greater WELLINGTON
REGIONAL COUNCIL
Te Pane Matua Taiao

Coastal State of the Environment monitoring programme

Annual data report, 2013/14

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GW/ESCI-T-14/122
ISBN: 978-1-927217-66-5 (online)

November 2014

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The report may be cited as:

Oliver MD. 2014. *Coastal state of the environment monitoring programme: Annual data report 2013/14.* Greater Wellington Regional Council, Publication No. GW/ESCI-T-14/122, Wellington.

Contents

1. Introduction

This report summarises the key results of microbiological water quality, sediment quality, ecological health and habitat monitoring undertaken in the Wellington region's near-shore coastal environment for the period 1 July 2013 to 30 June 2014. 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 2014 for the 2013/14 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 (2014), with the location of the 61 monitoring sites shown in Figure 2.1 and listed in Appendix 1. In terms of coastal ecological monitoring, the core monitoring sites are located in Porirua and Wellington harbours, Waikanae, Hutt and Whareama estuaries, and Castlepoint and Peka Peka beaches (Figure 2.2, Appendix 1).

In addition, habitat mapping of key substrate and habitat types is carried out at selected sites approximately every five years. In the past, habitat mapping has been limited to the intertidal areas of estuaries but in early 2014, habitat mapping was extended to the subtidal areas of Porirua Harbour.

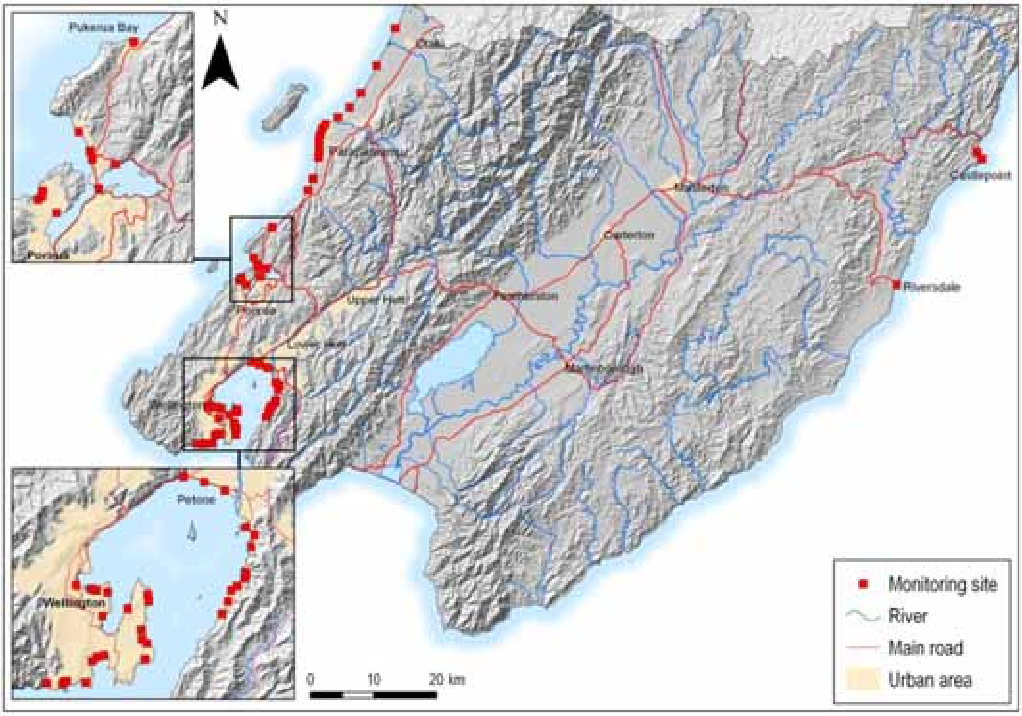


Figure 2.1: Coastal microbiological water quality monitoring sites sampled during 2013/14

