Annual coastal monitoring report for the Wellington region, 2010/11

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Cover photo: Waikanae Estuary (Leigh Stevens, Wriggle Coastal Management)

Contents

1. Introduction

Greater Wellington Regional Council (Greater Wellington) has a responsibility to manage and monitor the Wellington region's near-shore coastal environment; the area extending from mean high water springs to 12 nautical miles offshore. The coastline of the region is almost 500 km long and stretches from Otaki on the west coast, south through Cook Strait and north along the east coast to Mataikona. It is characterised by long stretches of wide sandy beaches, rugged rocky shores and some of the strongest tidal currents in the world. The near-shore environment contains significant habitats for a wide variety of plants and animals, and also provides for a diverse range of human activities and values.

This report summarises the results of water quality, sediment quality and ecological health monitoring undertaken in the Wellington region's near-shore coastal environment for the period 1 July 2010 to 30 June 2011. Note that the suitability of coastal waters for contact recreation purposes is assessed separately under Greater Wellington's recreational water quality monitoring programme (see Morar & Warr 2011).

2. Overview of coastal monitoring programme

2.1 Background

Coastal monitoring in the Wellington region began over 20 years ago, with a focus on microbiological water quality – a reflection of the high usage of much of the region's coastline for contact recreation such as swimming and surfing. Periodic assessments of contaminants in shellfish flesh commenced around 1997, with the most recent assessment undertaken at 20 sites in 2006 (see Milne 2006). In 2004 monitoring expanded into coastal ecology and sediment quality, with a key focus being the effects of urban stormwater on our coastal harbour environments. In addition, between 2004 and 2008 broad scale surveys of the region's coastal habitats were carried out, with fine scale sediment and ecological assessments undertaken at representative intertidal locations of selected estuaries and sandy beaches. The information gained from these surveys was combined with ecological vulnerability assessments to identify priorities for a long-term monitoring programme that would enable Greater Wellington to fulfil state of the environment monitoring obligations with respect to coastal ecosystems.

2.2 Monitoring objectives

The aims of Greater Wellington's coastal monitoring programme are to:

1. Assist in the detection of spatial and temporal changes in near-shore coastal waters;

2. Contribute to our understanding of coastal biodiversity in the region;

3. Determine the suitability of coastal waters for designated uses;

4. Provide information to assist in targeted investigations where remediation or mitigation of poor water quality is desired; and

5. Provide information required to determine the effectiveness of regional policies and plans.

2.3 Monitoring and investigations during 2010/11

Coastal monitoring and investigations undertaken over the period 1 July 2010 to 30 June 2011 included:

- Microbiological water quality monitoring at 74 sites across the region (Section 3);

- Monthly water quality monitoring at six sites in Porirua Harbour (Section 4);

- Fine-scale ecological monitoring in Waikanae Estuary (Section 5), Hutt Estuary (Section 6), Whareama Estuary (Section 7) and Porirua Harbour (Section 8); and

- A survey of subtidal sediment quality at five sites in Porirua Harbour (Section 9).

3. Microbiological water quality monitoring

3.1 Introduction

Microbiological water quality was monitored at 74 coastal sites across the Wellington region over 2010/11 (Figure 3.1, Appendix 1), as follows:

- Kapiti Coast District – 20 sites
- Porirua City – 13 sites
- Hutt City – 15 sites
- Wellington City – 21 sites
- Wairarapa – 5 sites

One site in Porirua City – the Pauatahanui Inlet at Browns Bay – remained in the monitoring programme but was sampled less frequently; this site is not recommended for contact recreation but water quality in Browns Bay is of community interest.

Monitoring was a joint effort involving Greater Wellington, Kapiti Coast District Council, Porirua City Council, Hutt City Council, and Wellington City Council. The sites monitored reflect their use by the public for contact recreation; in particular, swimming, surfing, and boating.

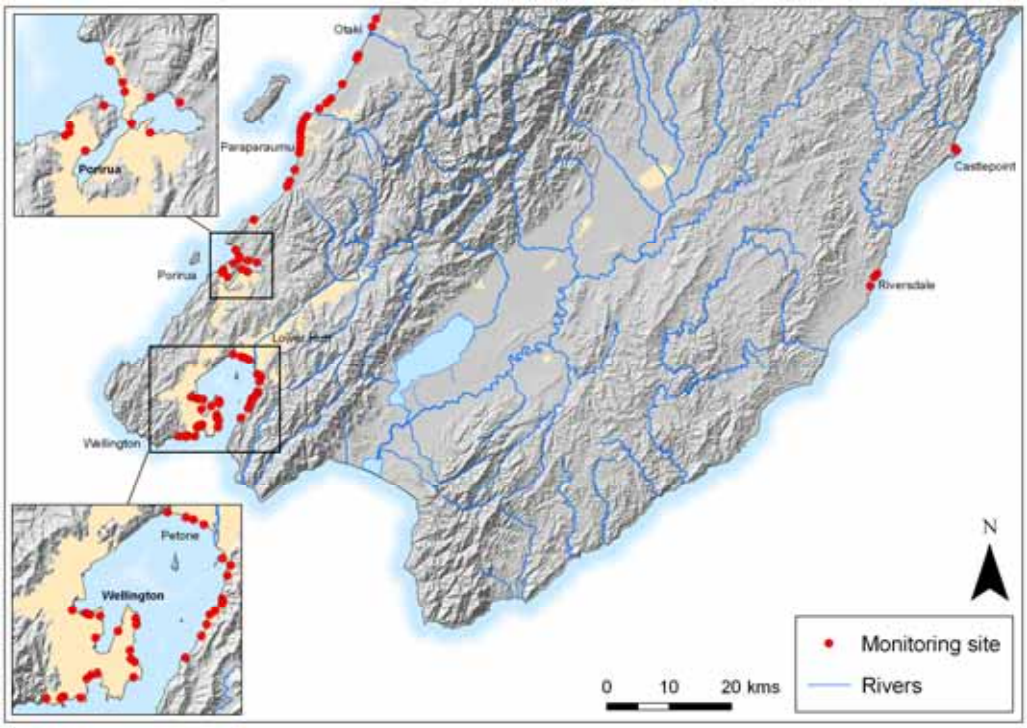


Figure 3.1: Coastal water quality sites monitored between July 2010 and June 2011

3.2 Monitoring protocol

Sites were sampled weekly – for 20 weeks – during the summer bathing season (November to March inclusive) as part of Greater Wellington's recreational water quality monitoring programme (see Morar & Warr 2011)[1], and at least

[1] Pauatahanui Inlet at Browns Bay (Porirua), Breaker Bay (Wellington City), Princess Bay (Wellington City) and Riversdale Beach South (Wairarapa) were sampled fortnightly during the summer months while Camp Bay (Hutt City) was sampled monthly.

monthly during the remainder of the year. On each sampling occasion a single water sample was collected 0.2 m below the surface in 0.5 m water depth and tested for enterococci indicator bacteria using a membrane filtration method. In addition, water samples from six sites popular for recreational shellfish gathering, and three sites in Porirua Harbour[2], were tested for faecal coliform indicator bacteria (Appendix 1).

Observations of weather and the state of the tide, and visual estimates of seaweed cover, were also made at each site to assist with the interpretation of the monitoring results. For example:

- Rainfall may increase enterococci counts by flushing accumulated debris from urban and agricultural areas into coastal waters.
- Wind direction can influence the movement of currents along the coastline and can therefore affect water quality at a particular site.
- In some cases, an increase in enterococci counts may be due to the presence of decaying seaweed. There is evidence that some strains of enterococci are able to replicate or persist in decaying seaweed (Anderson 2000).

An estimate of the daily rainfall in the catchment adjoining each site over the bathing season was made by obtaining records from the nearest rain gauge.

A list of field and laboratory methods can be found in Morar and Warr (2011).

3.3 Results

The results of microbiological water quality testing undertaken during the official summer bathing season are discussed in detail in *On the Beaches 2010/11: Annual recreational water quality monitoring report for the Wellington region* (Morar & Warr 2011). Tables 3.1 and 3.2 summarise the median, 95th percentile and maximum enterococci and faecal bacteria counts recorded from all sampling conducted during the period 1 July 2010 to 30 June 2011 for each of the 74 marine sites (ie, these statistics include the results of additional follow-up sampling conducted in response to an exceedance of the Ministry for the Environment/Ministry of Health (2003) microbiological water quality guidelines).

