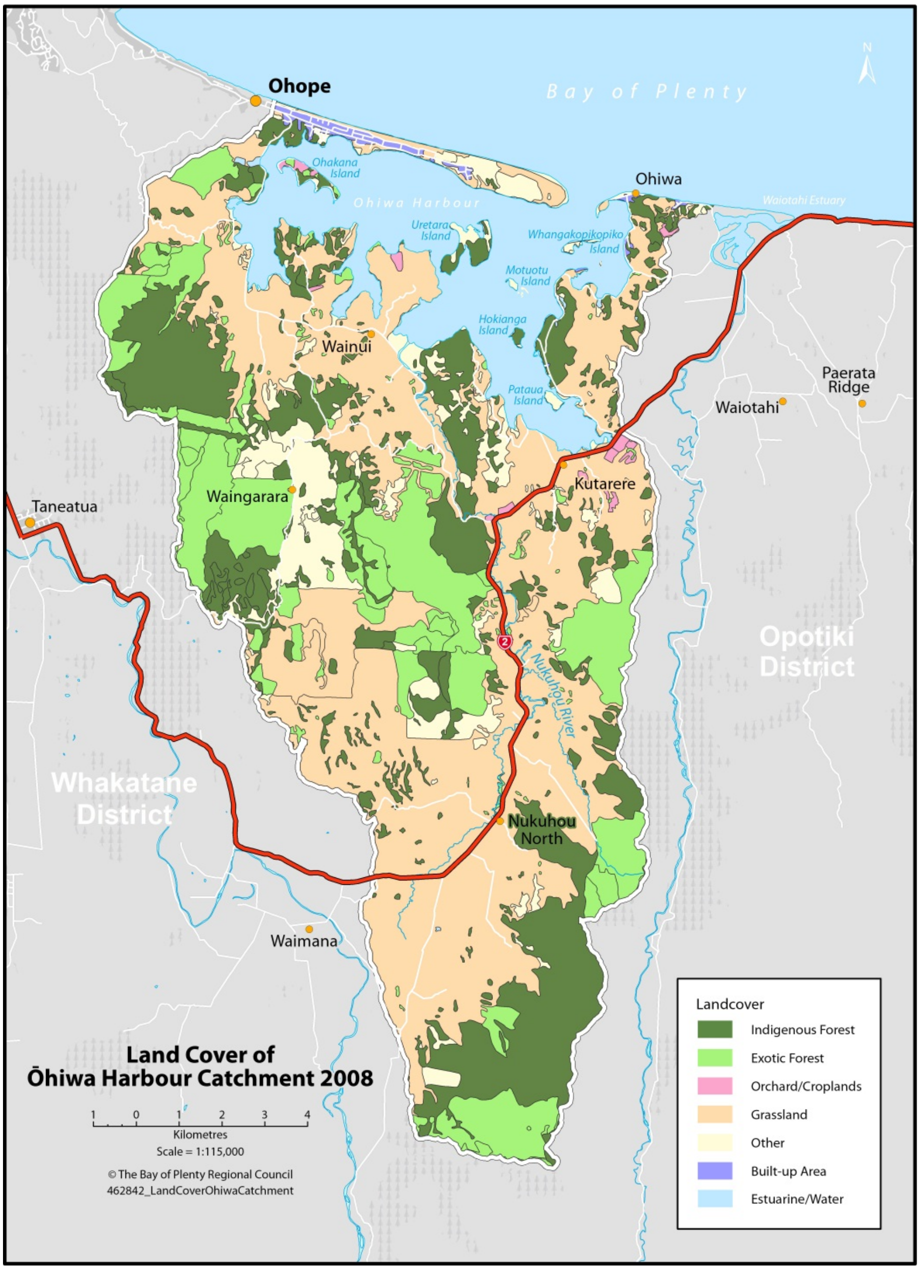

Figure 1.1 Land Cover of the Ōhiwa Harbour Catchment 2008.

[1] *LCDB3 contains detailed information on categories of land cover and their boundaries and is a record of land cover changes over time. It is a digital map of the surface of New Zealand derived from satellite imagery. The first two editions, LCDB-1 and LCDB-2, show the state of New Zealand's land cover in 1996-1997 and in 2000-2001 respectively. The LCDB programme is led by Landcare Research.*

Results

The total area used for this comparison is more than that of the Catchment area stated earlier due to historical differences in mapping. The LCDB includes areas of mangroves, saltmarsh and islands within the Harbour that were not included in the original Catchment for the Ōhiwa Harbour Strategy 2008. Future measures should use the LCDB4 and LCDB5 (which are updated versions) once available to ensure consistency between measures.

Generally only small changes have occurred in areas making up each cover class. The most significant change was the loss of 493 ha of indigenous scrub to pasture and 97 ha to exotic forest plantation respectively. Indigenous vegetation within the Ōhiwa Harbour Catchment is 5,726 ha (33%), of which only 22% (1,256 ha) is formally protected (see Protected Land 2.2).

Table 2.1 Land Cover of the Ōhiwa Harbour Catchment for 2001 and 2008 using Land Cover Database 3.

Combined LCDB land cover data for Ōhiwa Harbour Catchment					
Land cover	**Area 2001**		**Area 2008**		**Area of Change 2001 to 2008 (ha)**
	(ha)	**(%)**	**(ha)**	**(%)**	
Exotic Plantation	3201.5	18.28	3253.5	18.58	52.1
Exotic Scrub/Shrubland	25.1	0.14	25.1	0.14	0.0
Horticulture	51.4	0.29	82.8	0.47	31.5
Indigenous Forest	3576.6	20.42	3583.9	20.47	7.3
Indigenous Scrub/Shrubland	2379.7	13.59	1848.7	10.56	-531.0
Pasture	7769.0	44.36	8209.2	46.88	440.1
Saltmarsh, wetlands, dunes and mangroves	315.9	1.80	315.9	1.80	0.0
Urban and Roads	187.3	1.07	187.3	1.07	0.0
Water	5.4	0.03	5.4	0.03	0.0
Total	**17511.8**	**100 %**	**17511.8**	**100 %**	

Discussion

There was a loss of 531 ha of indigenous scrub/shrubland between 2001 and 2008. The loss of indigenous vegetation reduces the availability of habitat for terrestrial species, although no investigation on the quality of the habitat lost has been undertaken. This loss may also result in increased sediment runoff from affected areas due to vegetation removal and subsequent land use change.

Overall there is still the need to implement soil conservation spaced planting on hill country to encourage the more of Land Use Capability Class 6 and 7 land to convert to exotic forest options. Since 2008 there has not been a significant increase in exotic forestry plantings other than in the Waingarara stream catchment at approximately 190 ha.

There are unknowns and errors in LCDB3 data due to the level of mapping, being at a national scale rather than regional. LCDB4 is due for release in 2014 and will be the basis for analysis of the change up until 2012. Hopefully these future LCDB databases will take into account the regional knowledge to give more accurate mapping of land cover.

2.1.1 Fencing and Retirement

The fencing of riparian margins of the main tributaries entering Ōhiwa Harbour aims to reduce sediment and nutrient loads of waterways entering the Harbour.

Results

The total length of major streams in the Catchment fenced at the end of 2009 was 126.2 km leaving 26% of streams unfenced. At the end of 2012 the total length fenced was 137.5 km leaving 20% unfenced (Table 2.2). For unfenced and fenced distances on each of the major streams and Nukuhou River see Appendix 2.

Table 2.2 Stream and River length with stock exclusion for major rivers and streams in the Ōhiwa Harbour Catchment 2009 and 2012.

Year	Total stream length (km)	Stock excluded (km)	Percentage of river/stream length protected
2009	171.4	126.2	74 %
2012	171.4	138.5	81 %

Complete fencing of the Harbour margin to exclude stock was achieved in the 2011/12 financial year.

Discussion

The amount of riparian fencing of major streams and rivers within the Catchment is high. While, the width of stream margins fencing has been relatively narrow and with limited re-vegetation, the benefit is the removal of stock from having direct access to stream margins and beds. This provides protection from bank erosion due to stock trampling and the removal of stock from accessing waterways will remove direct effluent input. With limited re-vegetation in these areas, erosion due to other factors and over ground inflows will not be greatly reduced without sufficient re-vegetation plantings and retirement area width.

Generally streams with good riparian vegetation cover and shade have lower in-stream temperatures, higher oxygen saturation and a healthier overall ecosystem.

2.1.2 Forestry Activity

Results

Since June 2008 there has been approximately 1,962 ha of exotic forestry harvested within the Catchment. There is a total of 18.6% of the Catchment in exotic forestry, the area harvested is a large proportion of this approximately 60%, which makes up 12% of the Catchment. There is no current accurate mapping but field knowledge suggests only a small proportion of this has been converted to pasture, the remainder has been replanted.

There remains significant pressure on landowners to not replant harvested land with exotic forestry. This is due to the demand for grazing land driven by the current dairying boom and traditional sheep and beef farms being used as dairy support units. Pasture land cover has increased from 2001-2008 (Table 2.1), this is maybe from harvested forestry land and cleared indigenous scrub/shrubland.

Discussion

Increased sedimentation is the greatest risk posed to rivers, streams and harbours from forestry activities. The main contributors from forestry activities to increased sediment loads are roading, stream crossings and earthworks associated with harvesting (skid sites and logging roads). Fransen (2001) shows erosion rates directly related to these are up to three times that of surface erosion rates. Studies in pasture and plantation forestry catchments in the Hawkes Bay showed that during the logging and harvesting period, twice the amount of suspended sediments recorded from the forested catchment to that of pasture (Fahey *et. al.,* 2003). Overall afforested land reduces erosion and sediment into waterways significantly over the life cycle of the trees, which is 28-30 years for *pinus radiata*, however, the pre-harvesting and prior to replanting periods are a critical times for sedimentation risk and forestry companies pay particular detail to reducing this risk.

Considering the amount of harvested forestry within the Catchment we would have expected to see an increase in measured suspended solids in the Nukuhou River and other monitoring sites. However, suspended solids results for the Nukuhou River suggest that this has not occurred to the degree expected. This is a positive result in relation to forest harvest methods applied and the forestry company's management of their operations.

The area of forestry clearance from 2008 to the start of 2013 was over half of the forestry within the Catchment. It would be expected that sediment risk from forestry will be much lower due to a smaller area of harvestable age in forestry over the next ten years within the Catchment. It is important to maintain communication with forestry companies with a focus on reducing impacts of erosion due to forestry activities through education and the consenting process.

2.2 Protected Land

The area of legally protected land with the Catchment is 1,625 ha (9.5%). Of that, 82% is indigenous vegetation. The level of legal protection on different parcels of land varies. A table of the areas of different types of protection can be viewed in Appendix 3 with a discussion on the meaning of legal protection in Appendix 4.

Part 3: Terrestrial Biodiversity

3.1 Flora

3.1.1 Threatened Species

In 2011, 13 sites were surveyed for a total of 16 threatened or significant species. Sites surveyed were identified from historical records. A total of 25 populations of 10 significant species were located, including 13 new populations. The new populations included four populations of two nationally threatened species (*Pimelea tomentosa* and *Kunzea 'Thornton'*) at several sites. Five species not previously known to be present in the Catchment were also found (Wildlands, 2011). See Appendix 5 for a table of the threatened or significant species found within the Catchment.

3.1.2 Native Vegetation Cover

Native vegetation cover within the Catchment is discussed in 2.1 Land cover/use. The measure of indigenous cover does not give any indication of the condition of understory or the processes occurring within. The development of an on-going monitoring programme of sites throughout the Catchment to assess the condition of indigenous vegetation is required.

3.1.3 Pohutukawa Monitoring

Three sites monitored in 2012 as part of the five yearly pohutukawa (*Metrosideros excelsa*) monitoring of the Bay of Plenty are located within the Catchment (Whitiwhiti, Hiwarau and Pataua Island). Of these sites two (Whitiwhiti and Hiwarau) showed improved pohutukawa canopy with thicker canopies and less greying than that observed in 2007. In 2007 these two sites had increased canopy greying, dieback and thinning from 2005. Pataua Island showed a slight decline in pohutukawa canopy condition in 2007, it showed no change in 2007 from 2005. No possum (*Trichosurus vulpecula*) browse was observed at any of the three sites in 2012.

Puriri (*Vitex lucens*) dieback and greying at Hiwarau has increased since 2007. This dieback is common throughout the North Island and its cause is under investigation but not yet known. It is not thought to be directly related to possum impacts.

3.1.4 Pest Plants

A range of pest plants are found throughout the Catchment but this is no more than in similar environments and considerably less than in more densely populated areas. There are no pest plants present that are listed in the agency pest or eradication/exclusion pest categories of the Regional Pest Management Plan (RPMP).

As far as RPMP containment pests are concerned, the common farm weeds such as; blackberry (*Rubus fruticosus agg.*), gorse (*Ulex europaeus*) and ragwort (*Senecio jacobaera*) are locally common but generally have low impacts and are generally well controlled by landowners. Containment pests that have environmental impacts include; wild ginger (*Hedychium gardnerianum*), woolly nightshade (*Solanum mauritianum*) and old man's beard (*Clematis vitalba*). All these are being steadily controlled by landowners with support from the Bay of Plenty Regional Council and their populations have been reduced in density and distribution in recent years, though this reduction is hard to quantify. All known infestations of old man's beard are reduced to zero density each year, small infestations of yellow flag iris (*Iris pseudacorus*) and climbing spindle berry (Celastrus orbiculatus) have been eradicated. Two infestations of the invasive estuarine cord grass (*Spartina sp.*) have also been eradicated from the Harbour mudflats.

Other invasive weeds with substantial environmental impacts include; Japanese honeysuckle (*Lonicera japonica*), Chinese privet (*Ligustrum sinense*) and three species of wattle (*Acacia sp, Paraserianthes sp.*) which are all too widespread to be able to effectively tackle. Most infestations of Japanese walnut (*Juglans ailantifolia*), which particularly favours stream margins, have been controlled in recent years. A number of other weeds such as; wandering Willie (*Tradescantia fluminensis*) and jasmine (*Jasminum polyanthum*) are locally common. The grass weeds of estuarine margins, saltwater paspalum (*Paspalum vaginatum*) and sea couch (*Elytrigia repens*), are increasingly widespread around the Harbour are of considerable concern as they both completely displace native estuarine vegetation and consolidate the substrate in which they grow. No attempt to control these grasses has been made.

3.2 Fauna

3.2.1 North Island Long Tailed Bats

In February 2012 Digital Bat Recorders were set up in areas of potential bat flight paths at three sites within the Catchment; Waioeka Conservation Area, Kotare and Matekerepu Scenic Reserves. This was carried out to identify the presence or absence of bats within the Catchment.

Results

North Island Long Tailed Bats (*Chalinolobus tuberculata*) were detected in Waioeka Conservation Area, and not detected within either Kotare or Matekerepu Scenic Reserves.

Discussion

The survey carried out in 2012 was limited to only a few sites, it identified the presence of bats within the Catchment however it is unknown how far down the Catchment they are present.

3.2.2 Marshbirds of Ōhiwa Harbour

A survey of marshbird populations and habitat around Ōhiwa Harbour was conducted between November 2010 and January 2011. This work (Beattie, 2010) compared results on the abundance and distribution of marshbird species, as well as the overall health of the Harbour estuarine margin habitat, with a survey conducted by the Department of Conservation in 1990.

Results

Three marshbird species increased in abundance and distribution between 1990 and 2010, these were; Australasian bittern (*Botaurus poiciloptilus,* Nationally Endangered), banded rail (*Gallirallus philippensis assimilis,* Naturally Uncommon) and North Island fern bird (*Bowdleria punctata vealeae,* Declining). While one the spotless crake (*Porzana tabuensis tabuensis,* Relict) species decreased in abundance. Marsh crake (*Porzana pusilla affinis,* Sparse) were not observed during either survey. The total number of recorded bird species increased, but this is suspected to be largely due to increased recording of non-target species.

A similar range of threats and impacts was reported between the two surveys, and there was a slight increase in surveyed habitat quality. Weka were recorded during this survey and not previously in 1990.

Discussion

The snapshot nature of the survey and the cryptic behaviour of marsh birds limits the interpretation of these results. However, this survey still demonstrates the Harbour is of national significance for Australasian bittern and banded rail, and regional significance for North Island fern bird. The work of care groups within the Harbour has greatly increased the value of some habitat areas for marshbird species. Maintaining habitat diversity, and addressing the threats and impacts are essential for ensuring the long-term viability of marshbird populations at the Harbour.

The increase in presence of weka around the Harbour could affect marshbird habitat and is something that may require future monitoring or at least particular attention during future marshbird surveys.

Partial re-measures of marshbird sites have been scheduled five yearly with all sites to be re-measured ten yearly. The five yearly re-measure will provide more regular information and potentially any trends occurring within the sites of Outstanding, High and some Moderate quality habitat.

