greater WELLINGTON
REGIONAL COUNCIL
Te Pane Matua Taiao

Coastal State of the Environment monitoring programme

Annual data report, 2012/13

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Contents

1. Introduction

This report summarises the key 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 2012 to 30 June 2013. Note that the suitability of coastal waters for contact recreation purposes is assessed separately under Greater Wellington Regional Council's (GWRC) recreational water quality monitoring programme (see Morar & Greenfield 2013 for the 2012/13 results).

2. Overview of Coastal SoE monitoring programme

Coastal monitoring in the Wellington region began around 25 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 GWRC to fulfil State of the Environment (SoE) monitoring obligations with respect to coastal ecosystems.

2.1 Monitoring objectives

The aims of GWRC's Coastal SoE 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 Wellington 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 or ecosystem health is desired; and
5. Provide information required to determine the effectiveness of regional plans and policies.

2.2 Monitoring sites and frequency

Details on microbiological water quality monitoring are outlined in Morar and Greenfield (2013), with the location of the 61 monitoring sites shown in Figure 2.1 and listed in Appendix 1. In terms of coastal ecological monitoring, aside from broad scale habitat mapping which applies to the intertidal coastline region-wide and is intended to be repeated every 5–10 years, the core monitoring sites are located in Porirua and Wellington harbours, Waikanae, Hutt and Whareama estuaries, Lake Onoke and at Castlepoint Beach (Figure 2.2, Appendix 1). There are currently two ecology-based monitoring programmes for Porirua Harbour – one focuses on the dominant intertidal habitat and the other focuses on the muddier subtidal basin habitat. Between January 2011 and January 2013, physico-chemical water quality was also monitored in Porirua Harbour (refer Figure 4.1, Section 4).

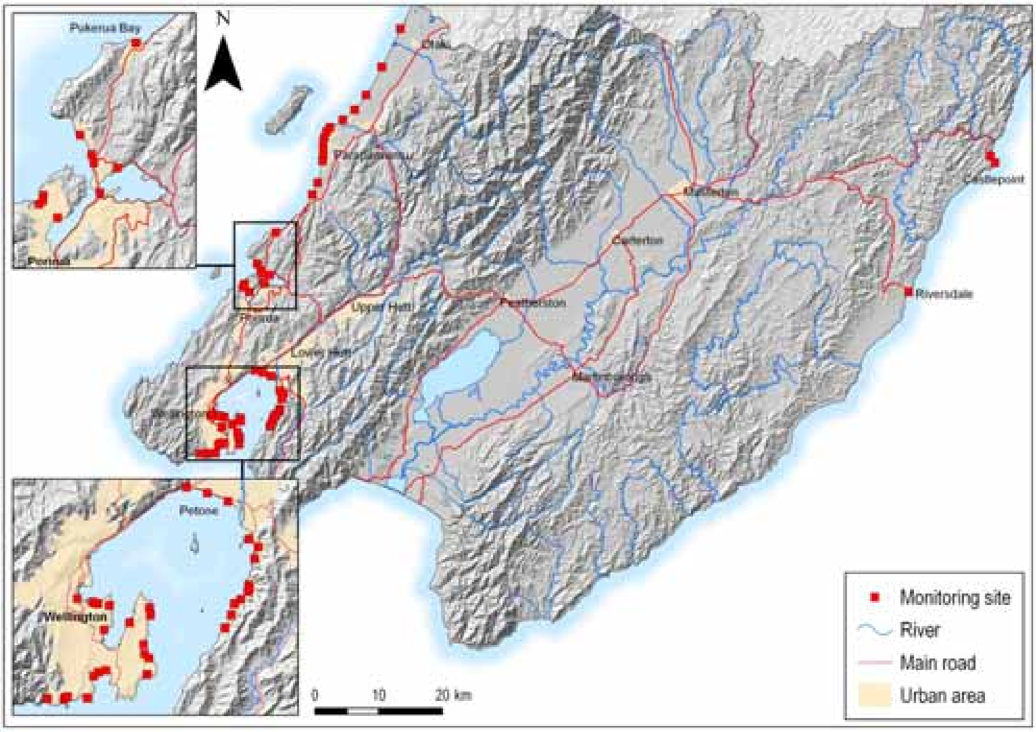

Figure 2.1: Coastal microbiological water quality monitoring sites sampled during 2012/13