A total of 14 sites recorded a maximum enterococci sample result of more than 1,000 cfu/100mL. The highest maximum counts were recorded in samples taken at Owhiro Bay (9,000 cfu/100mL on 8 June 2011), Raumati Beach at Hydes Road (8,900 cfu/100mL on 22 November 2010), Lyall Bay at Tirangi Road (4,800 cfu/100mL on 7 February 2011) and Robinson Bay at HW Shortt Recreation Ground (3,800 cfu/100mL on 15 June 2011). The elevated results at most of these sites coincided with at least 8 mm of rainfall either on the day or in the 72 hours prior to sampling. However, the Robinson Bay at HW Shortt Recreation Ground enterococci result coincided with only a minimal amount of rainfall; the cause of this high result is unknown.

[2] These sites, introduced in July 2007, are not recommended shellfish gathering sites but are monitored in response to community interest.

Table 3.1: Summary of enterococci counts recorded at 74 coastal sites monitored between 1 July 2010 and 30 June 2011 inclusive

Bathing site	Total no. of samples	Enterococci (cfu/100 mL)		
		Median	95th percentile	Max
Kapiti Coast				
Otaki Beach @ Surf Club	28	3	125	735
Otaki Beach @ Rangiuru Rd	28	5	128	790
Te Horo Beach S of Mangaone Stream	34	40	686	1,090
Te Horo Beach @ Kitchener St	30	5	333	450
Peka Peka Beach @ Rd End	28	5	83	615
Waikanae Beach @ William St	29	5	159	340
Waikanae Beach @ Tutere St T.C.	28	5	86	330
Waikanae Beach @ Ara Kuaka C.P.	27	6	69	125
Paraparaumu Beach @ Ngapotiki St	29	20	154	745
Paraparaumu Beach @ Nathan Ave	28	15	73	249
Paraparaumu Beach @ Maclean Pk	29	15	157	455
Paraparaumu Beach @ Toru Rd	30	23	437	825
Paraparaumu Beach @ Wharemauku Rd	29	15	286	905
Raumati Beach @ Tainui St	29	10	279	955
Raumati Beach @ Marine Gardens	30	23	954	1,950
Raumati Beach @ Aotea Rd	30	10	235	330
Raumati Beach @ Hydes Rd	30	10	366	8,900
Paekakariki Beach @ Whareroa Rd	27	10	61	65
Paekakariki Beach @ Surf Club	28	7	67	600
Paekakariki Beach @ Memorial Hall	28	5	35	162
Porirua				
Pukerua Bay	28	4	176	450
Karehana Bay @ Cluny Rd	27	12	79	96
Plimmerton Beach @ Bath St	29	16	262	330
South Beach @ Plimmerton	31	52	810	1,200
Pauatahanui Inlet @ Water Ski Club	33	20	556	1,500
Pauatahanui Inlet @ Motukaraka Pt	29	12	164	390
Pauatahanui Inlet @ Browns Bay	18	16	196	570
Pauatahanui Inlet @ Paremata Bridge	28	12	201	380
Porirua Harbour @ Rowing Club	42	98	733	1,100
Titahi Bay @ Bay Drive	30	28	342	840
Titahi Bay at Toms Rd	27	16	101	610
Titahi Bay @ South Beach Access Rd	38	82	458	670
Onehunga Bay	27	8	70	130
Hutt				
Petone Beach @ Water Ski Club	29	4	224	360
Petone Beach @ Sydney St	30	12	397	720
Petone Beach @ Settlers Museum	29	8	400	640
Petone Beach @ Kiosk	28	6	90	220
Sorrento Bay	31	4	250	560
Lowry Bay @ Cheviot Rd	28	6	73	1,000

Table 3.1 *cont*.: Summary of enterococci counts recorded at 74 coastal sites monitored between 1 July 2010 and 30 June 2011 inclusive

Bathing site	Total no. of samples	Enterococci (cfu/100 mL)		
		Median	95th percentile	Max
Hutt				
York Bay	28	4	114	340
Days Bay @ Wellesley College	30	22	244	740
Days Bay @ Wharf	29	16	149	770
Days Bay @ Moana Rd	29	4	134	180
Rona Bay @ N end of Cliff Bishop Pk	28	12	81	560
Rona Bay @ Wharf	31	20	780	1,300
Robinson Bay @ HW Shortt Rec Grd	30	10	443	3,800
Robinson Bay @ Nikau St	28	12	110	160
Camp Bay	12	4	37	52
Wellington City				
Aotea Lagoon	30	4	581	1,600
Oriental Bay at Freyberg Beach	27	4	35	120
Oriental Bay at Wishing Well	30	4	202	380
Oriental Bay at Band Rotunda	31	4	180	530
Balaena Bay	28	2	50	190
Hataitai Beach	28	2	32	1,200
Shark Bay	30	2	465	840
Mahanga Bay	27	4	87	120
Scorching Bay	28	2	32	1,000
Worser Bay	29	4	220	450
Seatoun Beach at Wharf	27	4	104	120
Seatoun Beach at Inglis Street	28	3	82	660
Breaker Bay	17	2	9	12
Lyall Bay at Tirangi Road	29	4	133	4,800
Lyall Bay at Onepu Road	28	2	80	150
Lyall Bay at Queens Drive	29	4	200	460
Princess Bay	17	2	78	88
Island Bay at Surf Club	29	4	1,159	3,200
Island Bay at Reef St Rec Ground	30	8	503	2,900
Island Bay at Derwent Street	28	2	37	390
Owhiro Bay	36	30	1,148	9,000
Wairarapa				
Castlepoint Beach @ Castlepoint Stream	26	2	47	60
Castlepoint Beach @ Smelly Creek	26	2	29	36
Riversdale Beach @ Lagoon Mouth	26	2	25	180
Riversdale Beach Between the Flags	26	2	36	64
Riversdale Beach South	16	2	2	2

Table 3.2: Summary of faecal coliform counts recorded at nine coastal sites monitored between 1 July 2010 and 30 June 2011 inclusive

Site	Total no. of samples	Faecal coliforms (cfu/100 mL)		
		Median	95th percentile	Max
Kapiti Coast				
Otaki Beach @ Surf Club	28	13	445	460
Peka Peka Beach @ Rd End	28	14	286	1,135
Raumati Beach @ Hydes Rd	30	25	329	685
Porirua				
Pauatahanui Inlet @ Motukaraka Point	29	4	276	390
Pauatahanui Inlet @ Browns Bay	18	30	280	390
Porirua Harbour @ Rowing Club	42	80	458	800
Hutt				
Sorrento Bay	31	4	200	1,050
Wellington City				
Shark Bay	30	2	106	280
Mahanga Bay	27	4	28	52

Three sites recorded particularly high 95th percentile enterococci counts, indicating that significantly elevated bacteria levels were recorded on multiple occasions at these sites. These sites were Island Bay at Surf Club (1,159 cfu/100mL), Owhiro Bay (1,148 cfu/100mL), and Raumati Beach at Marine Gardens (954 cfu/100mL).

Two of the nine sites monitored for faecal coliform bacteria recorded maximum counts above 1,000 cfu/100mL: Peka Peka Beach at Road End (1,135 cfu/100mL on 19 January 2011) and Sorrento Bay (1,050 cfu/100mL on 23 February 2011). Both maximum counts coincided with more than 20 mm of rainfall in the 24 hours prior to sampling.

4. Porirua Harbour water quality monitoring

4.1 Introduction and background

Broad scale habitat mapping and fine scale intertidal monitoring undertaken between 2008 and early 2011 consistently rated Porirua Harbour as a moderately eutrophic estuary (Robertson & Stevens 2008a; Stevens & Robertson 2008; 2009a; 2010a). The estuary sediments have low to moderate stores of nitrogen and phosphorus and localised nuisance conditions related to excessive macroalgae growth. In 2010 Robertson and Stevens (2010a) recommended monitoring of nutrient and chlorophyll *a* concentrations in the water column of Porirua Harbour to assess the potential for ongoing nuisance conditions. In January 2011, Greater Wellington commenced monthly water sampling at six sites to establish a baseline for these variables in the harbour waters. This section briefly summarises the results of the first six months of water quality monitoring.

4.2 Monitoring sites, variables and methods

Harbour water samples were collected monthly on a mid-ebb tide from six sites in Porirua Harbour (Figure 4.1, Appendix 1). On each sampling occasion field measurements of water temperature, conductivity and dissolved oxygen were taken and the weather conditions recorded. Samples were collected 0.25 m below the surface in approximately 0.75 m water depth and analysed for pH, salinity, conductivity, turbidity, total suspended solids (TSS), soluble and total nitrogen and phosphorus, and chlorophyll *a*.