3.2.3 New Zealand Dotterel

New Zealand dotterel (*Charadrius obscurus aquilonius*) distribution has remained relatively constant since 2005, with breeding and flocking occurring at similar levels in the same locations. In general breeding success has been above the 'productive' level of 0.5 fledged chicks per pair per season (see table in Appendix 6), thanks largely to the volunteer efforts of the Ōhiwa Reserves Care Group and Forest and Bird volunteers (J. Barsdell *pers. comm.*). Predator control carried out for dotterel nest protection also benefits other species nesting success also e.g. Caspian tern (*Hydroprogne caspia,* Nationally Vulnerable), black billed gull (*Larus bulleri*, Nationally Endangered) and variable oyster catcher (*Haematopus unicolor,* Recovering).

3.2.4 Wading Birds

Wading bird counts have been taken in Ōhiwa Harbour by the Ornithological Society of New Zealand (OSNZ) since 1986. Bird counts are held every June and November providing a glimpse of what is happening on the day; they do not represent the actual numbers of birds that are breeding in the Harbour over each season.

Pest control has been occurring in four main breeding areas within the Harbour, concentrating on New Zealand dotterel, Variable oystercatchers, White-fronted terns and Caspian terns.

Results

Bird count data were plotted in Collins (2013) to view changes in bird numbers over time in light of pest control in some areas of the Harbour. November and June counts were plotted separately as some species are migratory.

Key results from this were:

- Bar Tailed godwit (*Limosa lapponica*) numbers have decreased over time.
- Variable oystercatchers have increased to record levels.

- Royal spoonbills (*Platalea regia*) arrived May 2006, and have returned each year in increasing numbers.
- Birds not reported in the last few years are, Eastern curlew (*Numenius madagascariensis*), Reef heron (*Egretta sacra sacra*) and Turnstone (*Arenaria interpres*).
- Caspian tern (*Hydroprogne caspia*) numbers have remained stable at 40-45 birds. They raise six to eight chicks per year.
- Black-backed gull (*Larus dominicanus dominicanus*) numbers have increased since the 1980's.

Discussion

The decrease in godwit numbers is similar to the decreased godwit numbers throughout New Zealand. This is likely due to feeding stop-over places in Asia being developed for farm and industrial lands.

Variable oystercatchers have shown the greatest increase in numbers, especially on Whangakopikopiko Island where it is most likely due to the intensive pest control of rats, stoats and rabbits.

Black-backed gulls are under pest control regimes, the eggs are pricked to try and reduce the impact they are having on nesting birds in the Harbour.

3.2.5 North Island Weka

North Island Weka (*Gallirallus australis greyi*) were not present in the Catchment before 2005, and are now being commonly seen and heard around the Harbour's eastern shores. Weka success in terms of spread and population increase is due to their ability to defend themselves against predators and favourable climatic conditions. This has been highlighted through the Mōtū Weka Project which has identified that over the last 10 years, juvenile and adult survivorship is the same between intensively managed sites and sites where there is no pest control (J. Barsdell *pers. comm.*).

Discussion

Increase in weka numbers around the Harbour is likely to affect marshbird habitat (Beattie, 2010).

3.2.6 North Island Brown Kiwi

Due to the Ōhope Kiwi project the population of North Island Brown Kiwi (*Apteryx mantelli*) in the Ōhope Scenic Reserve has increased overtime and is a continuing trend. Although the reserve is outside the Catchment the overflow effect with birds seeking out suitable habitat has meant more kiwi are present within the Catchment.

3.3 Identified Biodiversity Sites

There are two types of identified biodiversity sites, these are detailed below:

High Value Ecological Sites (HVES) are those priority sites on which the Council proposes to focus its support effort. There are 206 sites across the region identified as priorities for management. This list was derived from two primary criteria: Category 1[2] sites (identified under the Protected Natural Areas Criteria) and sites

[2] *Category 1 sites are the best quality or only remaining representative examples of indigenous vegetation or wildlife habitats on particular landform units within a bioclimatic zone in an ecological district. They contain some of the largest, best quality, or only remaining examples of indigenous vegetation or wildlife habitat.*

that have since been recognised as being of international, national or regional significance in a more recent assessment under the Regional Policy Statement Criteria.

'Biodiversity sites' are those with biodiversity values present which landowners and the community wish to protect, but are not High Value Ecological Areas."

The number and area of HVES and Biodiversity Sites within the Catchment can be seen in Table 3.1. There are 66 identified biodiversity sites within the Catchment, of which 10 are High Value Ecological Sites (HVES). The sites are a mixture of tenures including sites administered by DOC, district councils, and private land.

Seven HVES within the Catchment are managed (70%), however management does not always cover the entire site. Nukuhou Saltmarsh is part of a larger site that includes public and private land, and is managed under a Biodiversity Management Plan covering approximately 21 ha (Table 3.1). Of the non-HVES two are managed under Biodiversity Management Plans which total 86.17 ha.

Table 3.1 Number of Identified Biodiversity Sites and Biodiversity Management Plans (BMPs) existing in sites in the Ōhiwa Harbour Catchment.

	Number of Sites	**Area (ha)**	**Number of BMPs on sites**	**Area (ha)**
High Value Ecological Sites	10	1447	1	86.17
Biodiversity Sites	56	38777	2	21.2

3.4 Care Groups

There are currently four care groups operating within the Catchment. These groups work either around the Harbour margins or on islands within the Harbour. The total area managed by care group work is approximately 234.3 ha. The main goal of these groups is improved biodiversity.

The level of intensity and work carried out by the different care groups varies. Two groups carry out systematic animal pest control with regular trapping and baiting, weed control and re-vegetation planting. They also carry out outcome monitoring in the form of bird counts and monitoring. The remaining two carry out occasional rat control.

3.5 Introduced Mammals

The full suite of pest animals will always be present throughout the Catchment to some extent.

There has been intensive possum and rat (*Rattus* spp.) control delivered over 235 ha, including: Paparoa Road, Ōhiwa Domain, Whangakopikopiko Island, Nukohou Saltmarsh, Te Ru, Ōhiwa Spit and Uretara Island. Control of predators (mustelids and cats) is also delivered over most of these sites, along with another 641 ha including; Ngāti Awa farm and Waiotane Scenic Reserve. A total area of 876 ha is currently under some kind of animal pest control. Informal possum control also occurs subject to possum fur price but is generally intense enough to keep numbers relatively low in more open areas. Local goat (*Capra hircus*) control occurs within the Catchment.

Part 4: Water

4.1 Harbour Water Quality

4.1.1 Water

Water quality has been regularly monitored by Bay of Plenty Regional Council at two sites in Ōhiwa Harbour since 1990. These sites are located at the boat ramp at Ruatuna Road opposite Hokianga Island and at the Port Ohope wharf (Figure 4.1).

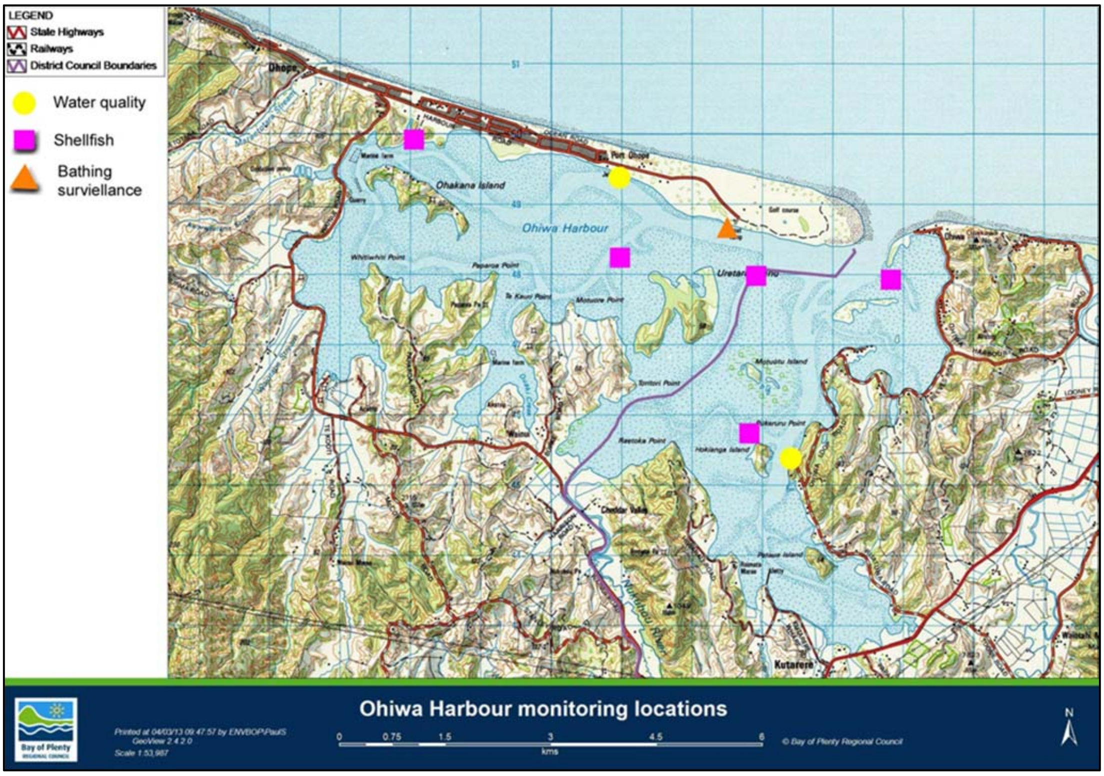

Figure 4.1. Location of water quality, shellfish quality and benthic macrofauna sampling sites in Ōhiwa Harbour.

Trend (SEN) analysis has been undertaken on estuary sites, positive slopes indicate an increase and negative slopes indicate decrease of a water quality parameter.

Results

Water quality statistics are presented in Appendix 7 (Tables 1 and 2). Overall these show that water quality results are good compared to other similar eastern bay estuaries in the Bay of Plenty. As shown by the conductivity levels in Tables 1 and 2 (Appendix 5) there is very little freshwater influence at these sites, particularly as samples are taken at high tide. Both sites within the estuary have some increasing and significantly increasing trends of some parameters. Suspended solids concentrations showed similar increases at both sites within the Harbour (Figures 4.3 and 4.4).

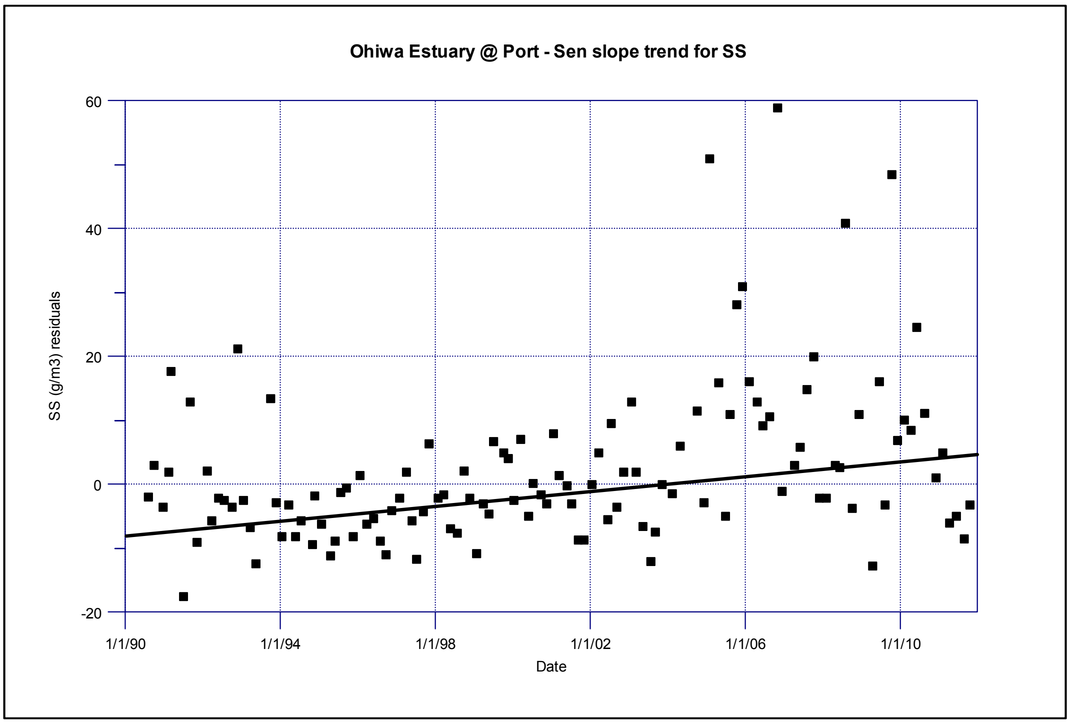

Figure 4.3 Suspended solid concentrations and trend slope, Ōhiwa Estuary.

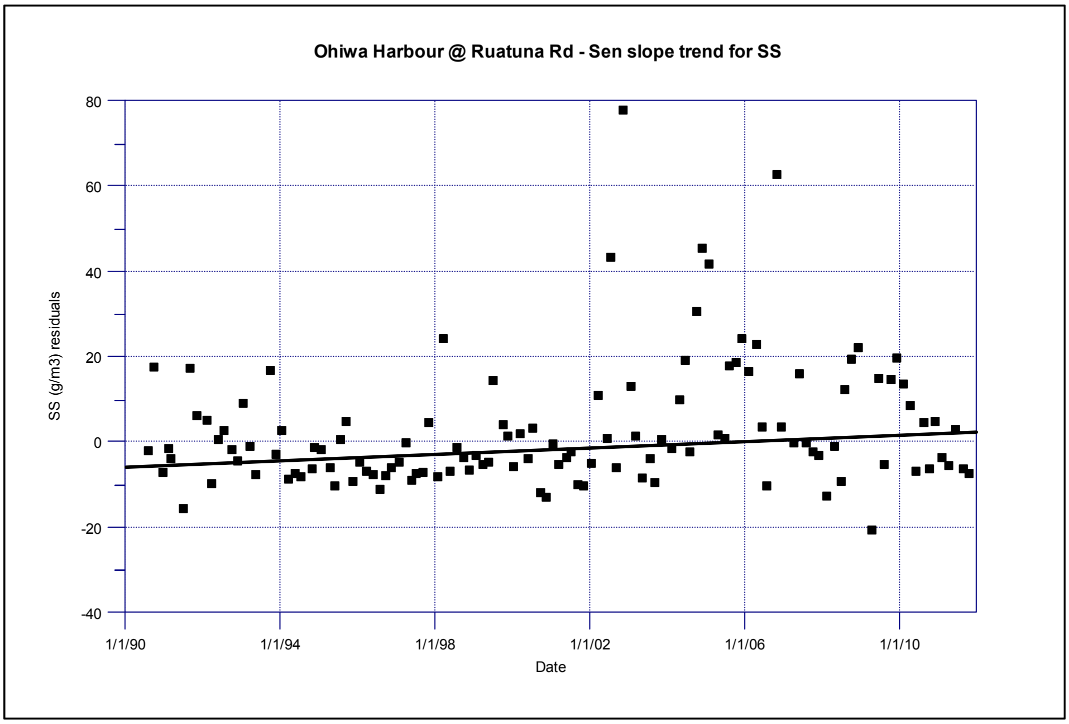

Figure 4.4 Suspended solid concentrations and trend slope, Ruatuna Road.

Ammonium (NH4-N) also shows a significant increasing trend at the Ruatuna Road site (Figure 4.5). Ammonium concentrations at Ruatuna Road are on average only slightly above those at Port Ōhope and less than similar sites in the Bay of Plenty.

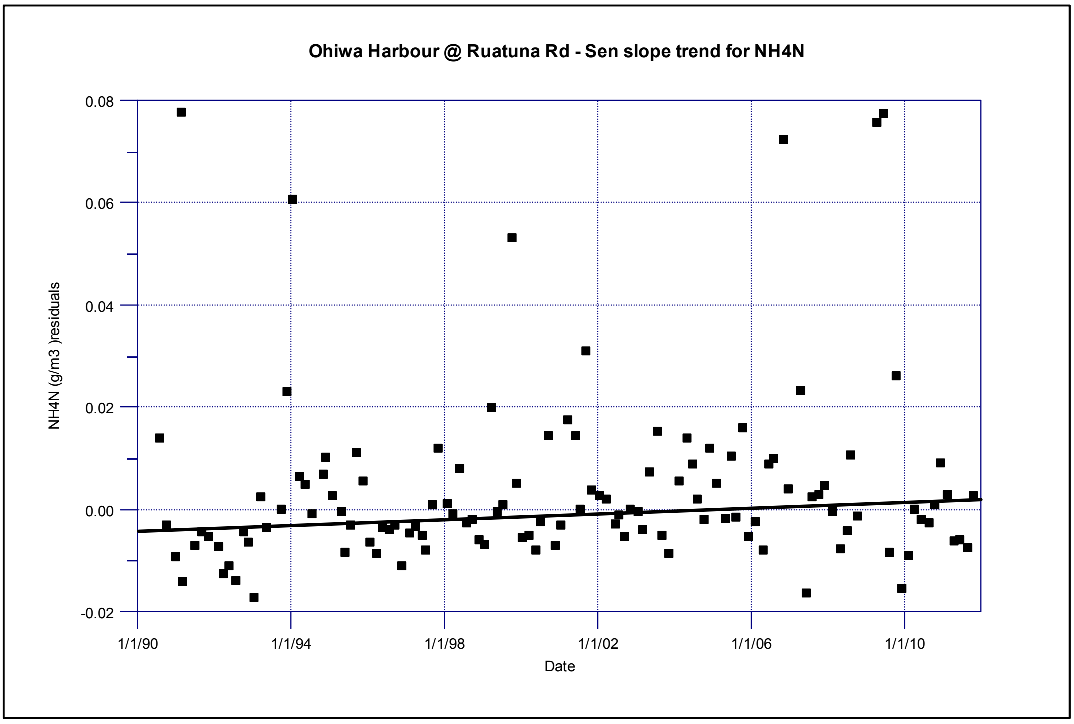

Figure 4.5 Adjusted ammonium concentrations and trend slope, Ruatuna Road.