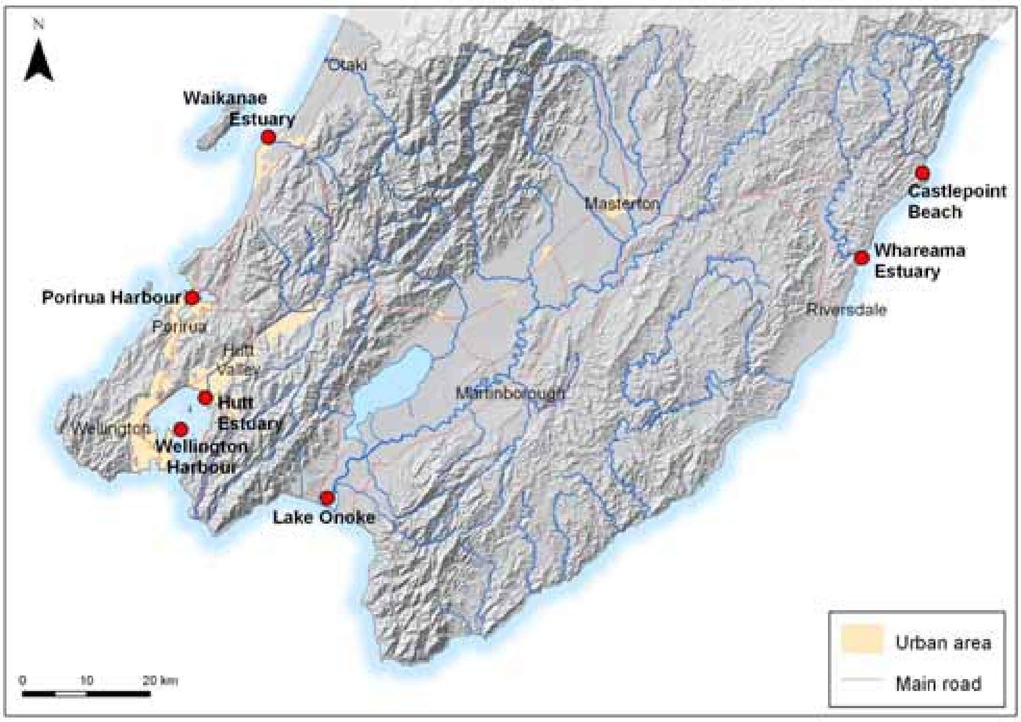

Figure 2.2: Map of the current core estuary, harbour and sandy beach ecological monitoring sites in the Wellington region as at 30 June 2013

Monitoring frequency varies across the sites, depending on the nature of the receiving environment, the purpose of monitoring and what the results indicate. The general approach is to monitor beach and estuary sites annually for three years to establish a baseline, with monitoring then reducing to five-yearly intervals unless specific issues have been identified that warrant more frequent monitoring (eg, sedimentation in Whareama Estuary). In contrast, subtidal monitoring in Porirua Harbour and Wellington Harbour is undertaken approximately every five years. See Oliver and Milne (2012) for more information.

2.2.1 Sites monitored during 2012/13

Coastal monitoring undertaken over the period 1 July 2012 to 30 June 2013 included:

- Microbiological water quality monitoring at 61 sites across the region (Section 3);
- Monthly water quality monitoring at six sites in Porirua Harbour (Section 4); and
- Fine scale ecological monitoring in Waikanae Estuary, Hutt Estuary Whareama Estuary and Porirua Harbour (Section 5).

2.3 Monitoring variables and protocol

The basic approach to monitoring coastal microbiological water quality, ecological condition of the region's estuaries and sandy beaches, and subtidal harbour sediment quality and ecology is outlined in detail in Oliver and Milne (2012) and summarised in Appendix 2.

3. Microbiological water quality

This section presents a tabulated summary of microbiological water quality at 61 marine recreational sites monitored weekly for 20 weeks between mid November 2012 and March 2013 during 2012/13 and monthly outside of this period. See Morar and Greenfield (2013) for a detailed analysis of microbiological water quality sampling results during the official summer bathing season.

Table 3.1 summarises the median, 95th percentile and maximum enterococci counts recorded from all water sampling conducted during the period 1 July 2012 to 30 June 2013 for each of the 61 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). Table 3.2 summarises the median, 95th percentile and maximum faecal coliform counts recorded from all water sampling conducted during the same period for each of the seven marine sites classed as recreational shellfish gathering sites.

Table 3.1: Summary of enterococci counts recorded at 61 marine recreation sites monitored between 1 July 2012 and 30 June 2013 inclusive

Site	Total no. of samples	Enterococci (cfu/100 mL)		
		Median	95th percentile	Max
Kapiti Coast				
Otaki Beach at Surf Club	29	5	89	170
Te Horo Beach at Sea Rd	29	12	242	405
Peka Peka Beach at Road End	28	4	33	155
Waikanae Beach at William St	28	4	71	220
Waikanae Beach at Ara Kuaka Carpark	29	5	237	400
Paraparaumu Beach at Ngapotiki St	28	11	88	365
Paraparaumu Beach at Nathan Ave	30	13	273	350
Paraparaumu Beach at Maclean Park	30	20	235	320
Paraparaumu Beach at Toru Rd	31	10	310	465
Raumati Beach at Tainui St	29	17	228	860
Raumati Beach at Marine Gardens	31	15	285	930
Raumati Beach at Aotea Rd	31	11	280	385
Paekakariki Beach at Whareroa Rd	29	10	368	860
Paekakariki Beach at Surf Club	27	7	63	80
Porirua				
Karehana Bay at Cluny Rd	30	12	868	4,700
Plimmerton Beach at Bath St	35	40	678	1,000
South Beach at Plimmerton	42	76	893	1,700
Pauatahanui Inlet at Paremata Br	33	4	444	1,100
Pauatahanui Inlet at Water Ski Club	32	8	412	2,200
Porirua Harbour at Rowing Club	36	58	950	3,600
Titahi Bay at Bay Dr	31	16	220	590
Pukerua Bay	31	4	160	450
Titahi Bay at Toms Rd	32	10	363	450
Titahi Bay at South Beach Access Rd	33	28	648	1,400