Figure 4.1: Location of Porirua Harbour water quality sampling sites

4.3 Key findings

Overall, based on the first six months of monitoring, results indicate that water quality was more variable at the inner estuary monitoring sites of both arms (sites P2 and O2); median concentrations of nutrients, suspended sediments and chlorophyll *a* were all higher at these sites (Table 4.1). This reflects the proximity of sites P2 and O2 to stream and stormwater inputs.

Table 4.1: Median (and range) of values for selected variables measured during monthly water sampling in Porirua Harbour between January and June 2011

	Porirua Harbour – Entrance E1	Pauatahanui Arm – North P1	Pauatahanui Arm – East P2	Pauatahanui Arm – South P3	Onepoto Arm – West O1	Onepoto Arm – South O2
TSS (mg/L)	6 (3–51)	11 (5–83)	6.5 (4–210)	11 (4–23)	8.5 (7–36)	35 (14–230)
Turbidity (NTU)	2.9 (2.0–19.5)	6.7 (3.0–54)	3.2 (2.1–169)	6.9 (2.7–15.6)	5.9 (4.7–25)	16.9 (6.4–126)
Salinity (ppt)	35 (32–35)	33 (29–35)	33 (11–35)	34 (22–35)	33 (29–35)	32 (23–34)
Chlorophyll *a* (mg/L)	0.0015 (0.0015–0.0015)	0.0015 (0.0015–0.003)	0.0015 (0.0015–0.016)	0.0015 (0.0015–0.0015)	0.0015 (0.0015–0.005)	0.0015 (0.0015–0.019)
Ammoniacal N (mg/L)	0.005 (0.005–0.026)	0.02 (0.005–0.041)	0.005 (0.005–0.074)	0.005 (0.005–0.038)	0.009 (0.005–0.051)	0.03 (0.005–0.110)
Nitrate-Nitrite N (mg/L)	0.002 (0.001–0.138)	0.003 (0.001–0.660)	0.004 (0.001–0.660)	0.001 (0.001–0.230)	0.002 (0.001–0.149)	0.005 (0.001–0.370)
Dissolved reactive phosphorus (mg/L)	0.006 (0.002–0.007)	0.007 (0.002–0.015)	0.01 (0.002–0.017)	0.006 (0.002–0.012)	0.008 (0.002–0.012)	0.009 (0.002–0.019)
Total phosphorus (mg/L)	0.02 (0.012–0.038)	0.03 (0.017–0.090)	0.03 (0.002–0.012)	0.03 (0.018–0.036)	0.03 (0.024–0.053)	0.06 (0.036–0.250)

4.4 Future monitoring

The existing water quality monitoring is to continue for the next 18 months, at which point the results will be reviewed and the need for further monitoring assessed.

5. Waikanae Estuary intertidal ecological monitoring

5.1 Introduction and background

In January of 2011, a second round of fine scale ecological monitoring was undertaken in Waikanae Estuary, a 2 km long, 'tidal river mouth' type estuary located on the Kapiti Coast. This monitoring, summarised here from reports by Robertson and Stevens (2011b) and Stevens and Robertson (2011d), follows an identical survey carried out one year earlier. The surveys were undertaken in response to a 2007 assessment of coastal habitats in the western Wellington region (Robertson & Stevens 2007) which recommended monitoring the long-term condition of the Waikanae Estuary, focusing on core indicators of sedimentation, eutrophication and, to a lesser extent, contamination.

5.2 Monitoring sites, variables and methods

Monitoring included a broad scale assessment of macroalgal cover over the estuary's intertidal habitat and a fine scale assessment of ecological health at one 60 m by 15 m site located on unvegetated intertidal mudflats in the upper estuary (Figure 5.1 & Appendix 1). Within this site 10 plots were assessed for selected fine scale sediment condition indicators – including grain size (texture), the degree of oxygenation, nutrient and organic content, and heavy metal concentrations – as well as benthic (sediment-dwelling) fauna abundance and diversity. In addition, four sedimentation monitoring plates buried in 2010 adjacent to the fine scale monitoring site, were measured one year after deployment to assess sedimentation rates in the upper estuary reaches.

(Source: Robertson & Stevens 2011b)

Figure 5.1: Location of the fine scale monitoring site and sedimentation monitoring plates within the Waikanae Estuary

5.3 Key findings

The second year of baseline monitoring showed that the dominant intertidal habitat in the Waikanae Estuary is generally in a 'good' condition. The presence of elevated mud contents, moderately oxygenated sediments (Figure 5.2), low to moderate nutrients, and a typical upper estuary benthic invertebrate community (high numbers of mud and low salinity tolerant species) suggests that the estuary is moderately enriched, and has excessive fine sediment inputs.

(Source: Wriggle Coastal Management)

Figure 5.2: A sediment core from the Waikanae Estuary, illustrating that the sediments at the sampling site are reasonably well oxygenated

Measurements made of the sedimentation plates indicated a mean sedimentation rate over the preceding year of 45 mm/yr (range 35–58 mm/yr). This is a very high sedimentation rate. However, there were two major flood events in the catchment in September 2010, and these flood events were likely responsible for the short term deposition of coarse grain sediments such as those found at the monitoring site.

Concentrations of potential toxicants, such as the heavy metals copper, lead and zinc, were at low to very low concentrations and all below ANZECC (2000) Interim Sediment Quality Guidelines (ISQG)-Low trigger criteria. Concentrations of the pesticide DDT were not reassessed in 2010/11 because concentrations in 2009/10 were all below analytical detection limits.

Mapping of intertidal macroalgae noted a slight increase in the cover of *Ulva intestinalis* and associated nuisance conditions in the embayment near the floodgate (Figure 5.3). The macroalgae coefficient, a measure of condition based on percentage cover, increased from 0.05 in 2010 to 0.2 in 2011. The overall condition rating of 'very good' remains but rotting macroalgae and poorly oxygenated and sulphide-rich sediments exist near the floodgate.

(Source: Wriggle Coastal Management)

Figure 5.3: Macroalgae (*Ulva intestinalis*) cover and associated nuisance conditions near the floodgate (centre of picture) of the Waikanae Estuary

5.4 Future monitoring

The 2011 fine scale ecological assessment and macroalgal mapping constitute the second in a proposed series of three annual assessments to establish a baseline of existing conditions in the Waikanae Estuary. Fine scale monitoring is due to be carried out again in early 2012, after which the frequency of monitoring will probably be reduced to five-yearly intervals.

6. Hutt River Estuary ecological monitoring

6.1 Introduction and background

Following the first fine scale assessment of the Hutt Estuary in January 2010, a second assessment was undertaken in January 2011. This monitoring, summarised here from reports by Robertson and Stevens (2011a) and Stevens and Robertson (2011a), follows a preliminary assessment of coastal habitats in the western Wellington region (Robertson & Stevens 2007) which recommended monitoring the long-term condition of the Hutt Estuary, with a focus on core indicators of sedimentation, eutrophication and contamination.

6.2 Monitoring sites, variables and methods

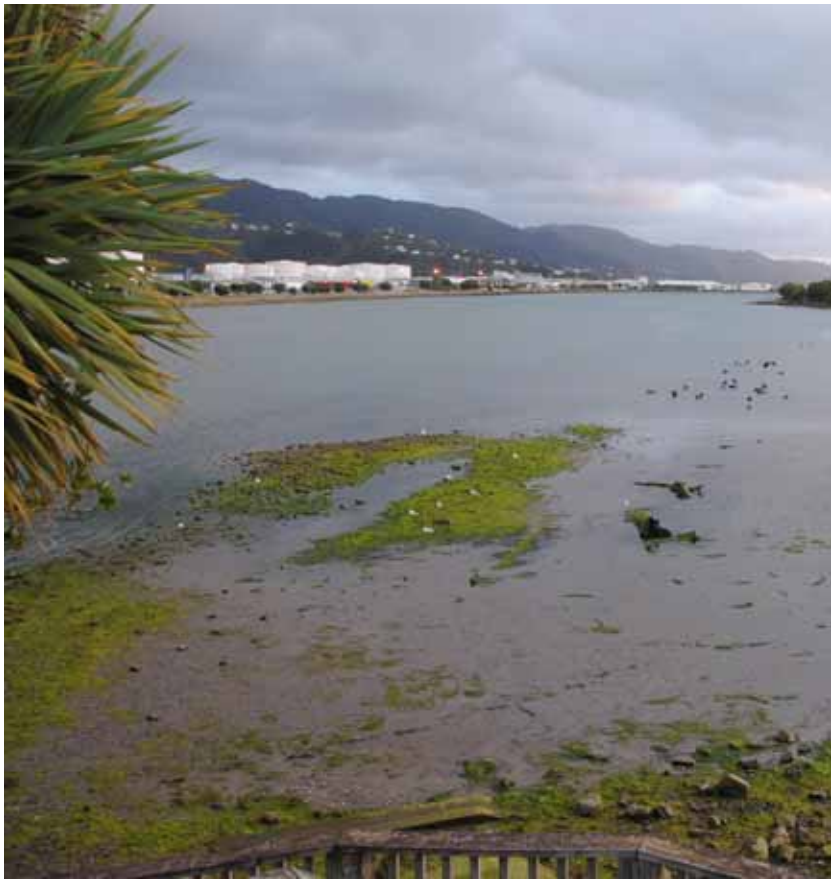
Monitoring included a broad scale assessment of macroalgal cover over the estuary's intertidal habitat and a fine scale assessment of ecological health at two shallow subtidal margin locations which represented the dominant estuarine habitat (Figure 6.1 & Appendix 1). At each of these two sites a 20 m long transect, aligned parallel to the edge of the channel, was marked out. At 2 m intervals along each transect, 10 sampling points were assessed for selected fine scale sediment condition indicators – including grain size (texture), the degree of oxygenation, nutrient and organic content, and heavy metal and polycyclic aromatic hydrocarbon (PAH) concentrations – as well as benthic (sediment-dwelling) fauna abundance and diversity. In addition, four sedimentation monitoring plates buried on a small intertidal flat near the mouth of the estuary in 2010 were measured one year after deployment to assess sedimentation rates in this area of the estuary.