Also displaying an increasing trend at Ruatuna Road are the faecal indicator bacteria E. coli and enterococci (Figures 4.6 and 4.7).

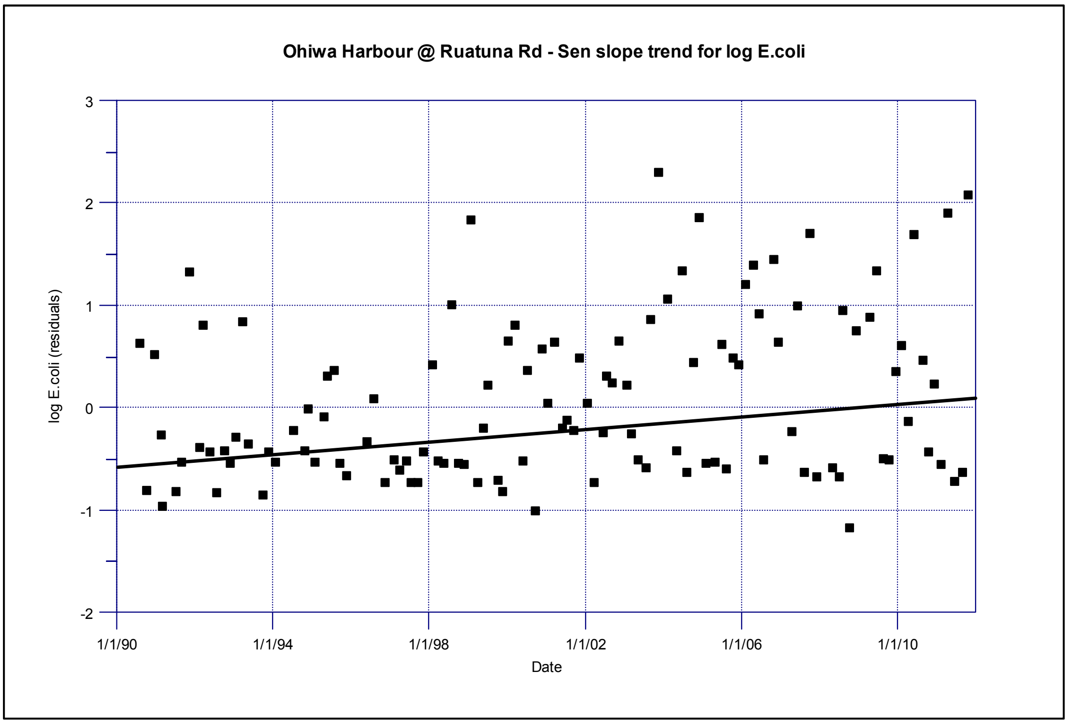

Figure 4.6 Log10 E.coli concentrations and trend slope, Ruatuna Road.

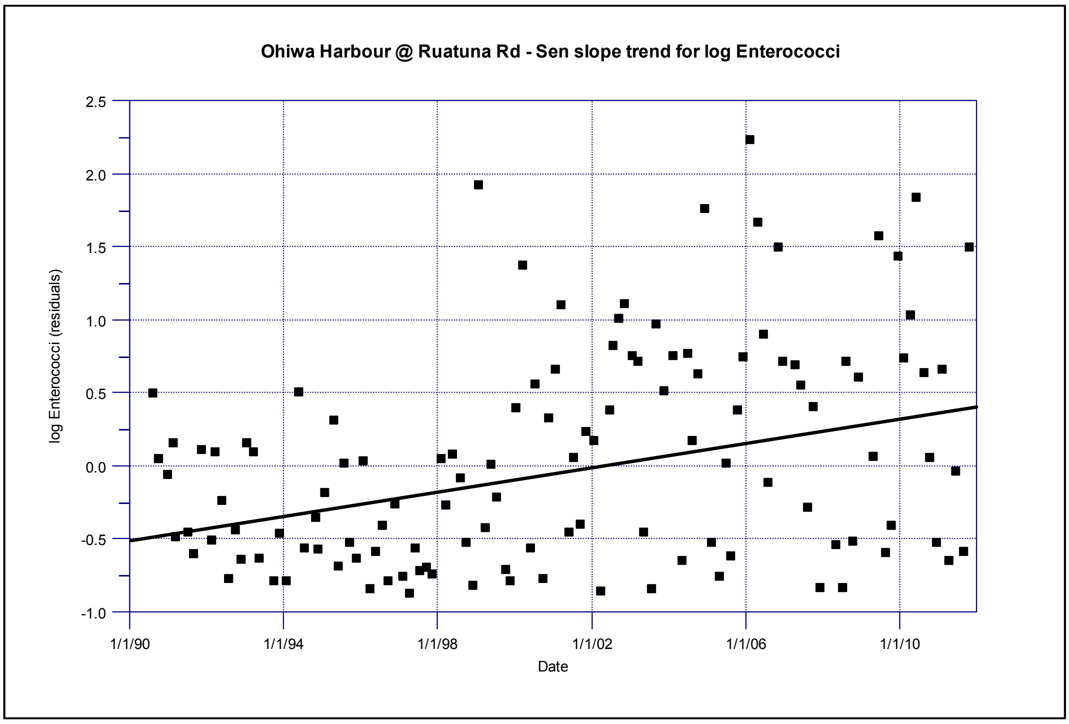

Figure 4.7 Log10 Enterococci concentrations and trend slope, Ruatuna Road.

Discussion

Suspended solid increases at monitored sites is most likely due to high sediment loads being introduced to the Harbour during several intense storm events post 2004. Increased sedimentation is the greatest risk posed to rivers, streams and eventually the Harbour, suspended solids can come from storms eroding vulnerable hill country or land use and management activities such as earthworks. The loading of the sediment during such storms will have detrimental impacts to the Harbour including smothering of fauna, decreased water clarity, increased nutrient loading, and potentially changes to habitat zones.

While ammonium levels are not near concentrations that might cause a toxicity concern, the increase at the Ruatuna Road site may be a symptom of land use related changes e.g. increased discharges from pastoral agriculture and wastewaters. The increases in the faecal indicator bacteria E. coli and enterococci also show an increase of impacts of land use, predominantly pastoral agriculture on the eastern side of the estuary. While average faecal indicator bacteria levels are well below contact recreation guidelines, maximum faecal indicator bacteria levels can be above these guidelines.

4.1.2 Bathing water quality

Ministry for the Environment sets out swimming guidelines for marine waters based on enterococci bacteria. These set out different levels with the acceptable “green” mode criteria that no single sample has greater than 140 enterococci/100 mL, an “orange alert mode”, and if two consecutive samples exceed 280 enterococci/ 100 mL it is classified into the “red action mode”.

Results

Bathing surveillance monitoring is undertaken in summer at the Ōhope Reserve boat ramp.

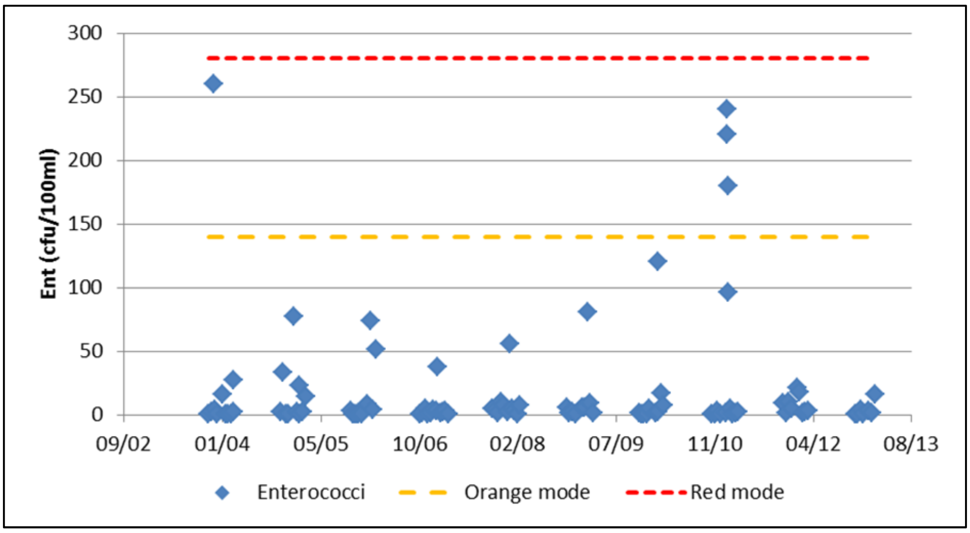

Figure 4.8 Enterococci concentrations 2003 to 2013.

Figure 4.8 displays enterococci results from 2003 to 2013. Apart from once in 2003, enterococci results have only been in the orange alert mode after an intense storm event in 2011. Ōhiwa Harbour rates as one of the best in the region for bathing water quality.

Discussion

Water quality results are good and are comparable to other similar eastern bay estuaries in the Bay of Plenty.

4.1.3 Shellfish

Shellfish have been sampled at a number of sites within Ōhiwa Harbour since 1992 (Figure 4.1). Most sampling was carried out for checking bacterial numbers in shellfish. Faecal coliform and Enterococci numbers are measured as indicators of the possible presence of disease causing bacteria/viruses, but do not cause sickness themselves. While there are no national guidelines, the shellfish industry uses a compliance standard according to which 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.

In Figure 4.9 the faecal coliform concentration present in shellfish flesh for sites around the Harbour are shown. Species tested include:

- Cockle *(Austrovenus stuchburyi)*; found throughout muddier intertidal and subtidal areas, only abundant in harvestable numbers at a few locations.
- Pipi *(Paphies australis);* often abundant around the mouth of the estuaries but extend to sandy areas of the inner estuary.
- Oyster *(Tiostrea chilensis lutria);* commonly found cemented to rocks or mangroves in the intertidal zone.

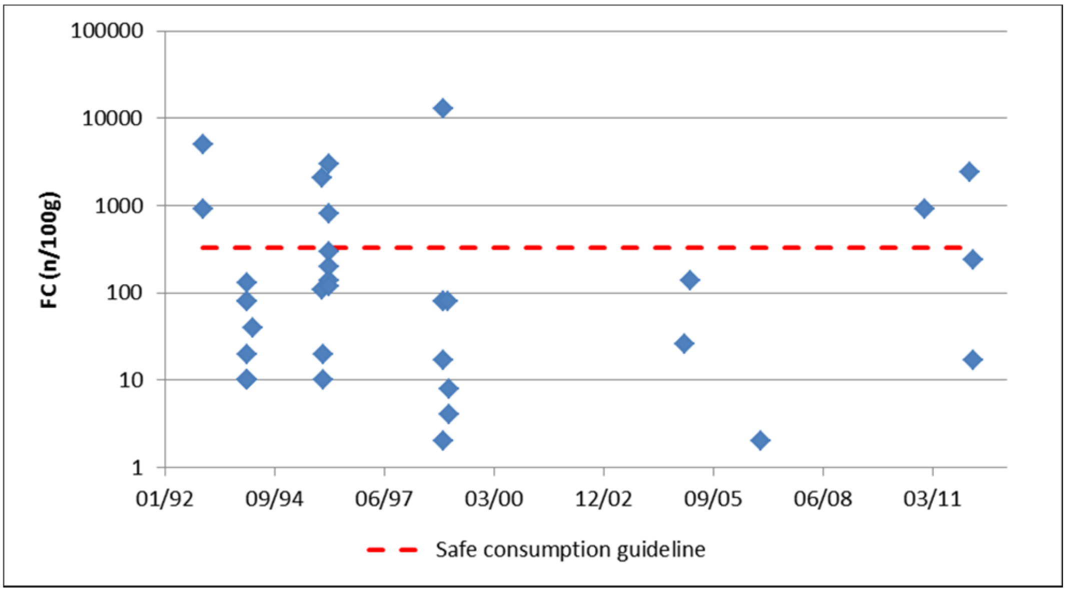

Figure 4.9 *Faecal coliform (FC) bacterial numbers recorded in shellfish flesh from sites in Ōhiwa Harbour from 1992 - 2012.*

Two sites in the Harbour are analysed for metal contamination of shellfish flesh. Cockles were sampled from just northwest of Hokianga Island and pipi from the bed opposite the Ōhope boat ramp where the Nukuhou channel ends. Results are shown in Table 4.1.

Table 4.1 *Metal concentrations in shellfish flesh from Ōhiwa Harbour (mg/kg wet weight).*

	Guideline	Cockles	Pipi
Arsenic	1.0 (inorganic)	2.4 (total)	2.9 (total)
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 arsenic guideline in Table 4.1 is in terms of inorganic arsenic where results presented are totals. Studies of results from Maketū Estuary have shown that inorganic arsenic is around a tenth of total arsenic. This would result in the inorganic arsenic in the table above being approximately 0.24 and 0.29 mg/kg for cockles and pipi respectively. All metal concentration results meet the guidelines for consumption of shellfish, except arsenic.

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. This is relevant due to soil types within the Catchment.

Discussion

Monitoring results of shellfish in the Harbour show a heightened risk to shellfish consumers due to increased Faecal coliform and Enterococci numbers after storm events. Strong winds in the Harbour may also raise bacterial numbers by re-suspending sediment and associated bacteria.

Studies have shown that shellfish may take a week or longer to expel potential pathogens before safe consumption levels are reached and it is therefore recommended people wait at least five days before collecting shellfish.

4.2 Nukuhou River

4.2.1 Water quality

The Nukuhou River Catchment is 103 km^2 or 60% of the Ōhiwa Harbour Catchment. Mean flow of the Nukuhou River based on data from 1990-2012 is around 1.67 m^3/sec. There is a water quality monitoring site on the Nukuhou River where data has been collected since 1990. Data from this site has been analysed for trends and overall water quality status and is presented in Appendix 7, Table 3.

Results

Dissolved oxygen levels in the Nukuhou River have been on occasion below 80% saturation[3], usually in mid to late summer. Suspended solid concentrations are improving with a trend rate of over 2.5% decrease per annum over the period 1990 to 2012 (Appendix 5, Table 3). The Nukuhou River also displays a trend of increasing temperature (Figure 4.10).

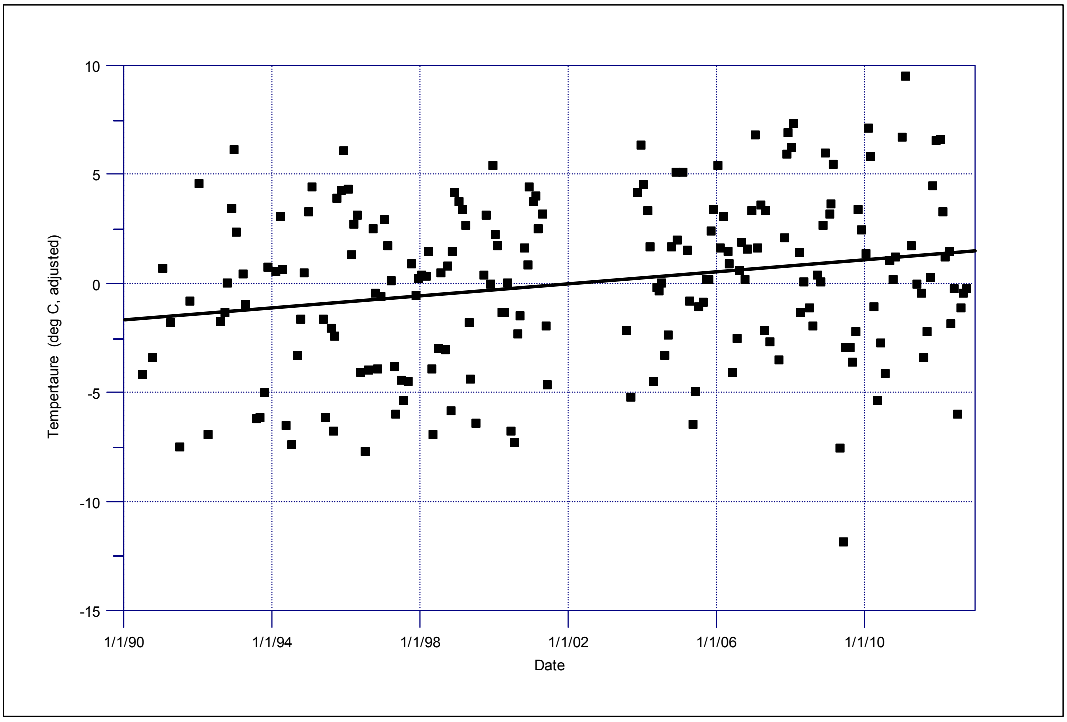

Figure 4.10 Adjusted temperature and trend slope, Nukuhou River.