Site	Total no. of samples	Enterococci (cfu/100 mL)		
		Median	95th percentile	Max
Wellington City				
Aotea Lagoon	31	12	460	800
Oriental Bay at Freyberg Beach	32	4	204	750
Oriental Bay at Wishing Well	31	8	195	460
Oriental Bay at Band Rotunda	34	10	286	2,000
Balaena Bay	29	2	46	580
Hataitai Beach	32	4	370	640
Shark Bay	31	2	233	550
Mahanga Bay	31	4	365	2,800
Scorching Bay	31	2	270	340
Worser Bay	31	8	310	3,000
Seatoun Beach at Wharf	30	4	182	800
Seatoun Beach at Inglis St	32	2	335	640
Breaker Bay	28	2	47	64
Lyall Bay at Tirangi Rd	35	4	363	440
Lyall Bay at Onepu Rd	29	4	104	920
Lyall Bay at Queens Dr	30	4	185	3,200
Princess Bay	28	2	39	60
Island Bay at Surf Club	34	16	1,412	4,700
Island Bay at Reef St Rec Grd	34	30	1,150	3,400
Island Bay at Derwent St	34	8	428	3,000
Owhiro Bay	45	60	2,920	5,600
Hutt				
Petone Beach at Sydney St	34	20	431	1,700
Petone Beach at Kiosk	31	36	500	740
Sorrento Bay	34	12	503	2,500
Lowry Bay at Cheviot Rd	30	12	608	1,300
York Bay	31	4	290	660
Days Bay at Wellesley College	29	12	334	530
Petone Beach at Water Ski Club	33	16	498	1,300
Days Bay at Wharf	30	6	463	3,400
Days Bay at Moana Rd	31	4	210	220
Rona Bay at N end of Cliff Bishop Park	32	16	310	530
Rona Bay at Wharf	32	8	243	430
Robinson Bay at HW Shortt Rec Grd	29	8	194	280
Robinson Bay at Nikau St	34	10	261	320
Wairarapa				
Castlepoint Beach at Castlepoint Stream	27	2	8	16
Castlepoint Beach at Smelly Creek	28	2	86	2,100
Riversdale Beach Between the Flags	26	2	17	56

Table 3.2: Summary of faecal coliform counts recorded at seven marine shellfish gathering sites monitored between 1 July 2012 and 30 June 2013 inclusive

Site	Total no. of samples	Faecal coliforms (cfu/100 mL)		
		Median	95th percentile	Max
Kapiti Coast				
Otaki Beach at Surf Club	29	18	401	1,000
Peka Peka Beach at Road End	28	11	123	160
Raumati Beach at Tainui St	29	41	744	1,195
Porirua				
Porirua Harbour at Rowing Club	34	44	897	3,200
Wellington City				
Shark Bay	31	4	122	650
Mahanga Bay	31	2	140	370
Hutt				
Sorrento Bay	29	16	520	740

4. Porirua Harbour physico-chemical water quality

The results of monthly water sampling at six locations in Porirua Harbour (Figure 4.1) for the period January 2011 to January 2013 are summarised in Table 4.1. Note that sampling ceased in January 2013, following two years of data collection.

Figure 4.1: Location of Porirua Harbour water quality sampling sites

The sampling results indicate that water quality is more variable at the Onepoto Arm sites (O1 and O2) and the inner estuary monitoring site of Pauatahanui Arm (P2); median concentrations of nutrients, suspended sediments and chlorophyll *a* were all higher at these sites (Table 4.1). This reflects the proximity of these sites to stream and stormwater inputs.

Table 4.1: Median (and range)[1] of values for selected variables measured during monthly water sampling in Porirua Harbour between January 2011 and January 2013 (*n*=25)

	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)	7 (2–51)	12 (3–230)	11 (4–210)	13 (3–-67)	11 (5–460)	22 (4–230)
Turbidity (NTU)	2.8 (0–19.5)	6.5 (2.0–86.0)	6.1 (1.7–169)	6.0 (1.2–18.6)	6.1 (2.2–210)	11.6 (1.6–126)
Salinity (ppt)	34 (24–35)	32 (20–35)	30 (9.2–35)	32 (22–35)	32 (22–35)	31 (4.8–34)
Chlorophyll *a* (mg/L)	0.0015 (0.0015–0.007)	0.0015 (0.0015–0.008)	0.0015 (0.0015–0.016)	0.0015 (0.0015–0.007)	0.0015 (0.0015–0.014)	0.0015 (0.0015–0.019)
Ammoniacal N (mg/L)	0.005 (0.005–0.034)	0.005 (0.005–0.043)	0.005 (0.005–0.108)	0.005 (0.005–0.038)	0.005 (0.005–0.064)	0.01 (0.005–0.11)
Nitrate-nitrite N (mg/L)	0.005 (0.001–0.25)	0.004 (0.001–0.35)	0.015 (0.001–0.66)	0.003 (0.001–0.23)	0.005 (0.001–0.42)	0.066 (0.001–0.52)
Dissolved inorganic nitrogen (mg/L)	0.01 (0.006–0.284)	0.09 (0.006–0.393)	0.02 (0.006–0.768)	0.08 (0.006–0.268)	0.01 (0.006–0.484)	0.076 (0.006–0.630)
Dissolved reactive phosphorus (mg/L)	0.005 (0.002–0.019)	0.006 (0.002–0.021)	0.008 (0.002–0.019)	0.006 (0.002–0.022)	0.004 (0.002–0.035)	0.01 (0.002–0.033)
Total phosphorus (mg/L)	0.017 (0.012–0.058)	0.029 (0.015–0.181)	0.028 (0.015–0.240)	0.024 (0.014–0.044)	0.03 (0.018–0.350)	0.043 (0.018–0.250)

[1] Values reported as below the laboratory detection limit have been halved.

4.1 Additional monitoring

During 2012/13 three continuous turbidity monitoring stations were established in the lower reaches of the Porirua, Pauatahanui and Horokiri streams in accordance with the actions of the Porirua Harbour and Catchment Strategy and Action Plan (PCC 2012). These streams drain the three largest subcatchments of Porirua Harbour and were identified via CLUES[1] modelling as the greatest contributors of sediment to the harbour.

The continuous turbidity stations are also equipped with autosamplers designed to collect water samples at pre-determined intervals related to stream flow and turbidity. These samples will be used to calibrate the turbidity sensors and after several years of data collection, to calculate catchment sediment loads.

During 2012/13 discrete wet weather water sampling also commenced with a focus on suspended sediment (and to a lesser extent nutrients) from the subcatchments of Porirua Stream.