(Source: Robertson & Stevens 2011a)

Figure 6.1: Location of the fine scale monitoring sites and sedimentation monitoring plates within the Hutt Estuary

6.3 Key findings

The results for the selected physical, chemical and biological indicators of estuary condition found that the dominant habitat of unvegetated subtidal mud and sand was in a 'fair' condition. More than 40% (4 ha) of the intertidal area had greater than 50% macroalgal cover (Figure 6.2), although nuisance conditions such as rotting macroalgae and sulphide rich sediments were only present in the subtidal areas near the mouth.



(Source: Wriggle Coastal Management)

Figure 6.2: Dense macroalgal cover on the intertidal flats of the Hutt River Estuary

The sediments were moderately oxygenated with low to moderate concentrations of total organic carbon, total nitrogen and total phosphorus. The sedimentation rate was reported as very low to low (mean rate -0.75 mm/yr) though the sediment had high concentrations of mud (35–43%) and a benthic community dominated by species tolerant of moderate organic enrichment and mud. The most abundant species was the tube-dwelling amphipod *Paracorophium excavatum* which has a strong mud preference. There were also moderate numbers of cockles (*Austrovenus stutchburyi)* and juvenile pipis (*Paphies australis*) which typically have a preference for sand and are deemed to be growing in sub-optimal conditions.

Despite exposure to urban run-off, heavy metal concentrations were all well below ANZECC (2000) ISQG Low-trigger values, and concentrations of PAHs were all below detection limits. These results indicate that there is no widespread toxicity in the mud/sand habitat of the estuary.

Overall, it is recognised that the Hutt Estuary has been highly modified with extensive areas of reclamation and channelisation for urban development and flood protection. Consequently the estuary lacks significant areas of high value habitats, such as saltmarsh, seagrass, intertidal flats, and naturally vegetated margins, which reduces the healthy functioning of the estuary.

6.4 Future monitoring

The 2011 fine scale ecological assessment constitutes the second in a proposed series of three or four annual assessments to establish a baseline of existing conditions in the Hutt Estuary. After the baseline has been established, the frequency of monitoring will probably be reduced to five-yearly intervals.

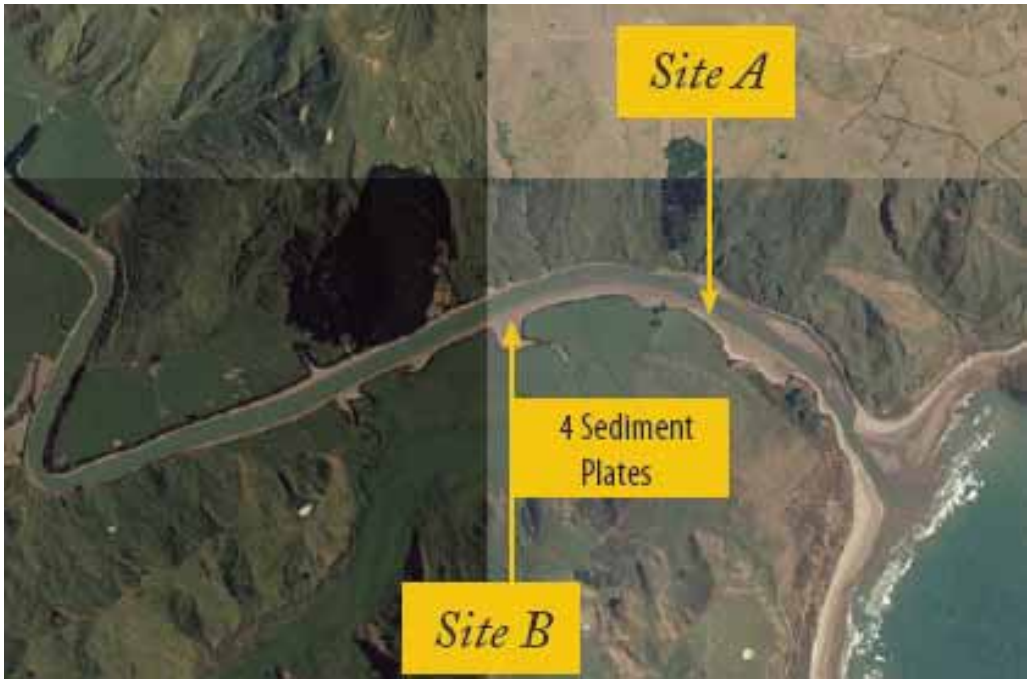
7. Whareama Estuary intertidal ecological monitoring

7.1 Introduction and background

The Whareama Estuary is a 12 km long, tidal river lagoon estuary located on Wairarapa's eastern coast. Three years of detailed fine scale monitoring (Robertson & Stevens 2008b; 2009b; 2010b) found the estuary to have high rates of sedimentation from the naturally erosion-prone catchment, poorly oxygenated sediments with a high mud content and a benthic invertebrate community increasingly dominated by mud-tolerant species. These findings triggered further annual monitoring of sedimentation rates, grain size and sediment oxygenation. This section briefly summarises the latest monitoring results; full details of the monitoring are reported in Stevens and Robertson (2011e).

7.2 Monitoring sites, variables and methods

Monitoring was undertaken at two sites located on the unvegetated intertidal mudflats during January 2011 (Figure 7.1 & Appendix 1). This monitoring included grain size analyses to monitor changes in mud content, redox potential discontinuity (RPD) depth as a proxy for sediment oxygenation, and the depths to four sedimentation monitoring plates deployed at right angles to the Whareama River channel in January 2008.



(Source: Robertson & Stevens (2011e)

Figure 7.1: Location of the fine scale monitoring sites and sedimentation monitoring plates within the Whareama Estuary

7.3 Key findings

Grain size monitoring results found that the mud content of the sediments has increased at both sites since 2010, from 23% to 40% at site A, and from 65% to 80% at site B (Figure 7.2). Overall, both sites are dominated by fine muds, almost certainly sourced from the surrounding soft-rock catchment.