The Nukuhou River also has higher than average nitrogen and phosphorus levels in the river compared to other eastern Bay of Plenty rivers. Dissolved nitrogen parameters, oxides of nitrogen (TOx-N) and ammonium (NH_4-N), are below levels at which toxic effects to organisms are likely to occur, but are above levels at which limitation of periphyton growth occurs. However, periphyton growth is limited by the sandy nature of the substrate in many locations.

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[3] The Regional Water and Land Plan S9(b), states 'The discharge shall not cause the oxygen level to fall below 80% of saturation concentration'.

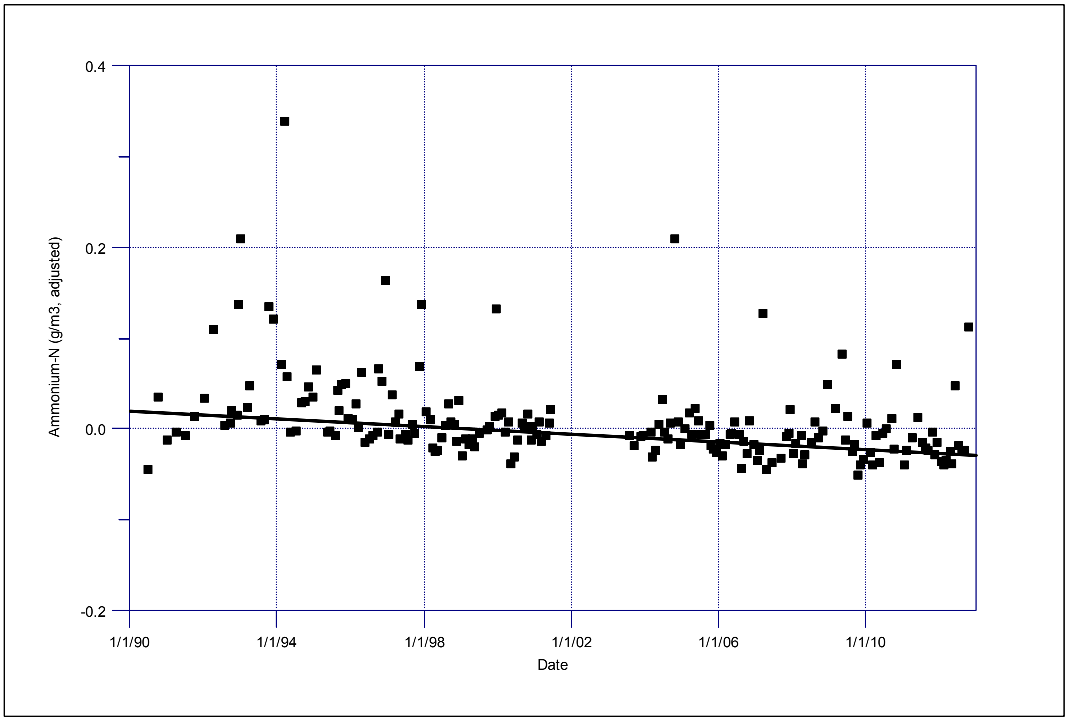

Figure 4.11 Adjusted ammonium (NH4-N) and trend slope, Nukuhou River.

Nitrogen trends in the river show a significant decreasing trend for dissolved and total nitrogen (TN) (Figure 4.11)

There are also decreasing trends in faecal indicator bacteria (Appendix 7, Table 3). However, these concentrations are higher than other monitored Bay of Plenty streams and rivers and are at often at levels above those recommended for contact recreation.

Discussion

The decrease in suspended solid, nitrogen concentrations and faecal indicator bacteria trends indicate improved land management practices to be showing dividends. However, suspended solid and faecal indicator bacteria levels are still elevated, compared to other Bay of Plenty rivers. The Nukuhou is a unique in terms of geology which is part of the reason for this difference. The trend of increasing temperature is probably due to widening of the stream in sections as well as changes in riparian vegetation.

The occasional low dissolved oxygen level, coupled with elevated temperatures and elevated levels of suspended solids, put the ecosystem under stress at these times. Low dissolved oxygen concentrations place aquatic organisms under stress and if sustained can cause death. Macroinvertebrate monitoring (Section 4.4) suggests that aquatic organisms may have been impacted.

4.3 Freshwater Fish

Bloxham (2007) identified that around 40% of streams surveyed within the Catchment contained complete or partial barriers to fish migration; many of these were close to the Harbour. Fish with the greatest climbing ability (banded kokopu (*Galaxias fasciatus*), eels (*Anguila* spp.) and redfin bully (*Gobiomorphus huttoni*)) were shown capable of negotiating all but one barrier, but in most instances barriers prevented fish without climbing ability (bluegill bully (*Gobiomorphus hubbsi*), common bully (*Gobiomorphus cotidianus*), giant bully (Gobiomorphus gobioides), inanga (*Galaxias maculatus*), smelt (*Retropinna retropinna*) and torrent fish (*Cheimarrichthys fosteri*)) from reaching and exploiting upstream habitat.

During this survey a total of eleven fish species were encountered. Historically sixteen freshwater fish species have been identified from the Catchment, including three brackish water species. During this survey no new species were recorded and no new shortjaw kokopu (*Galaxias postvectis*) or koaro (*Galaxias brevipinnis)* populations were found. Long fin eel, a species listed in Department of Conservation's fish classification system as "declining" were present at 59 percent of sites. Seven new populations of the "regionally threatened" banded kokopu were found, bringing the number of known populations in the Catchment to eleven. Also found were two new populations of bluegill bully and one of torrentfish and giant bully, which brings their total populations in the Catchment to four, two and two respectively. Redfin bullies, recorded previously from a number of streams in the Catchment, were again found to be widespread (over 50 percent containing this species) in streams with a closed or semi-closed native or mixed native/forestry riparian canopy. Smelt were found up to 20 km inland in larger streams containing barrier free fish passage. Although present in the neighbouring Catchment (Maraetōtara Stream), no giant kokopu (*Galaxias argenteus*) populations have been found in streams feeding the Harbour.

Surveys carried out in 2011-2012 to expand on this information identified two new bluegill bully populations and one new population of banded kokopu.

Discussion

To enable trends to be drawn from this data, follow up surveys are required. A large number of un-surveyed streams remain within the Catchment. However, a full survey of every stream within the Catchment would be a very large task.

4.3.1 Whitebait

Historical records (Mitchell, 1990) detail observed spawning of whitebait from three sites around Ōhiwa Harbour; Tunanui Stream, Waiotane Stream and a small stream on the Nukuhou River opposite the old dairy factory. Spawning activity was observed more recently, in April 2011, on the true left of the Nukuhou River in the recently established whitebait spawning area (Barsdell, 2011).

Discussion

Whitebait spawning is one area of 'assessing the ecological quality of Ōhiwa Harbour' (action 12.3.3) that requires more work. It is impossible to draw conclusions on the current status of whitebait with only limited information. A method for monitoring and recording potential whitebait spawning habitat is currently under development. Data from a survey using this method should be available for the next five yearly report.

4.4 Macroinvertebrate Monitoring

Freshwater invertebrates consist of aquatic insects, snails, worms, and shrimp. The different types of invertebrates found in streams and rivers can indicate a waterway's overall ecological condition. The advantage of monitoring these animals is that they integrate both water quality and habitat conditions in a stream over time.

Invertebrate communities have been sampled from four waterways in the Catchment: Nukuhou River, Kutarere and Wainui streams, and a small unnamed tributary (hereafter called Ōhiwa Tributary) as part of Bay of Plenty Regional Council's NERMN invertebrate monitoring programme (Figure 4.12).

Figure 4.12 Location of four study streams within the Ōhiwa Harbour catchment.

Waterways within the Catchment were assessed using more than one method, these are described below:

Freshwater Snail and Mayfly

Freshwater snail (*Potamopyrgus*) and the mayfly (*Deleatidium*), are particularly common and widespread, the differences between their habitat requirements can indicate stream health. The freshwater snail generally associated with organically enriched streams and high algal biomass, are tolerant of the pressures associated with land use changes (organic enrichment, high algal biomass, high sediment loads, and high water temperature). In contrast, mayflies are associated with less enriched streams with lower algal biomass, and are intolerant of pressures associated with land use changes. These invertebrates have almost opposite habitat requirements, and as stream health deteriorates, mayfly densities decrease and freshwater snail densities increase.

Macroinvertebrate Community Index

The Macroinvertebrate Community Index (MCI) relies on the presence or absence of invertebrates in a stream. It provides only a relatively coarse indication of stream health. It is not particularly sensitive to changes in the relative abundance of different taxa, which is arguably one of the first signs that a particular environment is under stress. Scores can range from 20 to 200. Scores > 120 represent streams in "excellent" condition, and scores < 60 indicate "highly degraded" streams.

Quantitative MCI

The quantitative MCI (QMCI) takes the relative abundance of each taxa into consideration and can be used to better describe the health of a particular waterway. QMCI scores range from 1 to 10. Streams with scores > 6 represent streams in "excellent" condition, and streams with scores < 2 represent "highly degraded" streams.

EPT

The number (number of different EPT taxa) and percentage (percentage of all invertebrates that are EPT) of *Ephemeroptera* (mayflies), *Plecoptera* (stoneflies), and *Trichoptera* (caddisflies) (EPT) taxa in a sample are two other commonly used metrics to describe invertebrate communities. Many species of these insect groups show reductions in density at sites affected by nutrient enrichment (subsequent algal blooms), heavy metals and sedimentation loads.

Results

The four waterways support invertebrate communities typical of lowland streams throughout the country. The relative abundance of freshwater snail was highest in the Nukuhou River and Wainui stream, suggesting environmental conditions in these streams have changed to the extent that sensitive taxa have decreased in abundance. In contrast, the relative abundance of mayfly was highest in the Kutarere Stream and the Ōhiwa tributary, suggesting environmental conditions in these two streams are still suitable for these more sensitive taxa.

Average MCI scores of all streams were relatively high, placing them all in the "good" water quality class (Table 4.2). Average QMCI scores show a much wider range of stream health, with Ōhiwa tributary having an average QMCI score of 6.2, placing it in the "excellent" water quality class, and Wainui Stream having an average score of only 3.6, placing it in the "poor" water quality class. These differences in the water quality class rankings of each stream highlight the differences between the QMCI and the MCI. The relative abundance of invertebrates indicative of good water quality was much reduced in the Wainui Stream, shown by the lower number of EPT taxa (5) than in the other three streams, as well as a lower percentage of EPT (12.9%). The Ōhiwa tributary had the highest values of all four measures, suggesting it is in the best ecological condition of the four streams.

Table 4.2 Average values of the MCI and QMCI, and the number and percentage of EPT taxa.

Stream	MCI	QMCI	Number of EPT taxa	Percentage EPT taxa
Kutarere Stream	114.9	5.2	7.8	41.3
Wainui Stream	101.4	3.6	5.0	12.9
Ōhiwa Tributary	117.1	6.2	8.0	58.7
Nukuhou River	107.0	5.1	12.3	34.7

MCI scores in the Ōhiwa tributary increased significantly from 2002 to 2010 (Figure 4.13), whereas these scores fluctuated without pattern at the other three sites. Calculated MCI scores from the Nukuhou River also fluctuated without pattern over the time period (Figure 4.14).

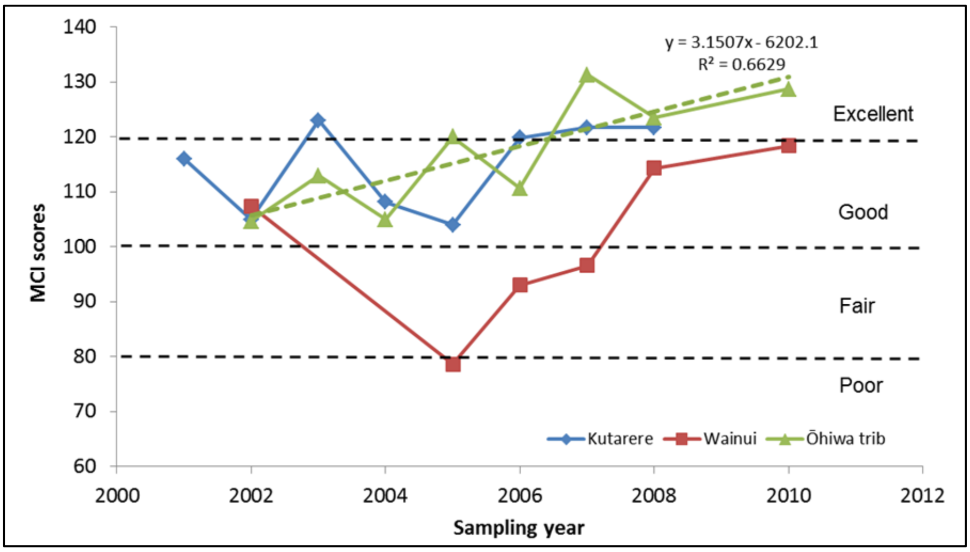

Figure 4.13 Temporal fluctuations in MCI scores in the Kutarere, Wainui streams and the Ōhiwa tributary over time.

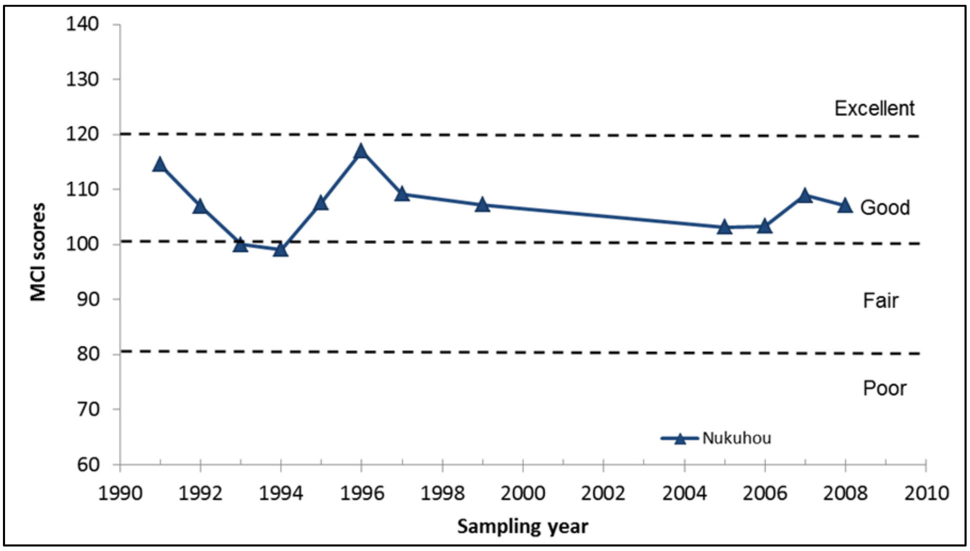

Figure 4.14 Temporal fluctuations in MCI scores in the Nukuhou River over time.

QMCI scores showed no trends at any site. QMCI scores in the Ōhiwa tributary were often greater than six over the sample period, placing the stream in the "excellent" water quality class. Kutarere stream fluctuated between having QMCI scores indicative of the "fair" and "good" water quality classes, whilst Wainui stream QMCI scores were all generally below four, indicating "poor" water quality conditions, and "probable severe pollution" at this site (Figure 4.15). QMCI scores in the Nukuhou River indicated "poor" water quality class on five occasions, and "good" water quality class conditions on seven occasions (Figure 4.16).