[1] CLUES (Catchment Land Use for Environmental Sustainability) is a GIS based modelling system which assesses the effects of land use change on water quality.

5. Estuary condition

In late January 2013, Wriggle Coastal Management carried out surveys of the Waikanae, Hutt and Whareama estuaries and Porirua Harbour (Onepoto and Pauatahanui Arms). The surveys are documented in full in Stevens and Robertson (2013a–g) and the key findings are summarised in Table 5.1.

In broad terms the surveys of the five key estuaries included measurements of Redox Potential Discontinuity (RPD)[2], sedimentation over buried plates and an assessment of the area and density of macroalgal cover. These are the fine and broad scale indicators selected for ongoing annual monitoring, following detailed baseline surveys between 2008 and 2012.

Table 4.1 presents the sedimentation rate measured over buried plates for the period February 2012 to January 2013. The mean annual sedimentation rate is also provided for context where multiple years of measurements have been made. Additional sediment plates were installed in subtidal areas of both arms of Porirua Harbour in 2013 to capture the expected higher rates of sedimentation in these despositional zones.

Broad scale habitat mapping was also carried out in Porirua Harbour in January 2013. This is the second broad scale survey and follows the baseline survey undertaken five years earlier in 2008 (Stevens and Roberston 2008). A summary of the dominant habitats and substrate categories is presented in Table 5.2.

[2] The RPD provides a measure of the depth of oxygenated sediment.

Table 5.1: Sedimentation and eutrophication indicator results for the five key estuaries monitored in early 2013. Porirua Harbour cells shaded in light blue and dark blue equate to intertidal and subtidal sites, respectively

		Sedimentation				Eutrophication	
		Sedimentation rate (2012/13)	Mean sedimentation rate (mm/yr)	No. of years measured	RPD (cm)	Low density macroalgal cover (MC)	High density macroalgal cover (% of estuary covered)
Waikanae Estuary		16.5	28.9	3	1.1	0.16	3%
Hutt Estuary		-2.0	-3.75	3	Not assessed	4.2	66%
Whareama Estuary		10	9.5	5	1	Not assessed	Not assessed
Porirua Harbour							
Onepoto Arm	1	14.3	2.5	5	1	2.3	12%
	2	12.3	12.3	1	1.5		
	3	4.3	2.2	5	1.5		
	S6	Installed	-		0		Not assessed
	S7	Installed	-		1		
	S8	Installed	-		2		
	S9	-14.0	-3.2	5	2		
Pauatahanui Arm	6	3.5	0.9	4	1	4.9	7.1%
	7	9.3	9.3	1	1		
	8	2.0	2.0	1	1		
	9	-0.8	0.1	5	1		
	10	-3.0	-3.0	1	3		
	11	Installed	-		2		
	S1	Installed	-		1		Not assessed
	S2	Installed	-		1		
	S3	Installed	-		1		
	S4	Installed	-		1		
	S5	Installed	-		1		

Table 5.2: Summary of dominant intertidal habitat and substrate categories determined from broad scale habitat mapping of Porirua Harbour in January 2013

Habitat/substrate category (ha)	Pauatahanui Arm	Onepoto Arm	Whole estuary
Seagrass	27.7	18.0	45.7
Saltmarsh	49.7	0.7	50.4
Artificial structures	2.8	2.6	5.4
Rock/boulder/gravel	19.4	20.0	39.4
Shell bank/mobile sand	8.5	6.5	15.0
Firm sand	17.0	0.6	17.6
Firm muddy sand	103.2	32.8	136.0
Soft mud	16.5	3.0	19.5
Very soft mud	0	0.3	0.3

6. Wellington Harbour subtidal sediment quality

During 2012/13 laboratory analysis was completed on subtidal sediment samples collected from 16 sites in Wellington Harbour in late 2011. Analyses were largely complete by mid-2012, however, inconsistencies in the sediment particle size data necessitated reanalysis of the samples from both the 2006 and 2011 surveys. These sediment particle size reanalyses were undertaken in mid 2013 and a report documenting the 2011 survey findings will be available in early 2014.

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Acknowledgements

Coastal microbiological water quality monitoring in the western half of the Wellington region is a joint effort involving Kapiti Coast District Council, Porirua City Council, Wellington City Council and Hutt City Council.

Shyam Morar compiled the Porirua Harbour water quality summary statistics.

Appendix 1: Coastal monitoring sites

Tables A1.1 to A1.6 list coastal sites monitored during 2012/13. Refer to Oliver and Milne (2012) for other sites in GWRC's coastal monitoring programme.