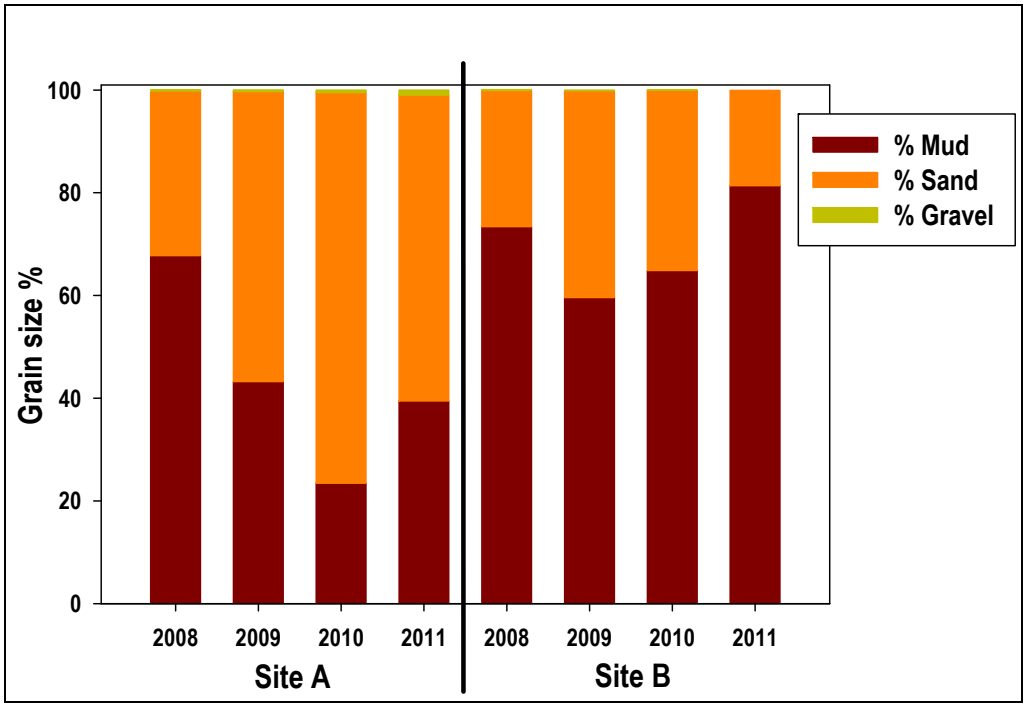


Figure 7.2: Sediment grain size analyses from Whareama Estuary, 2009–2011 (reproduced from Stevens and Robertson 2011e)

In addition, the sedimentation rate, as measured by the depths to four buried plates at site B, was the highest since measurements began, ranging from 15 to 31 mm/yr with a mean of 21.8 mm/yr (Table 7.1). Such a level of sedimentation indicates that the intertidal flats of the Whareama Estuary are infilling at a variable but high rate (11.4 mm/yr based in monitoring over the period 2008–2011).

Table 7.1: Sediment plate data from Site B, Whareama Estuary 2008–2011 (after Stevens and Robertson 2011e)

Plate no.	Change (mm)			Site mean (mm/yr)			Overall rate (mm/yr)
	2008–09	2009–10	2010–11	2008–09	2009–10	2010–11	2008–11
1	6	-3	17	+14.5	-2.0	+21.8	+11.4
2	14	0	31				
3	19	-2	24				
4	19	-3	15				

Finally, the redox potential discontinuity (RPD) depth, a direct measure of sediment oxygenation, remains shallow (1 cm) as in previous years, indicating that the sediments are poorly oxygenated and anoxic. Such sediments are rich in sulphides and can be toxic to some aquatic life (Figure 7.3).

(Source: Wriggle Coastal Management)

Figure 7.3: A sediment core from site A in the Whareama Estuary shows that the sediments are black and anoxic at relatively shallow depths

7.4 Future monitoring

Annual monitoring of sediment indicators will be carried out again in early 2012. A detailed fine scale assessment is due to be repeated in early 2015.

8. Porirua Harbour intertidal ecological monitoring

8.1 Introduction and background

Routine intertidal sediment quality and ecological monitoring in Porirua Harbour began in January 2008. Three detailed fine scale surveys were completed in 2008, 2009 and 2010 with the results showing that Porirua Harbour had low to moderate intertidal sedimentation rates, increasingly muddy sediments that were not well oxygenated and moderate nutrient concentrations (Robertson & Stevens 2008a; 2009a; 2010a).

Based on these findings it was decided to continue the annual monitoring to measure sedimentation rates, grain size, sediment oxygenation and macroalgal cover. This section briefly summarises the latest monitoring results; full details of the monitoring are reported in Stevens and Robertson (2011c; 2011b). Refer to Section 4 for the related water quality monitoring results.

8.2 Monitoring sites, variables and methods

The fourth intertidal survey was undertaken in January 2011 at two intertidal sites in each arm of Porirua Harbour and a single subtidal site in Onepoto Arm (Figure 8.1 & Appendix 1). The monitoring included measurements of sediment depth over buried sediment plates, grain size analyses to monitor changes in mud content, and redox potential discontinuity (RPD) depth as a proxy for sediment oxygenation. In addition, the percentage cover of macroalgae (eg, sea lettuce) was mapped for the fourth time as a broad measure of nutrient enrichment within the estuary.

(Source: Robertson & Stevens 2010b)

Figure 8.1: Location of the four fine scale intertidal monitoring sites and sedimentation monitoring plates within Porirua Harbour – site Por West represents the single subtidal sedimentation monitoring location

8.3 Key findings

Sedimentation rates for the intertidal sites were low to moderate, ranging from -1.7 to +3.2 mm/yr. The highest rates of intertidal deposition occurred in the upper estuary of each arm, most noticeably at the head of the Onepoto Arm, near Whitireia (site PorB). High variability at the upper Onepoto Arm sites prompted the installation of additional sedimentation plates at this site in 2011. Sediments at all sites were poorly oxygenated as indicated by a shallow RPD depth. Sediments at the upper estuary sites (PorB and PauB) also showed an increasing mud content.

Macroalgal cover was dense (50–100%) in the upper reaches of both Onepoto and Pauatahanui arms creating localised nuisance conditions, such as rotting macroalgae, poorly oxygenated and sulphide rich sediments (Figure 8.2).

(Source: Wriggle Coastal Management)

Figure 8.2: Dense macroalgal cover in the upper estuary area of Onepoto Arm

8.4 Future monitoring

Recommendations made in 2010 following three years of baseline monitoring were to continue broad scale macroalgal and fine scale sediment monitoring on an annual basis to assess ongoing nutrient and sediment inputs to the harbour. Given the findings of this recent monitoring, ongoing annual surveys will continue with the next survey planned for early 2012.

9. Porirua Harbour subtidal sediment quality monitoring

9.1 Introduction and background

Contaminants in urban stormwater discharges have been identified as a potential medium to long-term risk to the health of the marine organisms living in our harbours, largely through the accumulation of these contaminants in the sediments. Greater Wellington's Porirua Harbour subtidal sediment quality monitoring programme primarily focuses on heavy metals and several classes of organic contaminants which tend to be bound to the mud fraction of sediments. The subtidal basins in each arm of the harbour are dominated by fine muds and provide a 'sink' in which contaminants accumulate. Four surveys have been carried out to assess contaminant concentrations in the surface sediments of these basins, together with surveys of the health of benthic fauna present (Williamson et al. 2005; Stephenson & Mills 2006; Milne et al. 2009; Oliver et al. in press). These sediment surveys allow an ongoing evaluation of urban stormwater management actions directed at maintaining or enhancing the Porirua Harbour receiving environment.

This section briefly summarises the results of the fourth survey of sediment quality and benthic community health at five subtidal sites in Porirua Harbour, based on a report by Oliver et al. (in press). Recommendations made following the previous survey in 2008 were to carry out additional analyses of sediment samples for organochlorine pesticides at all sites and polycyclic aromatic hydrocarbons (PAHs) at one site (Milne et al. 2009).

9.2 Monitoring sites, variables and methods

Five subtidal sites were sampled in Porirua Harbour during November/ December 2010; three sites in the Pauatahanui Arm and two sites in the Onepoto Arm (Figure 9.1 & Appendix 1). Samples were collected with the use of a boat, GPS and scuba divers using similar protocol to previous surveys of contaminants in Porirua Harbour sediments (Williamson et al. 2005; Stephenson & Mills 2006).

9.2.1 Sediments

At each site 25 sediment core samples were collected from a sampling area 20 m in diameter, with samples randomly assigned into five replicate groups for analysis (top 30 mm). Samples were tested for:

- particle size distribution (sediment texture);
- total organic carbon (TOC);
- weak acid-extractable and total heavy metals;
- PAHs (site POR1 only); and
- selected organochlorine pesticides.