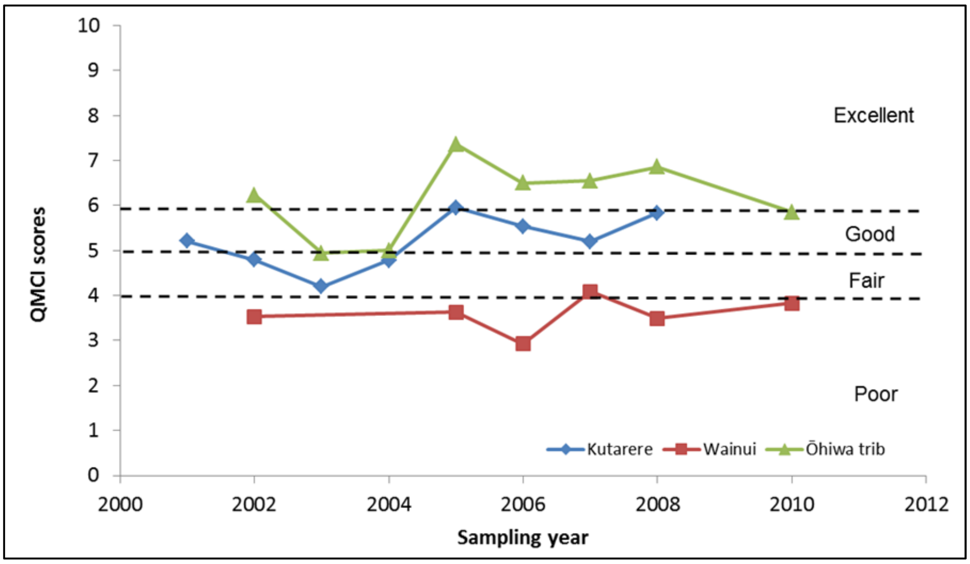

Figure 4.15 *Temporal fluctuations QMCI scores in the Kutarere, Wainui streams and Ōhiwa tributary over time, showing the lack of any trends.*

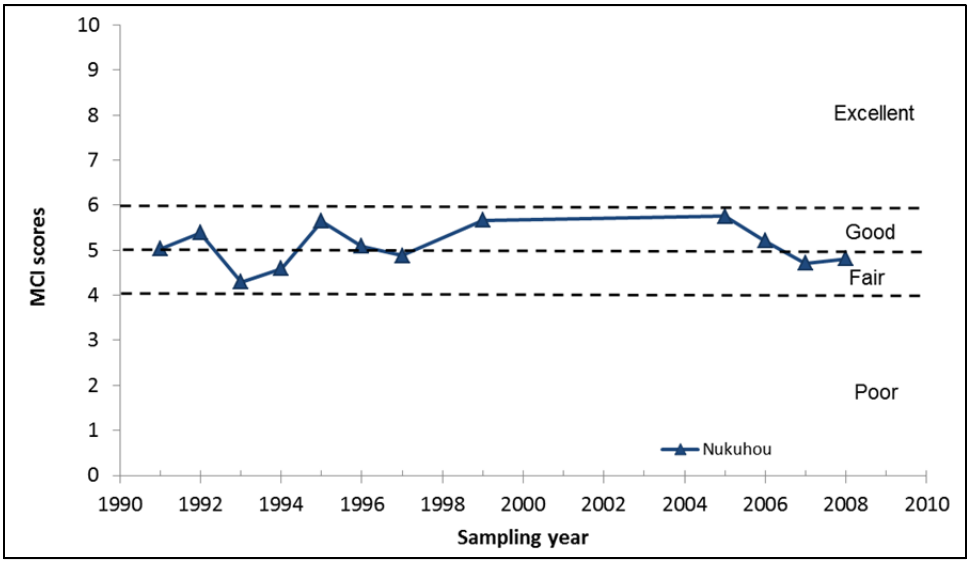

Figure 4.16 *Temporal fluctuations QMCI scores in the Nukuhou River over time showing the lack of any trends.*

Discussion

Analyses showed that stream health generally did not change over time, with the exception of the increased MCI scores and number of EPT taxa in the Ōhiwa tributary, and the percentage of EPT in the Kutarere stream. The Nukuhou River in particular has a long monitoring record (18 years), yet no trends were apparent. Results also show stream health in monitored streams is similar as in other pasture catchments regionally, and lower than would be expected under natural conditions.

Results indicate that ecological conditions of these streams have not improved sufficiently over time to result in improvements in invertebrate communities. They also indicate there has been no further deterioration. This suggests mitigation techniques have had limited positive effects on stream health within the Catchment. The expected response time for macro invertebrate communities would be 5-10 years, depending on stream size, and the extent of retirement area and revegetation planting.

Given the important role of riparian vegetation in terms of intercepting overland run-off, taking up soil nutrients, providing shade, bank stability, and overhanging shelter, increased focus may be required on riparian planting and the width of the retirement areas in relation to ground slope. This in combination with the continuation of other improved land management practices and continued decreasing trends for SS and nitrogen it would be expected that improvements will be more visible in the future.

Part 5: Marine and Estuary

5.1 Sediment Contaminants

Estuaries are very susceptible to the impact of a wide range of potential contamination sourced from land runoff and the atmosphere. They act as a trap where contaminants can accumulate to levels that have negative impacts on all marine life associated with them. Common contaminants include metals, pesticides and organic compounds. Some contaminants more commonly elevated in New Zealand estuaries include metals such as zinc and copper and polyaromatic hydrocarbons[4] (PAHs) and often historic but persistent pesticides like DDT.

Results

Seven sites in the harbour have been surveyed for surface (0-2 cm depth) sediment contamination every three years since 2006. The results of those surveys are presented as mean values in Appendix 8, (Table 1), for comparison the table has the value range from the 31 sites in Tauranga Harbour and the sediment quality guideline low and high values. The PAHs and metals are all well below the low guideline value which indicates that there is very little impact from the Catchment. Compared to Tauranga Harbour copper (Cu) and nickel (Ni) values tend to be higher on average which most likely relates to variations in Catchment geology.

Zinc and copper concentrations recorded at Ōhiwa Harbour sites from 2006 to 2012 are shown in Figures 5.1 and 5.2. These are the two metals that most commonly show elevated levels around New Zealand’s cities. As seen in the graphs there is no real indication of these two metals increasing over this time period.

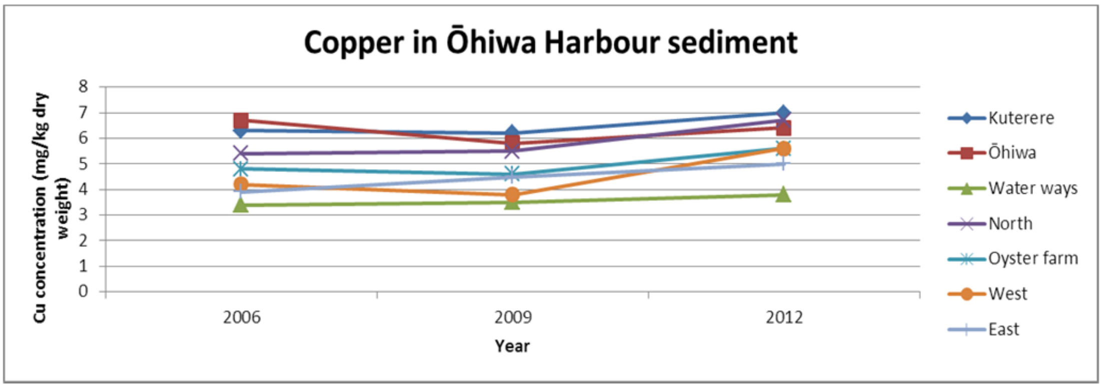

Figure 5.1 Copper concentrations at Ōhiwa Harbour sites from 2006 to 2012.

[4] *Polyaromatic hydrocarbons are a group of organic contaminants that form from the incomplete combustion of hydrocarbons, such as coal and gasoline. PAHs are an environmental concern because they are toxic to aquatic life and because several are suspected human carcinogens (Van Metre et. al.)*

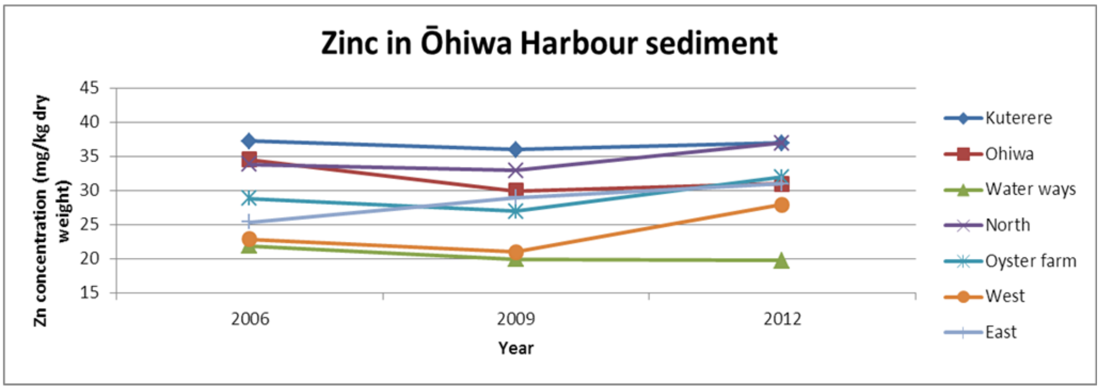

Figure 5.2 Zinc concentrations at Ōhiwa Harbour sites from 2006 to 2012.

5.2 Macrofauna

The soft-shores of harbours and estuaries can be very productive habitats supporting a large range of small animals living either in or on the sediment. This includes bivalves such as cockle (tuangi), crabs, anemones, snails and worms. These form benthic communities which are sensitive to sedimentation and contaminants, hence monitoring that can show whether the environment is stable over time or declining.

There are six sites in Ōhiwa Harbour monitored annually by Bay of Plenty Regional Council. Four of these are very stable physically and ideal for tracking any adverse water quality impacts. The location of these sites is shown in Figure 5.3. Species richness (number of animal species) found in samples taken from each site, is a good indicator of biodiversity or the health of these communities. Another useful indicator of health is species diversity (Shannon-Weiner index), which provides a measure of how evenly numbers of animals are spread amongst species present.

Figure 5.3 Location and number of currently monitored benthic macrofauna sites in Ōhiwa Harbour.

Results

Results of monitoring from 1991 to 2013 are provided in Figure 5.4 for species richness and Figure 5.5 for species diversity. There have been minor fluctuations over time but none of these sites is currently showing any significant long-term change over time based on either species richness or diversity.

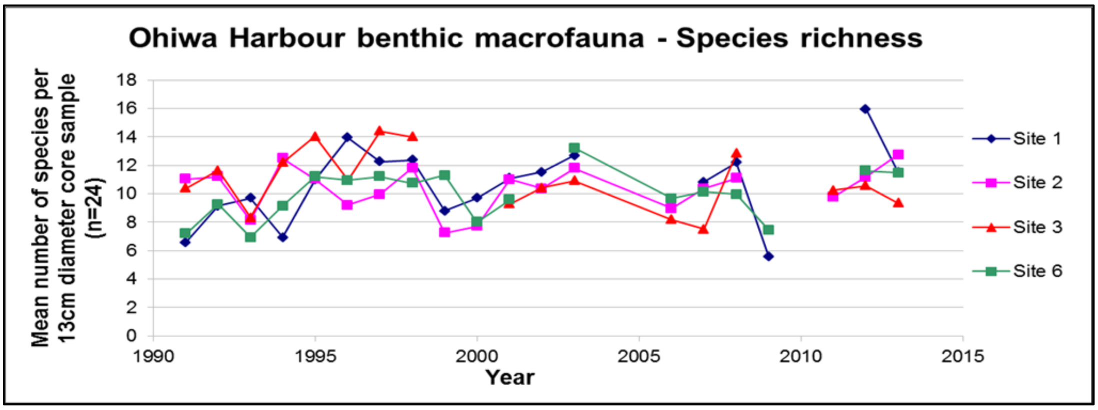

Figure 5.4 Mean species richness of macrofauna samples collected at four intertidal sandflat sites in Ōhiwa Harbour from 1991 to 2013.

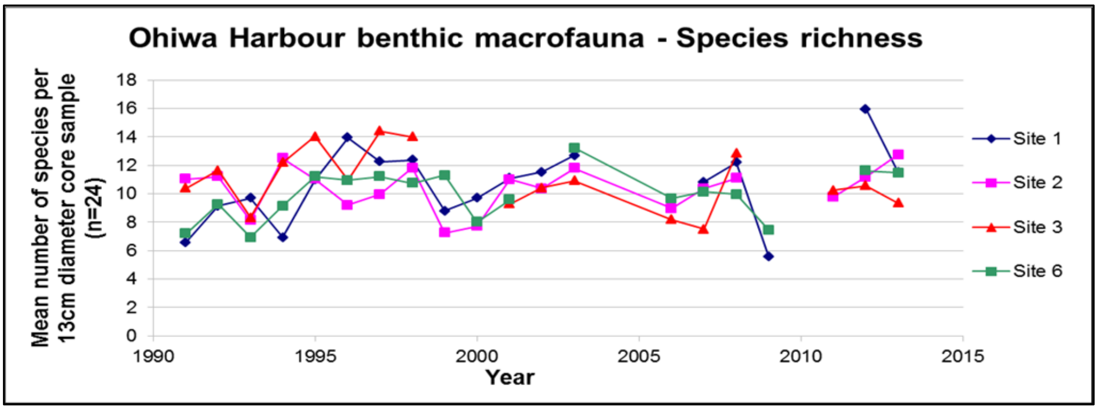

Figure 5.5 Mean species diversity of macrofauna samples collected at four intertidal sandflat sites in Ōhiwa Harbour from 1991 to 2013.

The mean numbers of cockle in samples from each site is shown in Figure 5.6. Numbers have varied over time with pulses of recruitment occurring, especially at sites 1-3 but show no significant long-term changes.

Pawley, 2011 carried out monitoring for the Ministry of Fisheries of the northern and eastern banks of Motuotu Island in 2005, 2006 and 2009 showing an increase in the number of both since 2005. However, the number and density of harvestable cockle in 2009 and 2006 (0.015 million) was less than that in 2005 (0.17 million). Despite the increase in pipi numbers, harvestable pipi numbers has dropped since 2005 and 2006 (2.52, 2.14 million respectively) and is now estimated at 1.15 million. This looks to agree with results from the Bay of Plenty Regional Council NERMN programme.

A number of sediment parameters are measured at each of the benthic macrofauna monitoring sites to track changes that may be detrimental to the animals living there. Heavy metal concentrations have been tested since 2006 but levels are very low compared to environmental guidelines and have not changed over time. In Figure 5.7 the percentage of the sediment that is mud (the very fine clay and silt particles) has been graphed. There has been a slight increase in mud content of sediment at Site 1 which is a decline in the quality of the habitat. Although species richness and diversity have remained stable at this site, sponges were present up to around the late 1990s but have since been absent from the site and surrounding area.

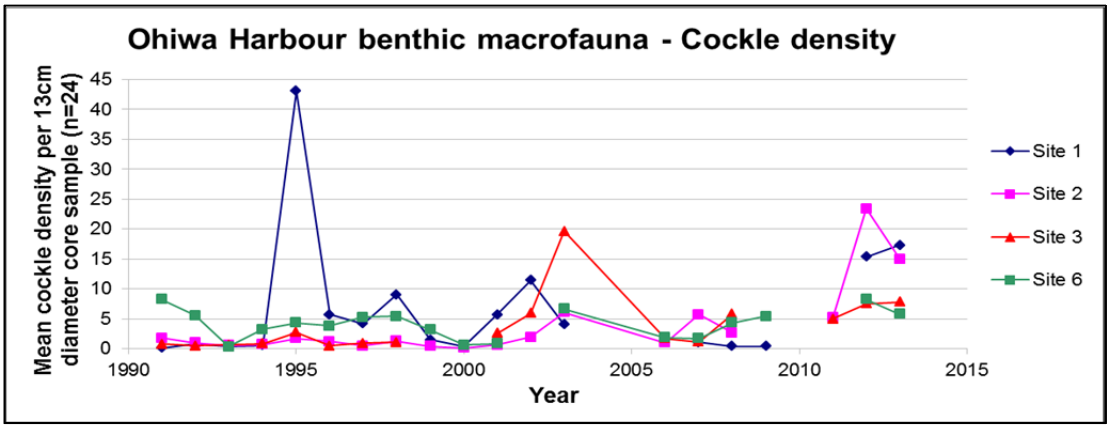

Figure 5.6 *Mean density of cockle in samples collected at four intertidal sandflat sites in Ōhiwa Harbour from 1991 to 2013.*

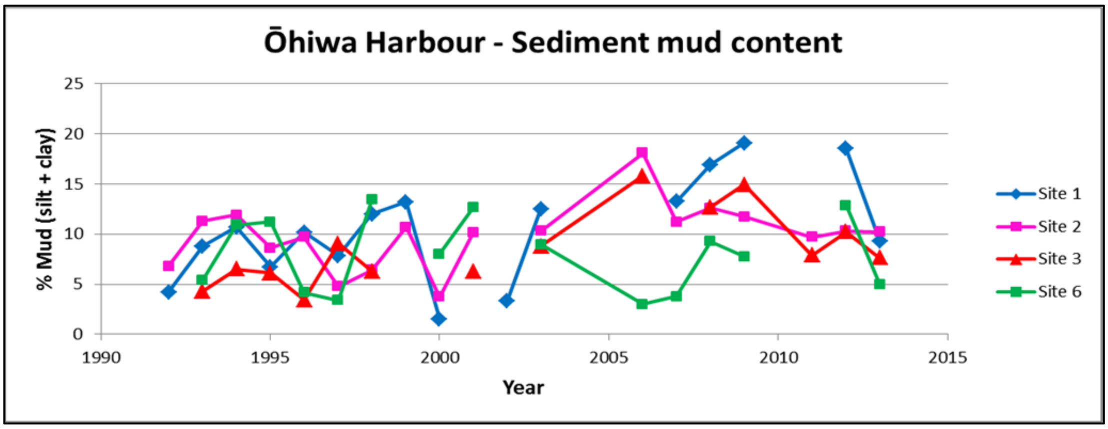

Figure 5.7 *Percentage mud content of the surface (2 cm depth) sediment at sites in Ōhiwa Harbour from 1991 to 2013.*

Discussion

Sponges are very sensitive to fine sediment as they are filter feeders and the loss of sponges from site one is highly likely to be related to the sediment increase. This highlights sediment inputs to the Harbour as one of the greatest environmental risks to the Harbour ecosystem.