Table A1.1: Microbiological water quality sampling locations

Site	NZTM co-ordinates		Type
	Easting	Northing	
Kapiti Coast			
Otaki Beach at Surf Club	1778622	5488330	Recreation
Paekakariki Beach at Surf Club	1764791	5462273	Recreation & shellfish gathering
Paekakariki Beach at Whareroa Road	1765598	5464128	Recreation
Paraparaumu Beach at Maclean Park	1766694	5471267	Recreation
Paraparaumu Beach at Nathan Avenue	1767033	5472174	Recreation
Paraparaumu Beach at Ngapotiki Street	1767543	5472762	Recreation
Paraparaumu Beach at Toru Road	1766577	5470715	Recreation
Peka Peka Beach at Road End	1773215	5477905	Recreation & shellfish gathering
Raumati Beach at Aotea Road	1766414	5467529	Recreation
Raumati Beach at Marine Gardens	1766516	5468441	Recreation
Raumati Beach at Tainui Street	1766531	5469229	Recreation & shellfish gathering
Te Horo Beach at Sea Road	1775692	5482324	Recreation
Waikanae Beach at Ara Kuaka Carpark	1769514	5473978	Recreation
Waikanae Beach at William Street	1771388	5475584	Recreation
Porirua			
Karehana Bay at Cluny Road	1756093	5451360	Recreation
Pauatahanui Inlet at Paremata Bridge	1757153	5448284	Recreation
Pauatahanui Inlet at Water Ski Club	1758074	5449593	Recreation
Plimmerton Beach at Bath Street	1756706	5450316	Recreation
Porirua Harbour at Rowing Club	1754891	5446947	Recreation & shellfish gathering
Pukerua Bay	1759058	5456278	Recreation
South Beach at Plimmerton	1756810	5449874	Recreation
Titahi Bay at Bay Drive	1754132	5448169	Recreation
Titahi Bay at South Beach Access Road	1753906	5447682	Recreation
Titahi Bay at Toms Road	1754110	5447857	Recreation
Wellington City			
Aotea Lagoon	1748985	5427683	Recreation
Balaena Bay	1750958	5427267	Recreation
Breaker Bay	1753312	5422970	Recreation
Hataitai Beach	1750632	5425730	Recreation
Island Bay at Derwent Street	1748155	5421415	Recreation
Island Bay at Reef St Recreation Ground	1748229	5421542	Recreation
Island Bay at Surf Club	1748377	5421590	Recreation
Lyall Bay at Onepu Road	1750286	5423116	Recreation
Lyall Bay at Queens Drive	1749990	5422868	Recreation
Lyall Bay at Tirangi Road	1750747	5423230	Recreation
Mahanga Bay	1753468	5427115	Recreation & shellfish gathering
Oriental Bay at Band Rotunda	1750243	5427375	Recreation
Oriental Bay at Freyberg Beach	1749920	5427464	Recreation
Oriental Bay at Wishing Well	1750118	5427386	Recreation
Owhiro Bay	1747122	5421463	Recreation
Princess Bay	1749586	5421504	Recreation

Site	NZTM co-ordinates		Type
	Easting	Northing	
Scorching Bay	1753517	5426647	Recreation
Seatoun Beach at Inglis Street	1753405	5423994	Recreation
Seatoun Beach at Wharf	1753129	5424234	Recreation
Shark Bay	1752211	5426197	Recreation & shellfish gathering
Worser Bay	1753074	5424823	Recreation
Hutt			
Days Bay at Moana Road	1759582	5428120	Recreation
Days Bay at Wellesley College	1759616	5428529	Recreation
Days Bay at Wharf	1759654	5428313	Recreation
Lowry Bay at Cheviot Road	1760206	5430891	Recreation
Petone Beach at Kiosk	1758326	5433711	Recreation
Petone Beach at Sydney Street	1757045	5434248	Recreation
Petone Beach at Water Ski Club	1755744	5434591	Recreation
Robinson Bay at HW Shortt Rec Ground	1758519	5426674	Recreation
Robinson Bay at Nikau Street	1758131	5425856	Recreation
Rona Bay at N end of Cliff Bishop Park	1759109	5427654	Recreation
Rona Bay at Wharf	1758730	5427371	Recreation
Sorrento Bay	1759632	5431384	Recreation & shellfish gathering
York Bay	1759977	5430160	Recreation
Wairarapa			
Castlepoint Beach at Castlepoint Stream	1871366	5467559	Recreation
Castlepoint Beach at Smelly Creek	1871670	5467202	Recreation
Riversdale Beach Between the Flags	1858435	5446948	Recreation

Table A1.2: Porirua Harbour water quality sampling locations

Sampling site	Location	NZTM co-ordinates	
		Easting	Northing
PH–E1	Porirua Harbour Entrance (Ngati Toa domain)	1756592	5448786
PH–P1	Pauatahanui Arm north (water ski club)	1757999	5449405
PH–P2	Pauatahanui Arm east (Ration Pt)	1760219	5448516
PH–P3	Pauatahanui Arm north (Brady's Bay)	1758653	5447986
PH–O1	Onepoto Arm north (speed boat club)	1755335	5446946
PH–O2	Onepoto Arm south (waka ama club)	1754535	5445707

Table A1.3: Porirua Harbour sediment plate locations

Sampling site	Location	NZTM co-ordinates Easting	Northing
1	Porirua A Railway	1756505	5447788
2	Aotea	1754771	5445520
3	Por B Polytech	1754561	5445430
S6	Titahi (subtidal)	1755704	5446797
S7	Onepoto (subtidal)	1754811	5446762
S8	Papkowhai (subtidal)	1754580	5445864
S9	Te Onepoto (subtidal)	1755551	5447105
6	Boatsheds	1757267	5448785
7	Kakaho	1758885	5449747
8	Horokiri	1760040	5448827
9	Paua B	1760333	5448378
10	Duck Creek	1759829	5447944
11	Browns Bay	1757971	5447956
S1	Kakaho (subtidal)	1758810	5449470
S2	Horokiri (subtidal)	1759325	5448867
S3	Duck Creek (subtidal)	1759529	5447896
S4	Bradeys Bay (subtidal)	1758763	5447865
S5	Browns Bay (subtidal)	1758040	5448015

Table A1.4: Waikanae Estuary intertidal sampling location

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

Table A1.5: Hutt Estuary sampling locations

Sampling site	NZTM co-ordinates Easting	Northing
Hutt A (South)	1759174 (Peg 1) 1759174 (Peg 2)	5433638 (Peg 1) 5433618 (Peg 2)
Hutt B (North)	1759369 (Peg 1) 1759369 (Peg 2)	5434135 (Peg 1) 5434116 (Peg 2)

Table A1.6: Whareama Estuary intertidal sampling locations

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

Appendix 2: Monitoring variables and methods

Microbiological water quality

Microbiological water quality monitoring is undertaken in accordance with the 2003[3] Ministry for the Environment (MfE) and the Ministry of Health (MoH) microbiological water quality guidelines for marine and freshwater recreational areas. In coastal waters, which are generally sampled weekly during the summer bathing season (November to March inclusive) and monthly during the remainder of the year, the recommended indicator is enterococci (with faecal coliforms the preferred indicator for shellfish gathering waters). Refer to Morar and Greenfield (2013) for full details of GWRC's microbiological water quality monitoring methods.