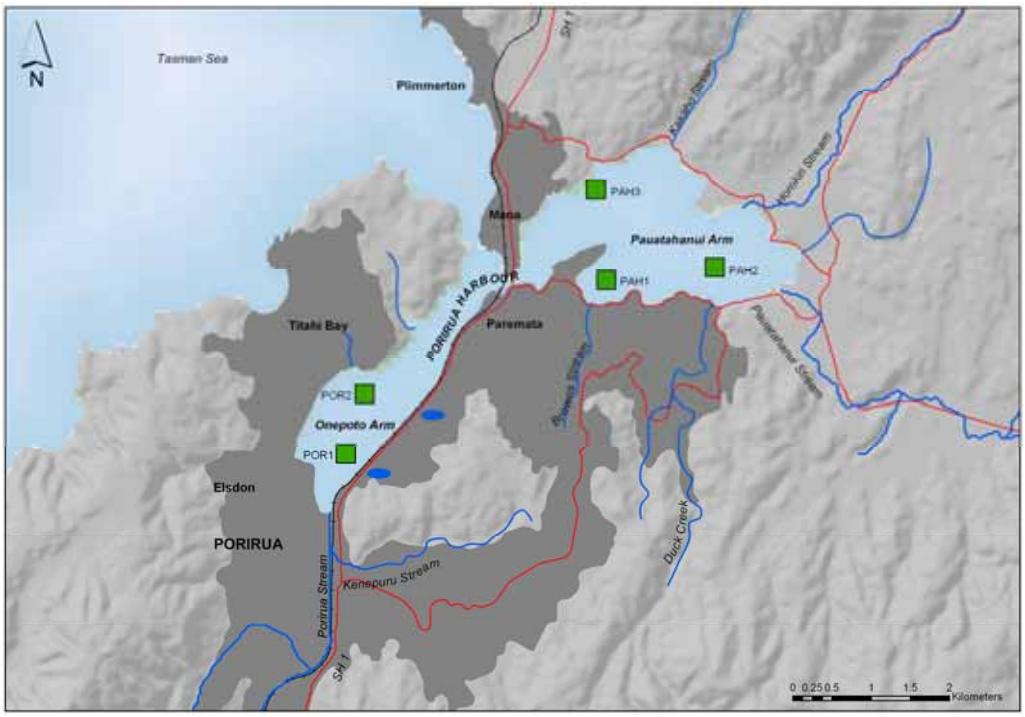


Figure 9.1: The five subtidal monitoring sites sampled in Porirua Harbour during November and December 2010

9.2.2 Benthic fauna

Eight benthic (sediment-dwelling) fauna samples were collected from an area adjacent to each sediment sampling site. Processing of the samples included:

- identification (to the lowest taxonomic level practicable) and enumeration of benthic fauna;
- measurement of shell lengths of selected species (eg, bivalve molluscs); and
- selection and labelling of specimens for a reference collection.

9.2.3 Guidelines

Both the ANZECC (2000) Interim Sediment Quality Guidelines (ISQG) and the Auckland Regional Council's (2004) Environmental Response Criteria (ERC) were used to assess the sediment chemistry results. These guidelines are not 'pass or fail' numbers; they are set at the concentrations which experimental and/or field evidence suggests are likely to result in impacts on aquatic life. Both the ANZECC and ERC guidelines have 'low' (effectively 'alert' or 'early warning') and 'high' values[3]; exceedances of these 'low' and 'high' values are indicated by orange and red hatching respectively in the graphs in Section 9.3.

9.3 Key findings

Total concentrations of all nine metals tested were higher in the surface sediments of the Onepoto Arm than of those in the Pauatahanui Arm. At both

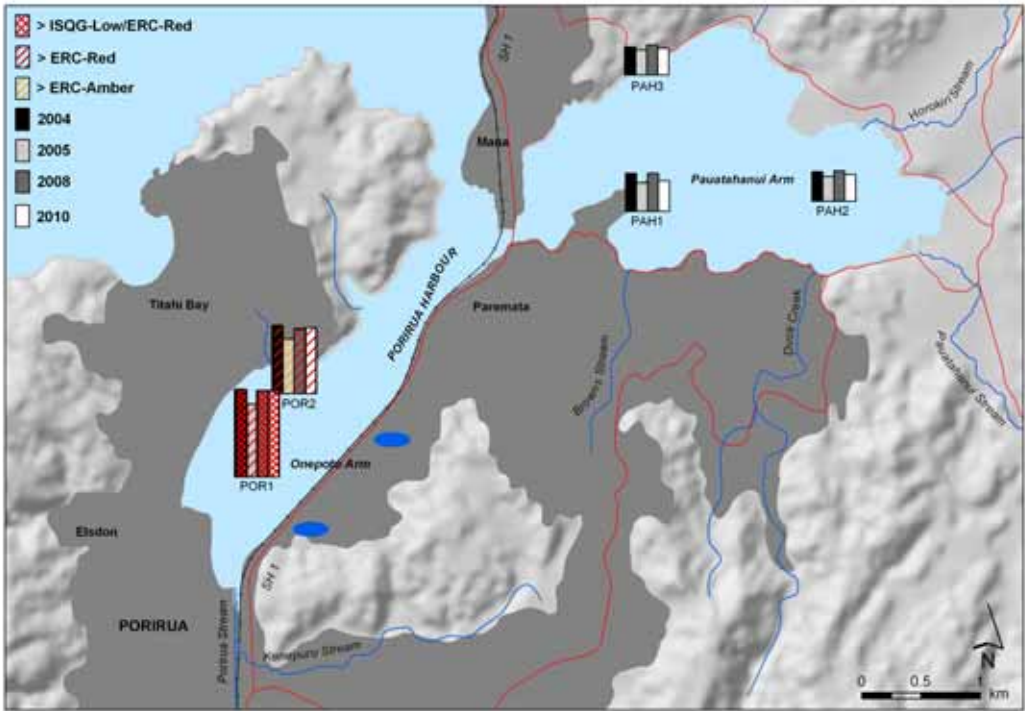
[3] These two sets of guidelines differ with respect to how they were derived and how they are interpreted – see Milne et al. (2009) for details.

sites in the Onepoto Arm, total zinc concentrations exceeded the ARC ERC Red threshold (Figure 9.2) and concentrations of total copper and lead exceeded their respective ARC ERC Amber thresholds (Figure 9.3). These results are all consistent with the findings of the 2008 survey.

The mean concentrations of weak acid-extractable copper, lead and zinc were also higher in the Onepoto Arm than the Pauatahanui Arm. The general trend across the four surveys has been for zinc concentrations to increase, lead concentrations to decrease and for copper concentrations to be variable, showing increases at some sites and decreases at others.

Although mean total PAH concentrations at site POR1 were not significantly different from the 2004 and 2005 surveys, TOC-normalised PAH concentrations (at 1% TOC) were significantly lower at this site than in the previous surveys (Figure 9.4). Likewise TOC-normalised concentrations of total high molecular weight (HMW) PAHs were significantly lower at site POR1 in 2010 than previously recorded.

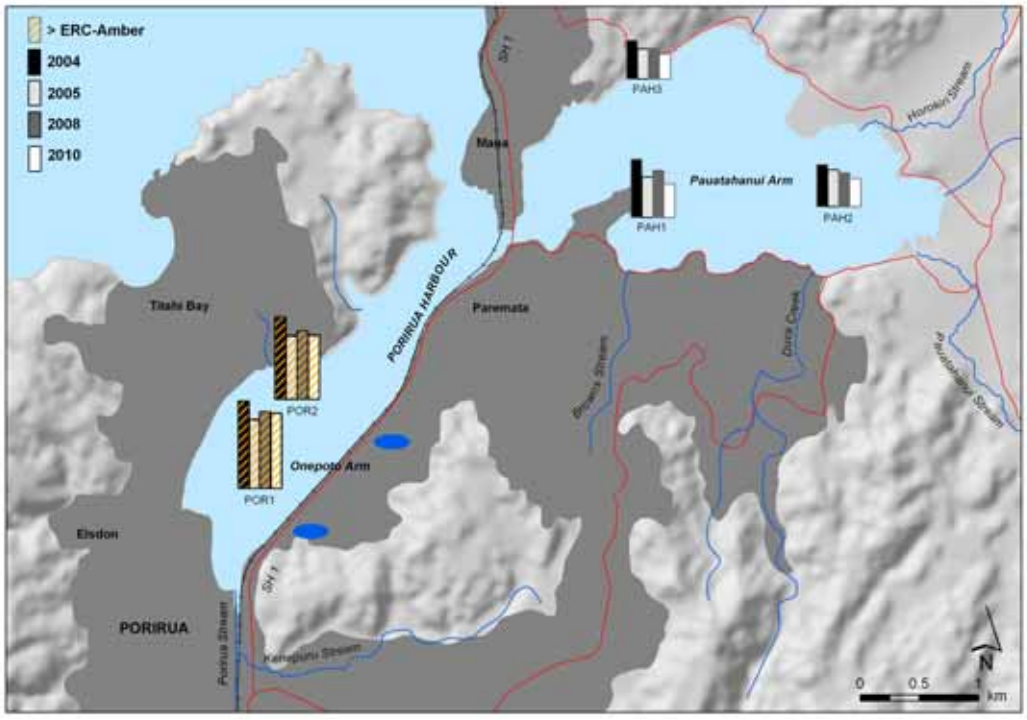
Consistent with previous surveys, the TOC-normalised total DDT concentrations exceeded the ANZECC (2000) ISQG-Low trigger value at all sites. Concentrations at sites PAH2, PAH3 and POR1 also exceeded the ARC ERC Red threshold. The dominant constituent of DDT was DDE; this is consistent with the presence of an aerobically weathered source of DDT, such as that found in the agricultural soils that dominate the surrounding catchments.