5.2.1 Green Lipped Mussels and Starfish

Surveys of green lipped mussel (*Perna canaliculus*) populations in Ōhiwa Harbour from 2007, 2008 and 2009 observed an increase in the size class of green lipped mussels, however there was a reduction in abundance and also a reduction in the mussel bed size (Paul-Burke, 2012).

Results

In 2007, 90% of mussels were in the smallest size class (0-22 mm), by 2008, 65% were in the size class 21-40 mm and by 2009, 69% of mussels were ‘adult’ (41-60 mm) size. There were an estimated 115 million mussels in 2007 with only 60 million estimated in 2008, this is consistent with individual size increases and competition for space as a result. However by 2009 there were only 1.2 million mussels, a significant reduction of 78% (Paul-Burke, 2012).

An increase in the population of starfish (*Coscinatsterias muricta)* and to a lesser degree reef star (*Stichaster australis)* was noted from not being mentioned in 2007 to significant in 2008 and by 2009 to the extent that they formed a line across the entire width of the original mussel beds (15 metres). They were noted to be moving across the mussel beds feeding (Paul-Burke, 2012). The mussel bed size decreased by 49% from 2008 to April 2009. Follow on surveys in June 2009 showed a further reduction in the bed size of 20% (Paul-Burke 2012).

Recommendations are made later in this report (Recommendations), for work to better understand the cycle between mussels and starfish, what is occurring within the Harbour, along with the potential results of human interference in this cycle.

Discussion

More work is required to develop a better understanding of what is occurring within the Harbour, the mussel and starfish populations and the relationship between the two before embarking on efforts/work to alter this cycle. It is especially important to understand the potential outcomes of any future human interference with this natural cycle.

5.3 Mangroves

Mangroves (*Avicennia marina var. australasica*), are literally trees in the tide. The mangrove is limited to northern areas of New Zealand as 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 Ōhiwa and Tauranga Harbours it tends to form shrublands with plants rarely exceeding 2 m in height. Ōhiwa Harbour represents the southern limit of mangroves on the east coast.

In economic and cultural terms mangroves can provide additional shellfish resources in the form of oysters attached to the stems, erosion protection and water quality improvement. In ecological terms they enhance species diversity, increase habitat complexity and extent and most importantly they provide habitat for the uncommon banded rail. However, mangroves are encroaching into areas of the Harbour with very different and significant ecological diversity. These are areas that provide food and habitat for many thousands of wading birds and also shellfish beds.

In the last few decades, 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 in the catchments. Once established, mangroves in turn trap further sediment and accelerate the succession from a marine to a terrestrial environment. Rates of spread may have also been accelerated by global warming and possibly increased nutrients in the sediments.

Results

In Ōhiwa Harbour mapping of distribution in 1945, 1992, 2003 and 2007 has shown marked increases (see Table 5.1). In 1945 there were 20.6 canopy ha and by 2007 this had increased to 118.76. This is an increase of almost 6 times the area over 62 years.

Table 5.1 Area (canopy hectares) of mangroves in Ōhiwa Harbour from 1945 to 2007.

Year	Area (ha)	Growth per year (ha)
1945	20.6	-
1992	91.1	1.5
2003	90.8	-0.03
2007	118.8	7.0

There has been some controlled mangrove removal within Ōhiwa Harbour, resulting in an area of 3.9 ha being cleared of mangroves in 2012 and a further 7.8 ha in 2013. This has been carried out as a result of a resource consent lead by Upokorehe for a period of ten years allowing for the removal of seedling and outlying plants (Tim Senior *pers. comm.*).

Discussion

The area covered by mangroves has increased almost 6 times the area over 62 years. The growth/spread has not been even over this time ranging from an average of -0.03 to 7 ha increases per year.

In some areas of the Harbour mangrove spread has markedly reduced open water areas. Although this can have both ecological advantages and disadvantages, many people view it as detrimental. Bay of Plenty Regional Council has sought to address the sedimentation issues that are the major cause of mangrove spread. There are a wide range of policy and associated works around the Harbour aimed at reducing sediment inputs. Many of the Harbour's natural mechanisms preventing sediment inputs have been lost. One example is the freshwater wetlands that used to exist in most of the valleys leading to the Harbour have been drained and lost. It is estimated that in 1840 that there were 557 ha compared to only 36 ha in 2012.

5.4 Sea grass

Sea grass (*Zostera muelleri*) beds are a common sight in New Zealand harbours and estuaries and form an important ecological component of Ōhiwa Harbour. Sea grass beds provide habitat complexity and stability which in turn increases productivity and species diversity. They have been shown to support distinct benthic assemblages of animals compared to the surrounding sandflats. Studies of subtidal seagrass beds elsewhere in New Zealand have shown that they also provide a nursery habitat for commercially important juvenile species such as snapper.

They are however, sensitive to impacts from land run-off and nationally there has been a marked long-term decline in the extent of seagrass beds. Many studies have documented the impact of sedimentation as a major factor responsible for at least part of that decline. Overall, the extent of seagrass beds provides an ideal indicator of environmental health.

Results

The area of seagrass beds in Ōhiwa Harbour has been mapped using Harbour-wide aerial photography from 1945 through to 2007. There are differences in detail and clarity of the 1945, 1992 and 1996 aerial photography compared to 2007, which has a higher resolution and lower mapping scale. This increase in quality and detail allows more accurate recording of distribution and abundance. However, it may also mean areas previously missed in the older photography were accurately mapped and confirmed by ground truth survey.

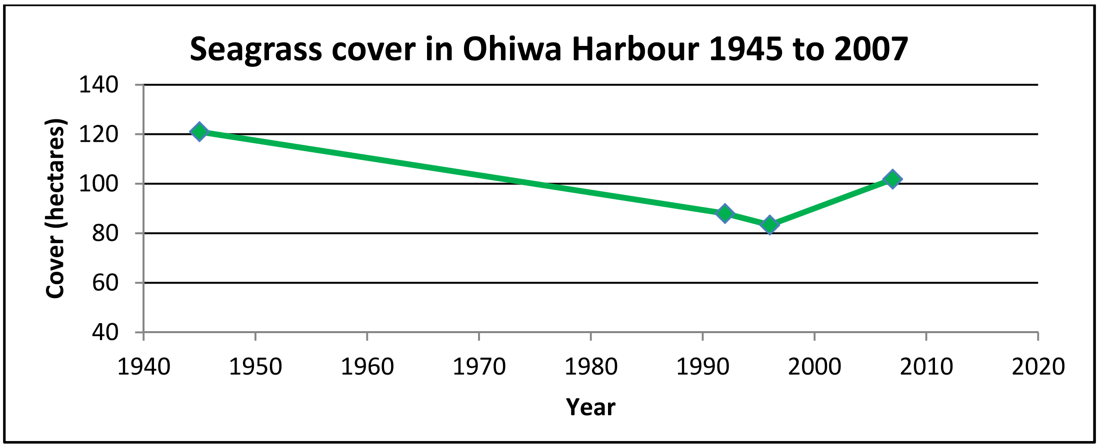

Figure 5.8 Seagrass cover (hectares) in Ōhiwa Harbour from 1945 to 2007.

As shown in Figure 5.8, the amount of seagrass recorded in 1945, 1992, 1996 and 2007 was 121, 88, 83.3 and 101.8 hectares respectively. This shows a marked decline for the period 1945 – 1996. The 2007 extents of seagrass are higher than 1992 and 1996, most likely due to the improved quality of aerial photography and not signalling an improvement in the Harbour environment. It does appear that there has not been any further reduction in sea grass extent since 1996. By comparing the area covered by seagrass beds in the upper reaches of the Harbour where greatest historic loss has occurred, indications are that they have maintained the same spatial coverage over that 11 year period. Visual field inspection has shown some areas are affected and potentially stressed by sedimentation, but this has not caused a reduction in extent.

Discussion

Differences in detail of aerial photography show changes in seagrass cover. However, comparison of seagrass beds in the upper reaches of the harbour where greatest historic loss has occurred indicates they have maintained the same spatial coverage. Some areas are affected and potentially stressed by sedimentation, but this has not caused a reduction in extent. There is a need for more accurate future mapping to better track the subtle changes in the marginal areas of the Harbour and hence provide even better data on the health of the seagrass beds.

A flock of at least twenty black swan (*Cygnus atratus*) has been noted as being present in Ōhiwa Harbour for approximately a year (Stephen Park, *pers. ob.*). In a PhD thesis by Virginie Dos Santos in 2011 research in Tauranga and Aotea harbours was carried out to quantify black swan grazing pressure on meadows. Results showed that patches of simulated high grazing had seagrass cover return after nine months, however, biomass recovery was limited with only 30% of the original biomass return after one year. This research suggests that black swan grazing at high intensity can cause long-lasting damage to seagrass meadows (Dos Santos, 2011). Therefore the establishment of a permanent black swan population within Ōhiwa Harbour may cause increased pressure on seagrass meadows. Black swan populations monitoring within the Harbour could be carried out to identify the drivers for any changes in seagrass bed extents in the future.

5.5 Coastal

5.5.1 Coastal Profiles

The coastal monitoring site at the eastern end of Ōhope Spit (CCS9) has shown a trend of retreat of several hundred metres (although this has stabilised during the last decade) which is directly opposite to the trend at CCS8 (Figure 5.5) on the opposite side of the Ōhiwa Harbour Entrance. Results suggest a complex link between the two spits which is controlled by climatic factors, sediment exchange between the ebb tidal delta and beach, and the location and orientation of the main and lateral channels of the tidal inlet.

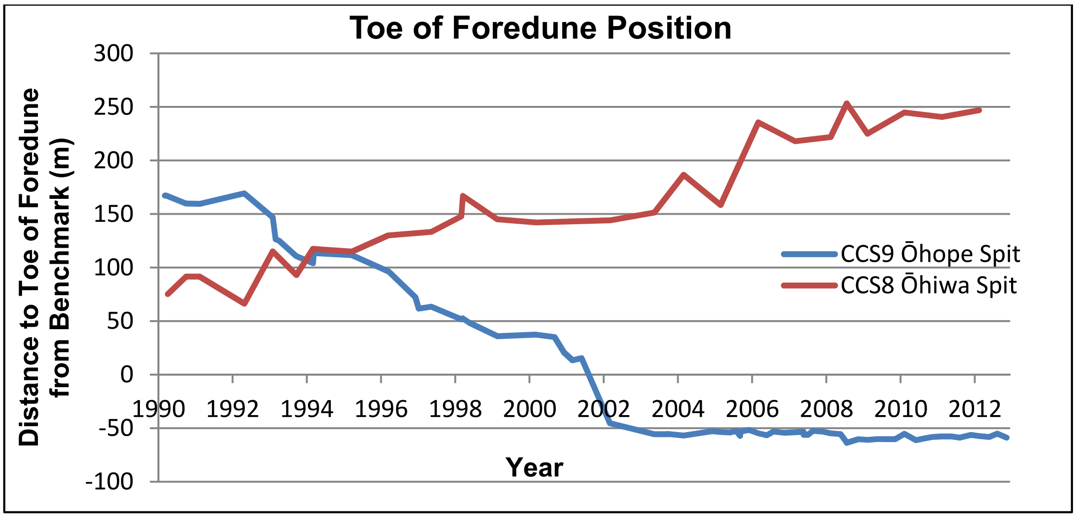

Figure 5.9 Graph showing change in position of the toe of foredune for coastal profiles CCS8 and CCS9.

Part 6: Summary

6.1 Land

Only small changes occurred in land cover, with the loss of 590 ha of indigenous vegetation. Indigenous vegetation cover within the Catchment is 35.7%. The area of formally protected land within the Catchment totals 1,625 ha with 82% being indigenous vegetation, however, only 22% of indigenous vegetation within the Catchment is protected.

By 2012 the margin of the Harbour was completely fenced from stock and the amount of riparian fencing of major streams and rivers within the Catchment is high with only 20% of major stream and river margins presently unfenced. This provides protection from erosion from stock trampling and removes direct effluent input from the Harbour and waterways.

Forestry harvesting occurred in 11.5% of the Catchment since 2008.

6.2 Terrestrial Biodiversity

6.2.1 Flora

Threatened species within the Harbour totalled 25 populations of 10 significant species. Some of these were not previously known to occur within the Catchment.

The condition of indigenous vegetation is not discussed in this report due to the need to establish condition monitoring rather than only extent monitoring. Pohutukawa monitoring in areas around the Harbour showed overall a small improvement in canopy condition.

Some pest plant populations (those covered by the RPMP) are being progressively reduced in density and distribution. The Catchment has no more pest plants than in similar environments and considerably less than in more densely populated areas. There are no agency pest or eradication/exclusion pest plants present in the Catchment.

6.2.2 Fauna

The 2010 marshbird survey showed the Harbour is of national significance for Australasian bittern and banded rail, and regional significance for North Island fern bird. These three species increase in abundance and distribution. The work of care groups within the Harbour in recent years has greatly increased the value of many habitat areas for marshbird species. Maintaining habitat diversity, and addressing the threats and impacts are essential for ensuring the long-term viability of marshbird populations at the Harbour.

New Zealand dotterel distribution has remained relatively constant since 2005 with breeding above the 'productive' level of 0.5 fledged chicks per pair per season. Wading birds have shown declines in numbers of bar-tailed godwit, eastern curlew, reef heron and turnstone. There were record increases in variable oyster catchers and an increase in black-backed gulls.

The presence of native bats has been confirmed within the Catchment.

Weka distribution is increasing around the Harbour.

Kiwi numbers are increasing in Ōhope Scenic Reserve and therefore more are frequenting the Catchment.

There are 66 identified biodiversity sites within the Catchment, of which 10 are High Value Ecological Sites. Management occurs over one HVES site and two non-HVES sites.

The general suit of introduced mammals are present within the Catchment, control of these is occurring over 876 ha.

6.3 Water

6.3.1 Harbour Water Quality

Water quality is good compared to other eastern bay estuaries. However suspended solids show increasing trends at both sites, and Ruatuna Road shows increasing trend for ammonium and faecal indicator bacteria.

Ōhiwa Harbour rates as one of the best in the Bay of Plenty for bathing water quality. After large storm events bacterial levels can be pushed into the orange alert mode.

Metal concentration results meet the guidelines for consumption of shellfish. However, by world standards arsenic and chromium are elevated in most shellfish in the Bay of Plenty due to natural background levels of these metals. Overall shellfish quality can be marginal at some sites around the Harbour after periods of strong wind or heavy rain. It is advised that anyone wanting to collect shellfish should do so at least five days or more after these events.

6.3.2 Nukuhou River

Water quality results show improvements with suspended solid levels showing a trend of 2.5% decrease per annum and nitrogen also showing a decreased trend. SS levels however remain high in comparison to other Bay of Plenty Rivers this may partly be due to its unique geology. Temperature shows an increasing trend and therefore there is a trend for decreased dissolved oxygen.

It would be expected that with continuation of improved management practices the trends of decreasing suspended solid and nitrogen should continue.

6.3.3 Freshwater Fish

Streams feeding into the Harbour contain relatively diverse native freshwater fish populations. However, around 40% of streams had barriers to fish migration, this figure needs to be reduced to improve the potential habitat for native fish species.

6.3.4 Macroinvertebrate Monitoring

Results suggest that overall macro invertebrate stream health has not changed in the Catchment since monitoring started, except in Ōhiwa tributary which showed improvement. The Nukuhou River in particular has a long monitoring record (18 years), yet no trends were apparent at this site over time. Comparison of the Kutarere, and Wainui and Nukuhou sites to others in the region showed that they had similar stream health as other pasture streams, all of which had a greatly reduced level of Macroinvertebrate stream health when compared to non-pasture streams.