Physico-chemical water quality

Water samples from Porirua Harbour are collected monthly on a mid-ebb tide. On each sampling occasion field measurements of water temperature, conductivity and dissolved oxygen are taken and the weather conditions recorded. Samples are collected 0.25 m below the surface in approximately 0.75 m water depth, with care taken to minimise any disturbance of harbour bed sediments.

Water samples requiring laboratory analysis are stored on ice upon collection and couriered overnight to RJ Hill Laboratories in Hamilton. The variables monitored and current analytical methods are summarised in Table A2.1. All harbour water samples for dissolved nutrient analysis are filtered in the laboratory.

Table A2.1: Porirua Harbour water quality analytical methods

Variable	Method	Detection limit
Electrical conductivity (EC)	Saline water, Conductivity meter, 25°C. APHA 2510 B 21st Ed. 2005.	0.10 mS/m
Salinity	Meter, no temp. compensation. APHA 2520 B 21st Ed. 2005.	0.2 ppt
Turbidity	Saline sample. Analysis using a Hach 2100N, Turbidity meter. APHA 2130 B 21st ed. 2005.	0.10 NTU
Total suspended solids (TSS)	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 21st Ed. 2005.	2 mg/L
Total ammoniacal nitrogen	Saline, filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4+-N + NH_3-N). APHA 4500-NH_3 F (modified from manual analysis) 21st Ed. 2005.	0.01 mg/L
Nitrite nitrogen (Nitrite-N)	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3-I (Proposed) 21st Ed. 2005.	0.002 mg/L
Nitrate nitrogen (Nitrate-N)	Calculation: (Nitrate-N + Nitrite-N) – NO_2N.	0.002 mg/L
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3-I (Proposed) 21st Ed. 2005.	0.002 mg/L
Total Kjeldahl nitrogen (TKN)	Total Kjeldahl digestion (sulphuric acid with copper sulphate catalyst), phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} C. (modified) 4500 NH_3 F (modified) 21st Ed. 2005.	0.1 mg/L
Total nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N.	0.05 mg/L

[3] The guidelines were published in June 2002 and updated in June 2003.

Variable	Method	Detection limit
Dissolved reactive phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 21st Ed. 2005.	0.004 mg/L
Total phosphorus	Total phosphorus digestion (acid persulphate), ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 21st Ed. 2005.	0.004 mg/L
Chlorophyll *a*	Acetone extraction. Spectroscopy. APHA 10200 H 21st Ed. 2005 (modified).	0.003 mg/L

Estuary condition

The broad and fine scale surveys undertaken in the region's estuaries to date have been based on the National Estuary Monitoring Protocol (Robertson et al. 2002) and recent extensions to these developed by Wriggle Coastal Management (eg, Robertson & Stevens 2008a; Stevens & Robertson 2008). The fine scale surveys target the dominant intertidal habitat and three of the five core indicators of estuarine ecosystem health: sedimentation, eutrophication (nutrient enrichment) and toxic contamination (Table A2.2). The remaining two indicators are habitat loss and disease risk, which are assessed through periodic broad scale surveys and GWRC's microbiological water quality programme, respectively. As outlined below, broad scale surveys also provide information relevant to assessing sedimentation and nutrient enrichment.

Broad scale monitoring involves defining the dominant habitats and features of an area and developing baseline maps with a combination of aerial photography, ground-truthing and digital mapping using GIS technology. The area boundaries are first defined at a scale appropriate for baseline monitoring, before vegetation (eg, saltmarsh, seagrass) and substrate types (eg, gravel, coarse sand, mud) are mapped (Robertson et al. 2002). Broad scale assessments of macroalgae cover have also been undertaken annually across most of the estuaries in GWRC's coastal monitoring programme. The data from these surveys are being used alongside information from the fine scale monitoring to assess nutrient enrichment.

Fine scale monitoring generally takes place at one or two locations (sites) within an estuary that are selected to be representative of the dominant (generally intertidal) habitat present. Each site is assessed for a suite of environmental characteristics that are indicative of estuary condition and will provide a means for detecting future change (Table A2.2) (Robertson et al. 2002).

Along with annual estuary-scale mapping of macroalgae cover to complement the fine scale assessments of estuary condition, sedimentation monitoring plates are used to measure sedimentation rates at specific locations within each estuary. Such plates have been deployed at several locations across five of the region's estuaries to date.