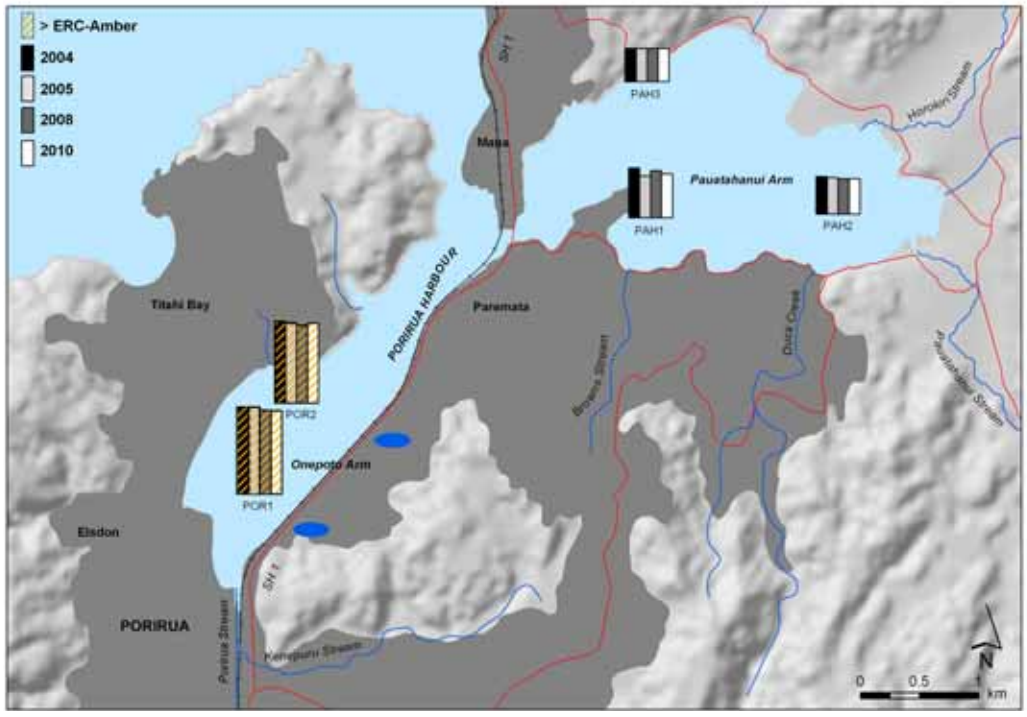
(Source: Oliver et al. in press)

Figure 9.2: Concentrations of total zinc in sediments of five sites sampled in Porirua Harbour in 2004, 2005, 2008 and 2010, based on the <500 mm fraction of a single composite sample from each site

A)

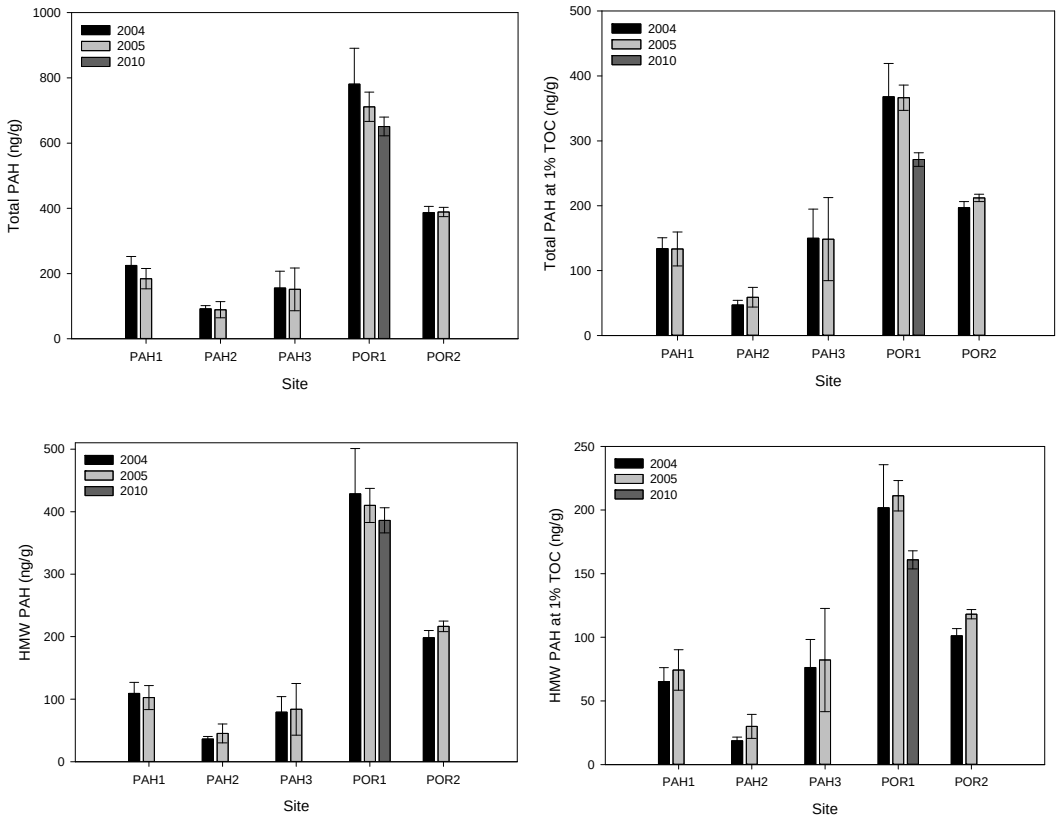


B)



(Source: Oliver et al. in press)

Figure 9.3: Concentrations of total A) copper and B) lead in surface sediments of five sites sampled in Porirua Harbour in 2004, 2005, 2008 and 2010, based on the <500 mm fraction of a single composite sample from each site



(Source: Oliver et al. in press)

Figure 9.4: Mean (± 95% CI) concentrations of total PAH, total PAH at 1% TOC, HMW PAH and HMW PAH at 1% TOC in sediments of five sites sampled in Porirua Harbour in 2004, 2005, and 2010, based on the <500 µm fraction of five composite samples from each site

A total of 58 taxa were identified, with all but four of the taxa found in Pauatahanui Arm; 29 taxa were recorded from sites in the Onepoto Arm. Polychaetes, or bristle worms (27 species), crustaceans (14 species) and bivalve molluscs (7 species) were the most common groups amongst the fauna collected. The biomass was dominated by bivalve molluscs at all sites, with the exception of site POR2 which was dominated by shrimp-like tanaid crustaceans.

Multivariate statistical analyses performed on monitoring data collected across all four surveys of Porirua Harbour did not identify any clear cause and effect relationships between sediment contaminant concentrations and species diversity and abundance or community composition. This is despite both monitoring sites in the Onepoto Arm clearly having higher sediment contaminant concentrations and supporting a lower diversity of benthic species than sites in the Pauatahanui Arm. However, when sediment heavy metal concentrations, and mud and organic carbon content were combined and treated as a sliding scale of 'environmental quality', a subtle relationship with underlying community structure was evident. From this analysis, Oliver et al. (in press) concluded that monitoring sites of higher 'environmental quality' – specifically those in the Pauatahanui Arm – had a healthier benthic invertebrate community structure.

9.4 Future monitoring

With four subtidal sediment quality surveys now having been undertaken in Porirua Harbour, a review of the scope and frequency of the existing monitoring programme is planned. This review will take into consideration the results of other monitoring being carried out in the harbour, particularly the intertidal sediment quality surveys (see Section 8).

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Acknowledgements

Alice Ryan compiled the microbiological summary statistics. Juliet Milne provided review comments on a draft version of this report.