6.4 Marine and Estuary

6.4.1 Sediment Contaminants

The PAHs and metals are all well below low guideline values, and there is no indication of zinc or copper increasing. This indicates that there is very little impact from the Catchment on sediment contaminants.

6.4.2 Macrofauna

Overall the results are reasonably encouraging as the benthic communities have maintained their species richness and diversity over the period of monitoring. There is minor degradation of habitat quality at Site 1 (slight mud increase). Cockle numbers have varied over time but show no significant long-term changes.

Mussel beds sizes were greatly reduced in 2009 compared with 2007, simultaneously starfish populations in the area increased. There is need for more work to develop a better understanding of what is occurring within the Harbour, the mussel and starfish populations and the relationship between the two before embarking on efforts/work to alter this cycle.

6.4.3 Mangroves

Mangrove extents continue to increase overtime with a 6 fold increase since 1945. The growth/spread of mangroves has not been even over this time period ranging from an average of -0.3 to 7 ha per year. A total of 11.7 ha of area has been cleared of mangroves between 2011-2013 under a resource consent.

6.4.4 Sea grass

Comparisons of areas covered by seagrass beds with the greatest historic loss, indicates they have maintained the same spatial coverage over the 11 year monitoring period. Visual field inspections have shown that some areas are affected and potentially stressed by sedimentation, however this has not caused a reduction in extent.

6.5 Coastal

Coastal profiles located at the Ōhiwa Harbour entrance show a trend of retreat of the Ōhope Spit (which has now stabilised) side of the Harbour and growth on the Ōhiwa Spit side of the Harbour.

Part 7: Recommendations

There are existing schedules for the majority of the monitoring carried out within the Ōhiwa Harbour Catchment thus limited recommendations are made within this report. The timeline schedule for monitoring within the Catchment can be viewed in Appendix 9. It is assumed that strategy partners and organisations will continue the current schedules detailed in this timeline.

7.1 Land

- Continue fencing, retiring and establishing vegetation on riparian margins of water courses within the Catchment. More consideration to be given to the width and re-vegetation of retirement areas to ensure more measurable improvement in water quality and macro invertebrate results in the future.

- Increase soil erosion prevention measures on steep/hill country with the highest erosion potential.

- Focus on reducing impacts of erosion due to forestry activities through networks, education and consenting processes.

- Carry out re-measurement and reporting with analysis of results for sediment cross sections within the Harbour.

- Carry out land use and cover change assessment upon release of LCDB4 in July 2014.

7.2 Terrestrial Biodiversity

- Establish monitoring programme for indigenous vegetation around the Harbour; further investigation into methods and costs involved in this monitoring is required.

- Cary out partial re-measures of marshbird sites in 2015. Halt further habitat loss and reduce predation to ensure survival of these populations long term.

- Encourage further benefits from more habitat being protected or managed by Care Groups.

7.3 Water

- Carry out the tidal intrusion model, followed by assessing the identified areas for potential whitebait spawning habitat.

- Look into the feasibility of further fish surveys on areas identified in Bloxham (2007) and not surveyed as first priority.

- Addressed issues of fish passage barriers identified and prioritised in Bloxham (2007) to meet Action 12.3.4 of the Ōhiwa Harbour Strategy, and to also increase the habitat available for native fish species.

7.4 Marine and Estuary

7.4.1 Macrofauna

Green Lipped Mussels and Starfish

More work is required to better understand the ecological cycle between mussels and starfish within the Harbour, along with the potential results of human interference before undertaking work to alter this cycle (Paul-Burke *pers. comm.*).

Recommendations for future work include:

1. Identify, measure, and map the distribution, size classes and population density of all mussel beds in the Harbour.
2. Investigate starfish impacts on mussel and mussel beds.
3. Carry out literature review on starfish and green lipped mussel management, methods and results nationally and internationally including information on the natural cycles of mussel and starfish populations.

7.4.2 Mangroves

Complete mapping of mangrove density over 2011 aerial photography and look at trends in growth/retreat rates of mangroves.

7.4.3 Sea grass

Establish monitoring of black swan populations within the Harbour to identify the potential as an influence on future changes in seagrass bed extents.

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Appendices

Appendix 1 – Land cover classes used in this report and relating ones used Land Cover Database3 (LCDB3)

Land Cover Name as used in this report	LCDB3 Name
Exotic plantation	Exotic Forest
Exotic plantation	Forest - Harvested
Exotic plantation	Deciduous Hardwoods
Exotic Scrub/Shrubland	Gorse and/or Broom
Exotic Scrub/Shrubland	Mixed Exotic Shrubland
Horticulture	Orchard Vineyard and Other Perennial Crops
Horticulture	Short-rotation Cropland
Indigenous forest	Indigenous Forest
Indigenous Scrub/Shrubland	Broadleaved Indigenous Hardwoods
Indigenous Scrub/Shrubland	Fernland
Indigenous Scrub/Shrubland	Manuka and/or Kanuka
Pasture	High Producing Exotic Grassland
Pasture	Low Producing Grassland
Salt Marsh, wetlands, dunes and mangroves	Coastal Sand and Gravel
Salt Marsh, wetlands, dunes and mangroves	Herbaceous Freshwater Vegetation
Salt Marsh, wetlands, dunes and mangroves	Herbaceous Saline Vegetation
Salt Marsh, wetlands, dunes and mangroves	Mangrove
Urban	Built-up Area (settlement)
Urban	Transport Infrastructure
Urban	Urban Parkland/Open Space
Water	Lake and Pond

Appendix 2 – Protection Status of Major Rivers and Streams in Ōhiwa Harbour Catchment 2009 and 2012

Secondary Catchment	Waterway Name	Total stream length (km)	Stock excluded 2009 (km)	Stock excluded 2012 (km)	Percent protected 2009	Percent protected 2012
Nukuhou	Arawhatawhata Stream	6.1	1.7	1.7	28	28
Wainui Area	Awaraputuna Stream	2.4	1.4	1.4	58	58
Nukuhou	Horowera Stream	6.9	1.8	1.8	26	26
Nukuhou	Kotare Stream	4.7	0.8	3.5	17	74
Kutarere Area	Kutarere Str	4.8	2.5	3.1	52	65
Nukuhou	Matahaka River	7.6	3.6	3.6	47	47
Nukuhou	Nukuhou River	25.3	23.2	25.2	92	99
Wainui Area	Ouaki Creek	1	1	1	100	100
Nukuhou	Taramaiere Stream	6	2.3	2.3	38	38
Wainui	Te Awawairoa Stream	1.8	0	1	0	55
Kutarere Area	Te Kakaha Stream	2.6	1.5	1.5	58	58
Nukuhou	Te Rereoterangi Stream	5.8	1.3	1.3	27	27
Nukuhou	Waingarara Stream	16.4	16.4	16.4	100	100
Wainui Area	Wainui Stream	10	9.8	10	98	98
Nukuhou	Waionepu Stream	5.4	4	4	74	74
Wainui Area	Waiotane Stream	5.1	5.1	5.1	100	100
Nukuhou	Werakihi Stream	5.8	4.3	5.6	74	97
Mixed	Unnamed Tributaries	53.7	45.5	50	85	93
	Total	**171.4**	**126.2**	**138.5**	**74 %**	**81 %**

Secondary Catchment	Total stream length (km)	Stock excluded 2009 (km)	Stock excluded 2012 (km)	Percentage protected 2009	Percentage protected 2012
Nukuhou	117	83.4	90	71%	77%
Wainui Area	41	34	37.7	83%	92%
Kutarere Area	13	8.7	10.7	67%	82%

Appendix 3 – Protection Status of Land in Ōhiwa Harbour Catchment

Protection Type	Area (ha)
Environmental Programme	1.0
Esplanade Reserve	1.0
Government Purpose Reserve	40.8
Historic Reserve	25.0
Land Improvement Agreement	165.1
Marginal Strip	23.3
Memorandum of Encumbrance	100.1
Nature Reserve	70.2
QEII Covenant	40.8
Quarry Reserve	2.0
Recreation Reserve	54.7
Scenic Reserve	371.8
Scientific Reserve	22.3
Stewardship Area	658.5
Unidentified	49.4
TOTAL	**1626.0**

Appendix 4 – Legal Protection

What does legal protection mean? (Willems, 2010)

The most important thing to note about legal protection is that it does not equal either physical protection for a site, or management to maintain a site. It is simply a designation over a parcel of land.

The type of reserve, and therefore degree of protection varies widely. Different reserve designations under the Reserves Act 1977 and the Conservation Act 1987 mean different things in terms of what activities can be undertaken on those reserves, and therefore whether or not infrastructure or other developments and activities that remove or potentially damage dune vegetation can occur.

Under the Reserves Act 1977, where values such as flora and fauna, historic, archaeological or biological features exist, the Act states that “those features shall be managed and protected to the extent compatible with the principal or primary purpose of the reserve”. Local purpose reserves are specifically for the designated purpose at gazettal, and many reserves under administration by the territorial authorities are designated for specific activities such as landing reserves, sporting grounds, and playgrounds, amongst other things.

The Conservation Act is a little more specific under some designations, but not others. A Stewardship Area “shall so be managed that its natural and historic resources are protected”. However a Government Purpose Reserve is designated or purposes “as specified in the designation of the reserve”. Often these are Wildlife Management Reserves, but even this can cause some conflicts where wildlife management involves promotion of game birds over ecological values. Scenic Reserves look to protect indigenous flora and fauna, while promoting removal of exotic species. Marginal strips promote protection of adjacent water courses and bodies of water, as well as public access to those. Recreation Reserves are for open access, and primarily for “recreation and sporting activities and the physical welfare and enjoyment of the public, and for the protection of the natural environment and beauty of the countryside”. All things being relative, neatly mown picnic areas might be preferred by some over native pohuehue vineland. In addition, access, recreation and sporting activities can be extremely damaging to native vegetation and wildlife values.

District Councils are required to develop District Reserves Plans under Section 41 of the Reserves Act 1977, and these plans also determine to what degree ecological values are given regard to when they maintain reserve areas. Some districts place more emphasis on maintaining ecological values, while others acknowledge them but primarily focus on other aspects, meeting only the minimum requirement of the Reserves Act. A small Landing Reserve, for example, is unlikely to retain a lot of ecological character as its primary purpose is to provide a landing area. Facilities for this will be developed at the expense of ecological values on the site where that specific area is required. Recreation and open space can also override ecological values where facilities are desired to provide for those things.

A Biodiversity Management Plan is set up to provide long term protection for the site, and constitutes an agreement between the partners to undertake various actions over time to protect the site’s biodiversity. This is a contract that states: “We, the undersigned signatories to this Biodiversity Management Plan acknowledge a commitment to the concept of partnering and agree to work in a cooperative and constructive manner to achieve the objectives, actions and responsibilities outlined in this Biodiversity Management Plan.”

Appendix 5 – Threatened Plants of Ōhiwa Harbour Catchment

Species	Threat Ranking	Number of Sites	New Record
Adelopetalum tuberculatum	At Risk-Naturally Uncommon	4	Y (3)
Astelia grandis	Regionally Uncommon. Not known from elsewhere in Tāneatua ED	1	N
Austroderia toetoe	Local. Uncommon in Tāneatua ED	1	Y
Austrostipa stipoides	Southern limit on eastern side of North Island	3	Y (1)
Bolboschoenus caldwellii	Regionally Uncommon	1	Y
Dianella sp.	Possible new record	1	Y
Drosera binata	Not known from elsewhere in Tāneatua ED	1	N
Epilobium pallidiflorum	Local. Not known from elsewhere in Tāneatua ED	1	Y
Ficinia spiralis	At Risk-Relict	1	Y
Hydrocotyle pterocarpa	Local. Not known from elsewhere in Tāneatua ED	1	Y
Kunzea 'Thornton'	Threatened Nationally Vulnerable	1	N
Lophomyrtus bullata	Local. Only known from two sites in Tāneatua ED	1	N
Nertera scapanioides	Local. Not known from elsewhere in Tāneatua ED	1	Y
Peperomia tetraphylla	At Risk-Naturally Uncommon	3	Y (1)
Pimelea tomentosa	Threatened Nationally Vulnerable	1	N
Poa billardierei	At Risk-Declining	1	Y
Ptisana salicina	At Risk-Declining	1	N
Tetraria capillaris	Regionally Uncommon. Not known from elsewhere in Tāneatua ED	1	N

Appendix 6 – Dotterel Breeding Success Table

Table A6.1 Dotterel breeding success and fledging rates from breeding season 2009/10 to 2012/13.

Site	*2009/10*			2010/11			2011/12			2012/13		
	No. Pairs	No. Chicks	Fledging rate (%)	No. Pairs	No. Chicks	Fledging rate (%)	No. Pairs	No. Chicks	Fledging rate (%)	No. Pairs	No. Chicks	Fledging rate (%)
Ōhope Spit	2	0	0	2	0	0	2	0	0	3	0	0
Whangakopikopiko Island	4	1	33	3	2	100	4	8	75	4	4	100
Ōhiwa Spit	1	2	66	2	4	25	0	2	0	3	1	100
Ruatuna Shellbank	0	0	0	2	4	0	2	5	0	2	1	50
Totals	7	3	50%	9	10	33%	8	15	40%	12	6	86%

Appendix 7 – Water Quality Results (Tables and Graphs)

Table A7.1 Water quality statistics and trends for Ruatuna Road.

	n	Mean	Median	Minimum	Maximum	SD	Data period
DO%	121	84.3	83.6	66.3	117.7	7.6	1990 - 2011
Temperature (ºC)	127	17.1	16.2	10.9	25.8	3.6	1990 – 2011
Conductivity (mS/m)	124	5031	5190	2950	5480	475	1990 – 2011
Suspended solids (g/m^3)	127	19.2	14.6	1.1	98.0	15.2	1990 – 2011
Turbidity (NTU)	91	6.3	4.7	1.1	33.0	5.5	1996 – 2011
pH	122	8.0	8.0	7.7	8.3	0.1	1990 – 2011
DRP (g/m^3)	124	0.009	0.008	0.001	0.025	0.0051	1990 – 2011
Ammonium-N (g/m^3)	125	0.021	0.017	0.001	0.095	0.0178	1990 – 2011
TOx-N (g/m^3)	108	0.028	0.008	0.001	0.293	0.0434	1993 – 2011
Total Nitrogen (g/m^3)	52	0.180	0.168	0.067	0.389	0.0763	1995 – 2011
Total Phosphorus (g/m^3)	120	0.025	0.022	0.006	0.071	0.0119	1990 – 2011
Escherichia coli (cfu/100mL)	121	20	1	1	380	56	1990 – 2011
Enterococci (cfu/100mL)	125	18	2	1	360	46	1990 – 2011
Faecal coliforms (cfu/100mL)	124	37	4	1	970	121	1990 – 2011
Chl-a (mg/m^3)	107	0.81	0.62	0.05	3.86	0.57	1992 - 2011

Site		DO %	SS (g/m^3)	Turbidity (NTU)	pH	E.coli (cfu/100mL)	Ent (cfu/100mL)	FC (cfu/100mL)	DRP (g/m^3)	NH_4-N (g/m^3)	TOx-N (g/m^3)	TN (g/m^3)	TP (g/m^3)	Chl-a (mg/m^3)
Ruatuna	***Trend***	□	➚	□	□	➚	➚	➚	□	➚	□	□	□	□
	%/yr (RSEN)	0.12	**2.93**	-1.12	0.004	6.5	16.6	8.27	1.3	**1.89**	13.3	0.35	-0.48	1.41

Trend: ⬀⬂ significant increasing or decreasing trend of parameter over time (p<0.05); ➚➘significant and meaningful trend (p<0.05, %/yr >1%); □ not significant. (Analysis period given in table above).