Table A2.2: Key broad scale (BS) and fine scale (FS) indicators used to assess estuarine condition in the Wellington region. Many of the indicators in the table are also applicable to assessing beach condition

(Source: Adapted from Robertson & Stevens (2008); Stevens & Robertson (2008a))

Issue	Indicator	Indicator type	Rationale
Sedimentation	Soft mud area	BS	Estuaries are a natural sink for catchment-derived sediment but if sediment inputs are excessive, estuaries infill quickly with muds, reducing biodiversity and human values and uses. In particular: - muddy sediments have a higher tendency to become anoxic and anoxic sediments contain toxic sulphides and very little aquatic life. - elevated sedimentation rates are likely to lead to major and detrimental ecological changes within estuary areas that could be very difficult to reverse.
	Sediment composition (% mud)	FS	
	Sedimentation rate	FS	
	Diversity of benthic fauna	FS	Soft sediment macrofauna can be used to represent benthic community health in relation to the extent of mud tolerant organisms compared with those that prefer sands.
Eutrophication (nutrient enrichment)	Nuisance macroalgae cover	BS	Mass blooms of green and red macroalgae, mainly of the genera *Enteromorpha, Cladophora, Ulva,* and *Gracilaria,* can present a significant nuisance problem, especially when loose mats accumulate and decompose. Algal blooms also have major ecological impacts on water and sediment quality, such as reduced clarity, physical smothering and lack of oxygen, and can displace estuarine animals.
	Organic content	FS	High sediment organic content can result in anoxic sediments and bottom water, release of excessive nutrients, and adverse impacts on biota.
	Sediment nutrient concentrations: • Nitrogen • Phosphorus	FS	In shallow estuaries the sediment compartment is often the largest nutrient pool in the system, and nutrient exchange between the water column and sediments can play a large role in determining trophic status and stimulating the production and abundance of fast-growing algae, such as phytoplankton and short-lived macroalgae (eg, sea lettuce).
	Sediment oxygenation (RPD depth)	FS	Surface sediments need to be well oxygenated to support healthy invertebrate communities (anoxic sediments contain toxic sulphides and very little aquatic life).
	Diversity of benthic fauna	FS	Soft sediment macrofauna can be used to represent benthic community health and classify estuary condition.
Toxic contamination	Sediment contamination – eg, concentrations of: • heavy metals • PAHs • pesticides	FS	Many chemicals discharged to estuaries via urban and rural runoff are toxic, even at very low concentrations. These chemicals can accumulate in sediments and bioaccumulate in fish and shellfish, causing health risks to people and marine life.
	Diversity of benthic fauna	FS	Soft sediment macrofauna can be used to represent benthic community health and classify estuary condition.
Habitat loss	Saltmarsh area	BS	Estuaries function best with a large area of rooted vegetation (ie, saltmarsh and seagrass), as well as a healthy vegetated terrestrial margin. Loss of this habitat reduces ecological, fishery and aesthetic values, and adversely impacts on an estuary's role in flood and erosion protection, contaminant mitigation, sediment stabilisation and nutrient cycling.
	Seagrass area	BS	
	Vegetated terrestrial buffer	BS	

A series of interim fine and broad scale estuary 'condition ratings' (reproduced below from reports prepared for GWRC by Wriggle Coastal Management) were proposed for Porirua Harbour, and Waikanae, Hutt and Whareama estuaries (based on the ratings developed for Southland's estuaries – eg, Robertson & Stevens (2006). The ratings are based on a review of estuary monitoring data, guideline criteria and expert opinion. They are designed to be used in combination with each other (usually involving expert input) when evaluating overall estuary condition and deciding on appropriate management. The condition ratings include an 'early warning trigger' to highlight rapid or unexpected change, and each rating has a recommended monitoring and management response. In most cases, initial management is to further assess an issue and consider what response actions may be appropriate (eg, develop an Evaluation and Response Plan – ERP).

Sedimentation Rate

Elevated sedimentation rates are likely to lead to major and detrimental ecological changes within estuary areas that could be very difficult to reverse, and indicate where changes in land use management may be needed.

SEDIMENTATION RATE CONDITION RATING		
RATING	DEFINITION	RECOMMENDED RESPONSE
Very Low	0-1mm/yr (typical pre-European rate)	Monitor at 5 year intervals after baseline established
Low	1-2mm/yr	Monitor at 5 year intervals after baseline established
Moderate	2-5mm/yr	Monitor at 5 year intervals after baseline established
High	5-10mm/yr	Monitor yearly. Initiate Evaluation & Response Plan
Very High	>10mm/yr	Monitor yearly. Manage source
Early Warning Trigger	Rate increasing	Initiate Evaluation and Response Plan

Redox Potential Discontinuity

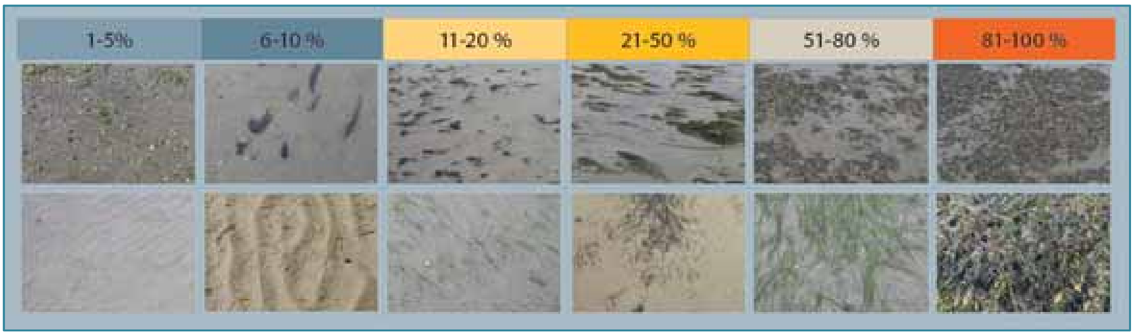
The RPD is the grey layer between the oxygenated yellow-brown sediments near the surface and the deeper anoxic black sediments. It is an effective ecological barrier for most but not all sediment-dwelling species. A rising RPD will force most macrofauna towards the sediment surface to where oxygen is available. The depth of the RPD layer is a critical estuary condition indicator in that it provides a measure of whether nutrient enrichment in the estuary exceeds levels causing nuisance anoxic conditions in the surface sediments. The majority of the other indicators (e.g. macroalgal blooms, soft muds, sediment organic carbon, TP, and TN) are less critical, in that they can be elevated, but not necessarily causing sediment anoxia and adverse impacts on aquatic life. Knowing if the surface sediments are moving towards anoxia (i.e. RPD close to the surface) is important for two main reasons:

1. As the RPD layer gets close to the surface, a "tipping point" is reached where the pool of sediment nutrients (which can be large), suddenly becomes available to fuel algal blooms and to worsen sediment conditions.
2. Anoxic sediments contain toxic sulphides and very little aquatic life.