Appendix 1: Monitoring sites

Table A1.1: Microbiological water quality sampling locations

Area	Site name	NZTM co-ordinates		Type
		Easting	Northing	
Hutt	Petone Beach @ Water Ski Club	1755744	5434591	Recreation
Hutt	Petone Beach @ Sydney Street	1757045	5434248	Recreation
Hutt	Petone Beach @ Settlers Museum	1757555	5434056	Recreation
Hutt	Petone Beach @ Kiosk	1758326	5433711	Recreation
Hutt	Sorrento Bay	1759632	5431384	Recreation and shellfish gathering
Hutt	Lowry Bay @ Cheviot Road	1760206	5430891	Recreation
Hutt	York Bay	1759977	5430160	Recreation
Hutt	Days Bay @ Wellesley College	1759616	5428529	Recreation
Hutt	Days Bay @ Wharf	1759654	5428313	Recreation
Hutt	Days Bay @ Moana Road	1759582	5428120	Recreation
Hutt	Rona Bay @ N end of Cliff Bishop Park	1759109	5427654	Recreation
Hutt	Rona Bay @ Wharf	1758730	5427371	Recreation
Hutt	Robinson Bay @ HW Shortt Rec Ground	1758519	5426674	Recreation
Hutt	Robinson Bay @ Nikau Street	1758131	5425856	Recreation
Hutt	Camp Bay	1756990	5424288	Recreation
Kapiti	Otaki Beach @ Surf Club	1778622	5488330	Recreation and shellfish gathering
Kapiti	Otaki Beach @ Rangiuru Road	1778010	5487069	Recreation
Kapiti	Te Horo Beach S of Mangaone Stream	1775779	5482478	Recreation
Kapiti	Te Horo Beach @ Kitchener Street	1775495	5481933	Recreation
Kapiti	Peka Peka Beach @ Road End	1773215	5477905	Recreation and shellfish gathering
Kapiti	Waikanae Beach @ William Street	1771388	5475584	Recreation
Kapiti	Waikanae Beach @ Tutere St Tennis Courts	1770655	5474862	Recreation
Kapiti	Waikanae Beach @ Ara Kuaka Carpark	1769514	5473978	Recreation
Kapiti	Paraparaumu Beach @ Ngapotiki Street	1767543	5472762	Recreation
Kapiti	Paraparaumu Beach @ Nathan Avenue	1767033	5472174	Recreation
Kapiti	Paraparaumu Beach @ Maclean Park	1766694	5471267	Recreation
Kapiti	Paraparaumu Beach @ Toru Road	1766577	5470715	Recreation
Kapiti	Paraparaumu Beach @ Wharemauku Road	1766503	5470070	Recreation
Kapiti	Raumati Beach @ Tainui Street	1766531	5469229	Recreation
Kapiti	Raumati Beach @ Marine Gardens	1766516	5468441	Recreation
Kapiti	Raumati Beach @ Aotea Road	1766414	5467529	Recreation
Kapiti	Raumati Beach @ Hydes Road	1766318	5466835	Recreation and shellfish gathering
Kapiti	Paekakariki Beach @ Whareroa Road	1765598	5464128	Recreation
Kapiti	Paekakariki Beach @ Surf Club	1764791	5462273	Recreation
Kapiti	Paekakariki Beach @ Memorial Hall	1764433	5461590	Recreation
Porirua	Pukerua Bay	1759058	5456278	Recreation
Porirua	Karehana Bay @ Cluny Road	1756093	5451360	Recreation
Porirua	Plimmerton Beach @ Bath Street	1756706	5450316	Recreation
Porirua	South Beach @ Plimmerton	1756810	5449874	Recreation
Porirua	Pauatahanui Inlet @ Water Ski Club	1758074	5449593	Recreation
Porirua	Pauatahanui Inlet @ Motukaraka Point	1759486	5449338	Recreation and shellfish gathering
Porirua	Pauatahanui Inlet @ Browns Bay	1758039	5447833	Recreation and shellfish gathering
Porirua	Porirua Harbour @ Rowing Club	1754891	5446947	Recreation and shellfish gathering

Area	Site name	NZTM co-ordinates		Type
		Easting	Northing	
Porirua	Titahi Bay @ Bay Drive	1754132	5448169	Recreation
Porirua	Titahi Bay at Toms Road	1754110	5447857	Recreation
Porirua	Titahi Bay @ South Beach Access Road	1753906	5447682	Recreation
Porirua	Onehunga Bay	1755796	5449181	Recreation
Porirua	Pauatahanui Inlet @ Paremata Bridge	1757153	5448284	Recreation
Wairarapa	Castlepoint Beach @ Castlepoint Stream	1871366	5467559	Recreation
Wairarapa	Castlepoint Beach @ Smelly Creek	1871670	5467202	Recreation
Wairarapa	Riversdale Beach @ Lagoon Mouth	1858965	5447543	Recreation
Wairarapa	Riversdale Beach Between the Flags	1858435	5446948	Recreation
Wairarapa	Riversdale Beach South	1857834	5445514	Recreation
Wellington	Aotea Lagoon	1748985	5427683	Recreation
Wellington	Oriental Bay @ Freyberg Beach	1749920	5427464	Recreation
Wellington	Oriental Bay @ Wishing Well	1750118	5427386	Recreation
Wellington	Oriental Bay @ Band Rotunda	1750243	5427375	Recreation
Wellington	Balaena Bay	1750958	5427267	Recreation
Wellington	Hataitai Beach	1750632	5425730	Recreation
Wellington	Shark Bay	1752211	5426197	Recreation and shellfish gathering
Wellington	Mahanga Bay	1753468	5427115	Recreation and shellfish gathering
Wellington	Scorching Bay	1753517	5426647	Recreation
Wellington	Worser Bay	1753074	5424823	Recreation
Wellington	Seatoun Beach @ Wharf	1753129	5424234	Recreation
Wellington	Seatoun Beach @ Inglis Street	1753405	5423994	Recreation
Wellington	Breaker Bay	1753312	5422970	Recreation
Wellington	Lyall Bay @ Tirangi Road	1750747	5423230	Recreation
Wellington	Lyall Bay @ Onepu Road	1750286	5423116	Recreation
Wellington	Lyall Bay @ Queens Drive	1749990	5422868	Recreation
Wellington	Princess Bay	1749586	5421504	Recreation
Wellington	Island Bay @ Surf Club	1748377	5421590	Recreation
Wellington	Island Bay @ Reef St Recreation Ground	1748229	5421542	Recreation
Wellington	Island Bay @ Derwent Street	1748155	5421415	Recreation
Wellington	Owhiro Bay	1747122	5421463	Recreation

Table A1.2: Porirua Harbour water quality sampling locations

Sampling site	NZTM	
	Easting	Northing
Harbour Entrance (PH–E1)	1756592	5448786
Pauatahanui Arm North (PH–P1)	1757999	5449405
Pauatahanui Arm East (PH–P2)	1760219	5448516
Pauatahanui Arm South (PH–P3)	1758653	5447986
Onepoto Arm West (PH–O1)	1755335	5446946
Onepoto Arm North (PH–O2)	1754535	5445707

Table A1.3: Waikanae Estuary intertidal sampling location

Sampling site	NZTM	
	Easting	Northing
Waikanae A	1769248 (Plot 01) 1769261 (Plot 10)	5473364 (Plot 01) 5473355 (Plot 10)

Table A1.4: Hutt Estuary sampling locations

Sampling site	NZTM	
	Easting	Northing
Hutt A	1759174 (Peg 1) 1759174 (Peg 2)	5433638 (Peg 1) 5433618 (Peg 2)
Hutt B	1759369 (Peg 1) 1759369 (Peg 2)	5434135 (Peg 1) 5434116 (Peg 2)

Table A1.5: Whareama Estuary intertidal sampling locations

Sampling site	NZTM	
	Easting	Northing
Whareama A	1860703 (Plot 01) 1860684 (Plot 10)	5455343 (Plot 01) 5455338 (Plot 10)
Whareama B	1860084 (Plot 01) 1860067 (Plot 10)	5455318 (Plot 01) 5455294 (Plot 10)

Table A1.6: Porirua Harbour intertidal sampling locations

Sampling site	NZTM	
	Easting	Northing
Porirua A	1756457 (Plot 01) 1756494 (Plot 10)	5447774 (Plot 01) 5447811 (Plot 10)
Porirua B	1754615 (Plot 01) 1754587 (Plot 10)	5445422 (Plot 01) 5445503 (Plot 10)
Pauatahanui A	1757243 (Plot 01) 1757246 (Plot 10)	5448644 (Plot 01) 5448601 (Plot 10)
Pauatahanui B	1760358 (Plot 01) 1760378 (Plot 10)	5448343 (Plot 01) 5448341 (Plot 10)

Table A1.7: Porirua Harbour subtidal sediment quality sampling locations

Site	Location	NZTM		Depth (m)
		Easting	Northing	
PAH1	Pauatahanui Arm off Browns Bay	1758157	5448052	2.0
PAH2	Pauatahanui Arm off Duck Creek	1759727	5448139	1.7
PAH3	Pauatahanui Arm off Camborne	1758151	5449206	1.7
POR1	Onepoto Arm South	1754864	5445871	2.0
POR2	Porirua Harbour North	1755179	5446506	2.8

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