Table A7.2 Water quality statistics and trends for Port Ohope.

	n	Mean	Median	Minimum	Maximum	SD	Data period
DO%	123	82.9	83.1	64.3	103.1	6.0	1990 – 2011
Temperature (ºC)	127	17.0	16.3	11.5	24.7	3.3	1990 – 2011
Conductivity (mS/m)	122	5076	5230	3060	5510	438	1990 – 2011
Suspended solids (g/m^3)	126	19.5	15.5	4.0	75.0	13.1	1990 – 2011
Turbidity (NTU)	89	7.3	5.0	1.2	62.2	8.0	1996 – 2011
pH	122	8.0	8.0	7.7	8.3	0.1	1990 – 2011
DRP (g/m^3)	124	0.009	0.008	0.001	0.032	0.0054	1990 – 2011
Ammonium-N (g/m^3)	124	0.016	0.010	0.001	0.158	0.0208	1990 – 2011
TOx-N (g/m^3)	108	0.026	0.008	0.001	0.393	0.0481	1993 – 2011
Total Nitrogen (g/m^3)	53	0.204	0.185	0.022	1.010	0.1533	1995 – 2011
Total Phosphorus (g/m^3)	120	0.026	0.023	0.006	0.148	0.0161	1990 – 2011
Escherichia coli (cfu/100mL)	122	12	1	1	600	58	1990 – 2011
Enterococci (cfu/100mL)	126	11	1	1	410	46	1990 – 2011
Faecal coliforms (cfu/100mL)	125	17	2	1	600	64	1990 – 2011
Chl-a (mg/m^3)	109	1.23	1.00	0.05	6.52	0.93	1992 - 2011

Site		DO %	SS (g/m^3)	Turbidity (NTU)	pH	E.coli (cfu/100mL)	Ent (cfu/100mL)	FC (cfu/100mL)	DRP (g/m^3)	NH_4-N (g/m^3)	TOx-N (g/m^3)	TN (g/m^3)	TP (g/m^3)	Chl-a (mg/m^3)
Port Ohope	***Trend***	▫	➚	▫	▫	▫	▫	▫	▫	▫	▫	▫	▫	▫
	%/yr (RSEN)	0.07	**4.4**	1.32	-0.005	10.3	12.6	3.1	<0.01	<0.01	<0.01	3.45	-0.44	1.38

Trend: ⬀⬂ significant increasing or decreasing trend of parameter over time ($p<0.05$); ➚➘significant and meaningful trend ($p<0.05$, %/yr >1%); ▫ not significant. (Analysis period given in table above).

Table A7.3 Water quality statistics and trends for Nukuhou River, 1990-2012.

	n	Mean	Median	Minimum	Maximum	SD	Data period
DO%	207	92.9	92.5	64.1	116.8	8.3	1990 – 2012
Temperature (ºC)	211	14.7	14.9	5.3	24.5	4.2	1990 – 2012
Conductivity (mS/m)	207	10.2	10.1	5.2	18.9	1.3	1990 – 2012
Suspended solids (g/m^3)	209	21.5	11.0	0.2	335.0	33.4	1990 – 2012
Turbidity (NTU)	206	10.9	6.9	0.8	140.0	13.8	1990 – 2012
pH	208	7.1	7.1	6.0	7.8	0.2	1990 – 2012
DRP (g/m^3)	206	0.037	0.032	0.006	0.23	0.023	1990 – 2012
Ammonium-N (g/m^3)	207	0.060	0.044	0.002	0.73	0.067	1990 – 2012
TOx-N (g/m^3)	202	0.528	0.504	0.029	1.42	0.242	1990 – 2012
Total Nitrogen (g/m^3)	198	0.961	0.937	0.325	5.13	0.430	1990 – 2012
Total Phosphorus (g/m^3)	207	0.081	0.070	0.01500	0.43	0.051	1990 – 2012
Escherichia coli (cfu/100mL)	197	2038	570	3	99000	8258	1990 – 2012
Enterococci (cfu/100mL)	209	596	170	7	50000	3485	1990 – 2012
Faecal coliforms (cfu/100mL)	210	2305	715	19	94000	8018	1990 – 2012
Flow (m^3/s)	202	1.67	1.14	0.10	25.21	2.28	1990 – 2012

Site		DO %	SS (g/m^3)	Turbidity (NTU)	pH	E.coli (cfu/100mL)	Ent (cfu/100mL)	FC (cfu/100mL)	NH_4-N (g/m^3)	TOx-N (g/m^3)	TN (g/m^3)	TP (g/m^3)	Temp (deg C)
Nukuhou @ Quarry	***Trend***	⬀	➘	□	□	⬂	□	⬂	➘	➘	➘	⬀	⬀
	%/yr (RSEN)	0.2	**-2.9**	-0.2	-0.04	-0.4	-0.3	-0.7	**-5.0**	**-1.3**	**-2.3**	<0.01	0.91

Trend: ⬀⬂ significant increasing or decreasing trend of parameter over time ($p<0.05$); ➚➘significant and meaningful trend ($p<0.05$, %/yr >1%); □ not significant. (Analysis period given in table above).

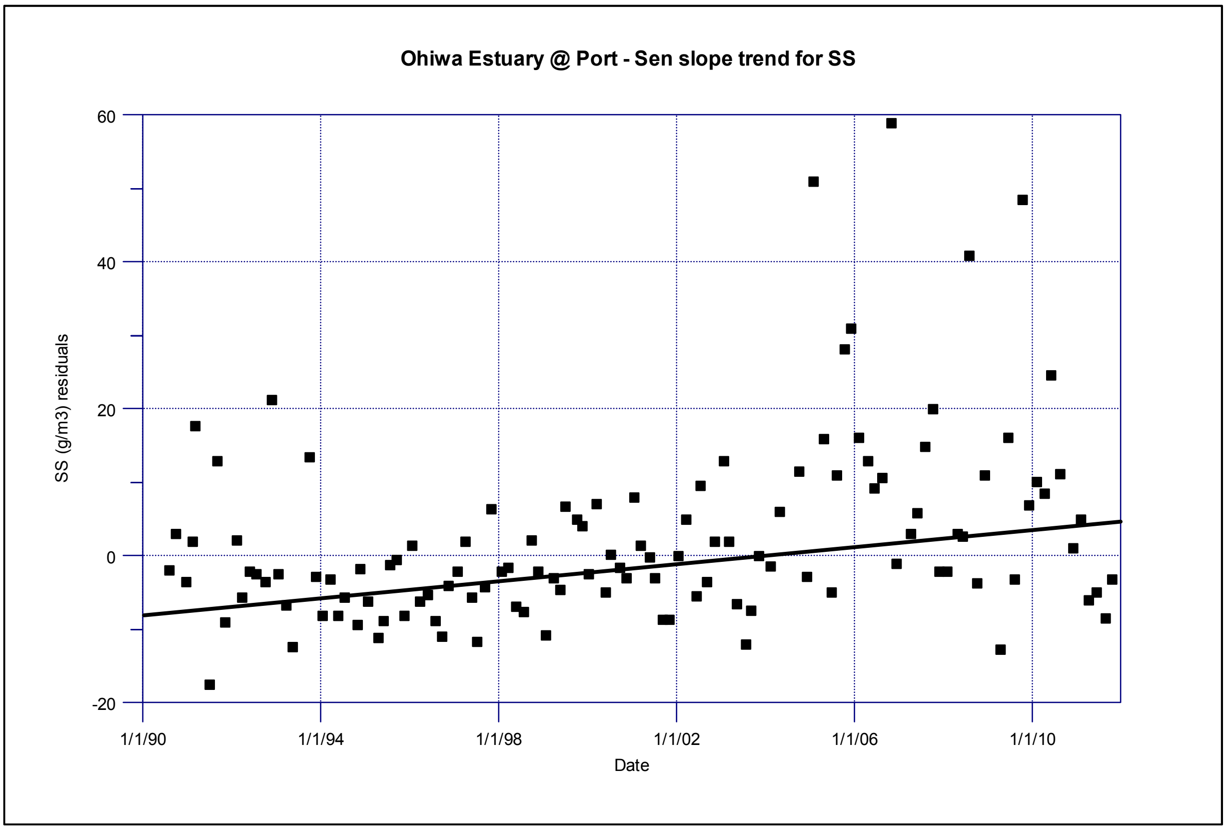

Figure A7.1 Ōhiwa Estuary adjusted suspended solids concentrations and trend slope.

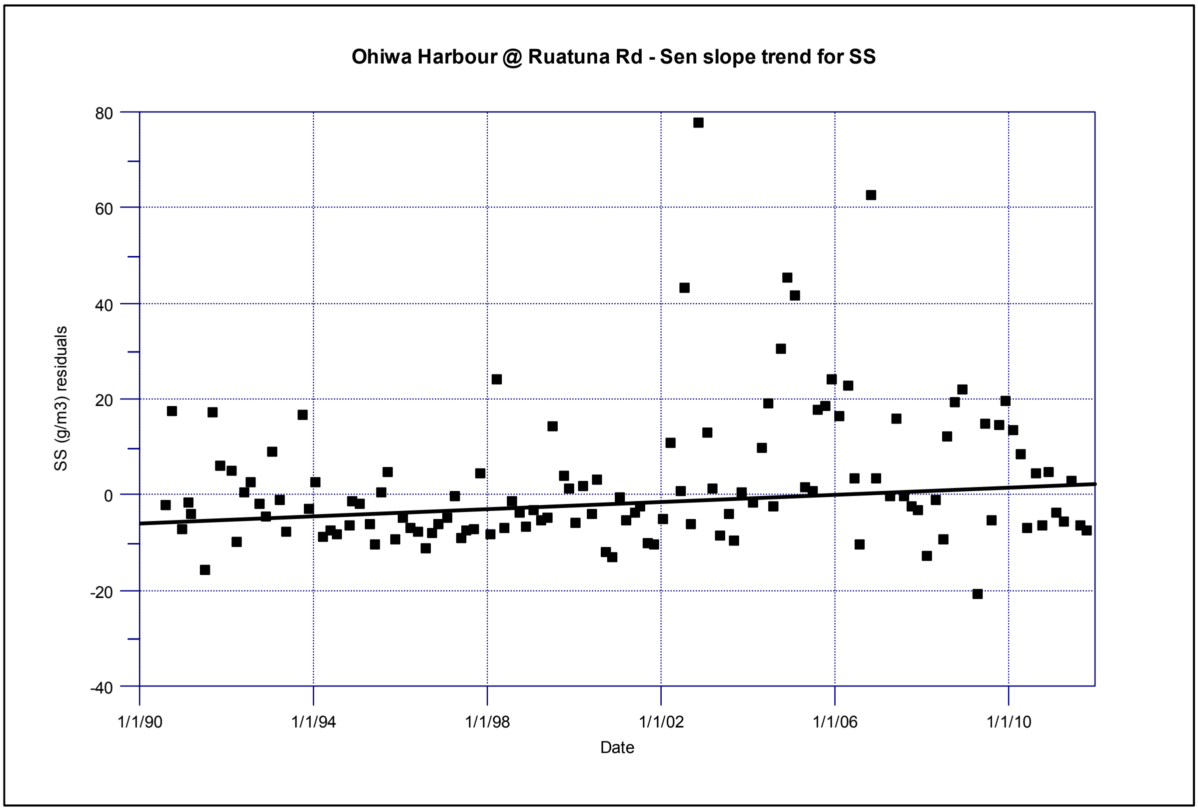

Figure A7.2 Ruatuna Road Adjusted suspended solids concentrations and trend slope.

Appendix 8 – Sediment Contaminants

Table 1 Mean concentration of total polyaromatic hydrocarbons (PAH's) and metals (mg/kg dry weight) collected for Ōhiwa Harbour sediment monitoring sites, based on whole sediment samples collected in 2006, 2009, 2012.

Site		Mud %	Total Organic Carbon (TOC) g/100g	PAH	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	(Lead) Pb	Mercury (Hg)	Nickle (Ni)	Zinc (Zn)
Tauranga Harbour												
	min	11.2	0.31	0.000	1.4	0.03	1.5	0.8	1.6	0.01	0.6	9.5
	max	71.4	1.57	0.315	8.1	0.16	14.0	6.0	10.3	0.14	5.2	61.3
Ōhiwa Harbour												
Kuterere	14	54.1	0.67	0.030	6.0	0.03	7.7	6.5	6.6	0.07	5.6	36.8
Ōhiwa camp	23	65.7	0.55	0.011	5.6	0.04	7.3	6.3	5.9	0.06	5.2	31.9
Water ways	1002	28.7	0.34	0.03	4.3	0.01	4.4	3.6	3.7	0.03	3.3	20.6
North	1007	36.8	0.51	0.037	5.6	0.02	7.8	5.9	6.0	0.05	5.8	34.6
Oyster farm	1009	42.8	0.62	0.006	4.6	0.02	5.9	5.0	5.3	0.04	4.1	29.3
West	1019	32.6	0.44	0.002	3.2	0.02	4.8	4.5	4.4	0.04	3.7	24.0
East	1054	37.1	0.31	0.003	5.3	0.02	6.6	4.5	5.1	0.03	4.6	28.5
ISQG Low				**4**	**20**	**1.5**	**80**	**65**	**50**	**0.15**	**21**	**200**
ISQG high				45	70	10	370	270	220	1	52	410

ISQG Low – Interim Sediment Quality Guidelines Low

ISQG high – Interim Sediment Quality Guidelines High

Appendix 9 – Monitoring Timeline for Ōhiwa Harbour Catchment

Monitoring Type / Year	Monitoring frequency	Reported on	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Ōhiwa Harbour Strategy			O					PR									
Dotterel Nesting results	Annually	Annually					B	PB	PB	PB	PB	PB	PB	PB	PB	PB	PB
Kiwi Within Catchment	Annually	Annually	B	B	B	B	B	PB	PB	PB	PB	PB	PB	PB	PB	PB	PB
Marshbird Survey - Partial Monitor	5 yearly	5 yearly			E and R					PB					PB		
Marshbird Survey - Full Monitor	10 yearly	10 yearly			E and R										PB		
National Wader Count	Annually	Annually	B	B	B	B	B	PB	PB	PB	PB	PB	PB	PB	PB	PB	PB
Pest Animals	?	?															
Weka Distribution	?	?				B											
Fish passage	Not Defined	Not Defined															
Freshwater fish monitoring	Not Defined	Not Defined				M											
Marine Fish	?	?															
Shellfish	?	?			M												
Whitebait/Inanga Habitat Monitoring (being established)	Not Defined	Not Defined					B										PB
Coastal and Estuarine Benthic Macroinvertebrate monitoring	Annually	3-4 yearly	M	M	B	M	M	PB	PM	PM	PB	PM	PM	PB	PM	PM	PB
Macroinvertebrate monitoring	Annually	Undefined					M	PB	PM	PM	PM	PM	PM	PM	PM	PM	PM
20m x 20m Vegetation plots Ōhiwa Scenic Reserve	5 yearly	5 yearly					B				PB					PB	
20m x 20m Vegetation plots Oscar Reeve Scenic Reserve	5 yearly	5 yearly					B				PB					PB	
20m x 20m Vegetation plots Pataua Island	5 yearly	5 yearly					B				PB					PB	
Coastal pohutukawa monitoring	5 yearly	5 yearly					B					PB					PB
Dune land mapping Full monitor	10 yearly	10 yearly		E	R									PB			
Dune land mapping Transects only	5 yearly	5 yearly		E and R					PB								
Mangrove extent mapping	5 yearly	As required			R?		PM										
Maritime wetland extents	10-15yrly	10-15yrly						PM							PM		
Regional Forest Monitoring	5-10 yearly	5-10 yearly															
Regional Wetland Monitoring	5 yearly	5 yearly						PE									
Sea grass extent mapping	5 yearly	As required			R?		PM										
Threatened plants Survey	5 yearly	5 yearly				E and R					PB					PB	

Monitoring Type / Year	Monitoring frequency	Reported on	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Weeds (RPMP ones)	Annually	As required					PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
Area of identified Significant Sites (SNA/PNA mapping)	Various	Various															
Area of Protected Land (Covenants etc.)	On-going	As required				B											
Areas of forestry harvesting in catchment	N/A	N/A															
Care groups - Area Covered	N/A	As required															
Harbour margin retirement	Annually	Annually		R	B	B	B	PB	PB	PB	PB	PB	PB	PB	PB	PB	PB
Land cover and land use	5 yearly	5 yearly					B					PB					PB
Land Cover Changes - based on LCDB	Developing	Developing															
LCDB 4 and 5 (Landcare setting up these new levels)	Developing	Developing															
Riparian Fencing	Annually	Annually		R	B	B	B	PB	PB	PB	PB	PB	PB	PB	PB	PB	PB
Riparian margin retirement	Annually	Annually		R	B	B	B	PB	PB	PB	PB	PB	PB	PB	PB	PB	PB
Coastal Profiles	1/4, Annually	5 yearly	M	M	M	B	M	PM	PM	PM	PB	PM	PM	PM	PM	PB	PM
Marine Sediment and Contaminants Survey Coastal and Estuarine Ecology Survey	Annually	3-4 yearly	B	M	M	M	M	PM	PM	PB	PM	PM	PB	PM	PM	PB	PM
Marine Sediment and Contaminants Sediment Survey	3 yearly	3-4 yearly	R	M?			PM			PB			PB			PB	
Sediment cross sections	3-5 Yearly	N/A						PM									
Bathing Beaches	Annually	Annually	M	M	B	B	M	PB	PB	PB	PB	PB	PB	PB	PB	PB	PB
Estuarine Water Quality	2 monthly	5 yearly	M	M	M	M	B	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
River Water Quality	Monthly	3-5 yearly	M	B	M	M	M	PM	PB	PM	PM	PM	PM	PB	PM	PM	PM

KEY	
Operational	**O**
Both Monitor and Report	**B**
Report	**R**
Established	**E**
Measure/Monitor/Map	**M**
Planned Establishment	**PE**
Planned Measure/Monitor/Map	**PM**
Planned Report	**PR**
Both Planned Monitor and Planned Report	**PB**