The tendency for sediments to become anoxic is much greater if the sediments are muddy. In sandy porous sediments, the RPD layer is usually relatively deep (>3cm) and is maintained primarily by current or wave action that pumps oxygenated water into the sediments. In finer silt/clay sediments, physical diffusion limits oxygen penetration to <1cm (Jørgensen and Revsbech 1985) unless bioturbation by infauna oxygenates the sediments.

RPD CONDITION RATING		
RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	>10cm depth below surface	Monitor at 5 year intervals after baseline established
Good	3-10cm depth below sediment surface	Monitor at 5 year intervals after baseline established
Fair	1-3cm depth below sediment surface	Monitor at 5 year intervals. Initiate Evaluation & Response Plan
Poor	<1cm depth below sediment surface	Monitor at 2 year intervals. Initiate Evaluation & Response Plan
Early Warning Trigger	>1.3 x Mean of highest baseline year	Initiate Evaluation and Response Plan

Visual rating scale for percentage cover estiamtes for macroalgae (top) and seagrass (bottom)



LOW DENSITY MACROALGAL COVER

A two part macroalgae condition rating has been developed: 1. for low density (<50%) macroalgal cover throughout the estuary, and 2. a warning indicator for hotspots of high density (>50%) cover (see following rating). Low density macroalgal condition is rated using a continuous index (the macroalgae coefficient - MC) based on the percentage cover of macroalgae in defined categories in the estuary where cover is <50%. The equation used is: *MC=((0 x %macroalgal cover <1%)+(0.5 x %cover 1-5%)+(1.5 x %cover 5-10%)+(4.5 x %cover 10-20%)+(7.5 x %cover 20-50%))/100.*

LOW DENSITY MACROALGAL COVER CONDITION RATING

CONDITION RATING	DEFINITION	MC	RECOMMENDED RESPONSE
Very Low	Very Low	0.0 - 0.2	Monitor at 5 year intervals after baseline established
Low	Low	>0.2 - 0.8	Monitor at 5 year intervals after baseline established
	Low Low-Moderate	>0.8 - 1.5	Monitor at 5 year intervals after baseline established
Moderate	Low-Moderate	>1.5 - 2.2	Monitor yearly. Initiate ERP
	Moderate	>2.2 - 4.5	Monitor yearly. Initiate ERP
High	High	>4.5 - 7.0	Monitor yearly. Initiate ERP
	Very High	>7.0	Monitor yearly. Initiate ERP
Early Warning Trigger	Trend of increasing Macroalgae Coefficient		Initiate ERP (Evaluation and Response Plan)

HIGH DENSITY MACROALGAL COVER

The high density macroalgae condition rating targets areas of high density growth and is applied to the percentage of the estuary where the cover of intertidal macroalgae exceeds 50%. While this may not necessarily be combined with the presence of nuisance conditions, dense growths are an early warning of the estuary potentially exceeding its assimilative capacity and developing gross eutrophic conditions. A trend of an increasing dense macroalgal cover, or an increasing Macroalgal Coefficient for low density cover, provides an "early warning trigger" for initiating management action.

HIGH DENSITY MACROALGAL COVER CONDITION RATING

CONDITION RATING	>50% MACROALGAL COVER OVER:	RECOMMENDED RESPONSE
Very Low	<1% of estuary	Monitor at 5 year intervals after baseline established
Low	1-5% of estuary	Post baseline, monitor 5 yearly. Initiate ERP
Moderate	6-10% of estuary	Monitor yearly. Initiate Evaluation & Response Plan
High	11-30% of estuary	Monitor yearly. Initiate Evaluation & Response Plan
Very High	>30% of estuary	Monitor yearly. Initiate Evaluation & Response Plan

Harbour subtidal sediment quality

GWRC's harbour monitoring programme focuses on the impacts of urban-derived stormwater contaminants on subtidal sediment quality and benthic ecology. The design of the programme followed initial advice from the National Institute of Water and Atmospheric Research Limited (NIWA) and was modelled on the programme used to assess intertidal sediment contamination in harbours in the Auckland region (Ray et al. 2003). At each monitoring site sediment core samples are collected (along with 'benthos' sediment core samples) and the surface (top 30 mm) sediments analysed for a suite of persistent and toxic sediment contaminants associated with urban stormwater discharges, including heavy metals, polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCPs) and organotin compounds associated with anti-fouling products. Supporting sediment variables that assist with the interpretation of these contaminants and the health of the benthic fauna community are also monitored, namely particle size and total organic carbon. Refer to Oliver and Milne (2012) for details of the analytical methods.

Sandy beach condition

There is currently no nationally recognised protocol for ecological monitoring of sandy beaches. The monitoring methods employed at Castlepoint Beach were devised by Robertson and Stevenson (2008b) based on an approach taken by Aerts et al. (2004) for monitoring a sandy beach in Ecuador. Six stations are sampled along two transects that span from high to low tide, with the following fine scale variables measured at each station: sediment particle size, sediment oxygenation, and benthic fauna abundance and diversity. Other fine scale indicators relating to eutrophication and sediment contamination are not monitored at Castlepoint because this beach has no major nutrient or toxic contaminant inputs.