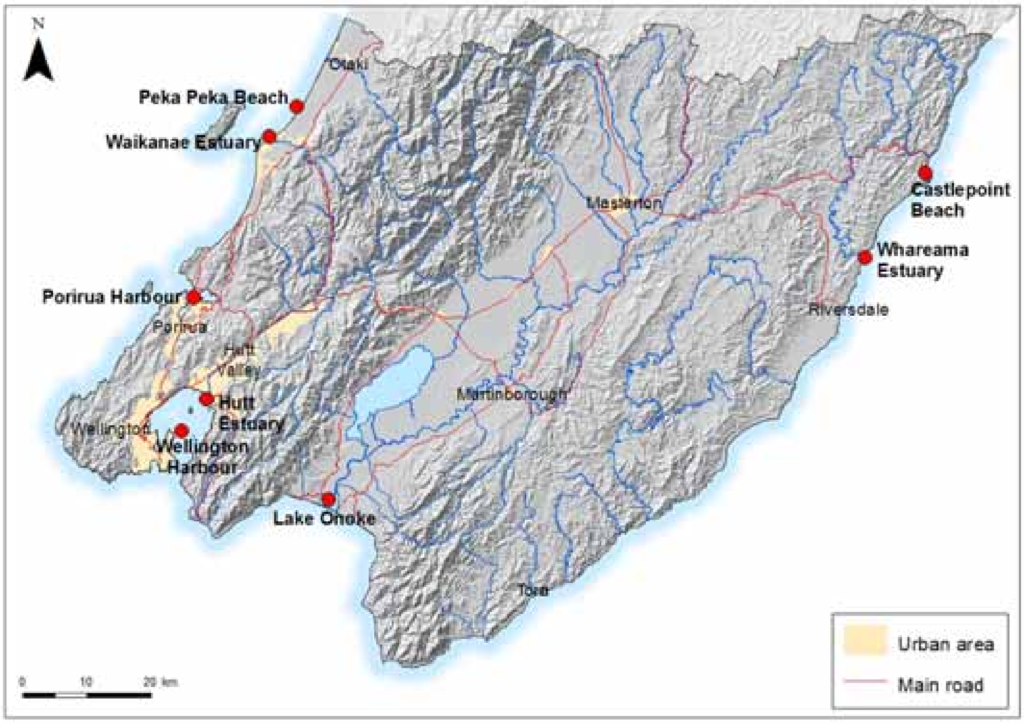


Figure 2.2: Map of the current core estuary, harbour and sandy beach ecological monitoring sites in the Wellington region as at 30 June 2014

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 2013/14

Coastal monitoring undertaken over the period 1 July 2013 to 30 June 2014 included:

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

In addition to the monitoring undertaken in 2013/14, a summary of the 2011 Wellington Harbour subtidal sediment survey is presented in Section 6. Reporting on this survey was completed in early 2014, following lengthy delays with further laboratory sample analysis.

2.3 Monitoring variables

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 2013 and March 2014 during 2013/14 and monthly outside of this period. See Morar and Greenfield (2014) 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 2013 to 30 June 2014 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 2013 and 30 June 2014 inclusive

Site	Total no. of samples	Enterococci (cfu/100 mL)		
		Median	95th percentile	Max
Kapiti Coast				
Otaki Beach at Surf Club	31	10	218	755
Te Horo Beach at Sea Rd	30	15	196	510
Peka Peka Beach at Road End	28	5	51	155
Waikanae Beach at William St	27	5	46	85
Waikanae Beach at Ara Kuaka Carpark	27	3	53	70
Paraparaumu Beach at Ngapotiki St	29	22	176	205
Paraparaumu Beach at Nathan Ave	32	18	232	255
Paraparaumu Beach at Maclean Park	31	33	319	670
Paraparaumu Beach at Toru Rd	31	25	240	500
Raumati Beach at Tainui St	35	20	292	550
Raumati Beach at Marine Gardens	29	24	145	305
Raumati Beach at Aotea Rd	31	15	198	300
Paekakariki Beach at Whareroa Rd	29	14	126	225
Paekakariki Beach at Surf Club	28	4	86	240
Porirua				
Pukerua Bay	28	6	217	1,500
Karehana Bay at Cluny Road	30	6	290	900
Plimmerton Beach at Bath Street	32	12	309	1,300
South Beach at Plimmerton	33	32	1,050	1,500
Pauatahanui Inlet at Water Ski Club	30	18	731	4,000
Pauatahanui Inlet at Paremata Bridge	31	12	275	560
Porirua Harbour at Rowing Club	36	46	1,025	1,300
Titahi Bay at Bay Drive	29	20	206	530
Titahi Bay at Toms Road	32	14	803	2,100
Titahi Bay at South Beach Access Road	31	56	485	1,300

Site	Total no. of samples	Enterococci (cfu/100 mL)		
		Median	95th percentile	Max
Wellington City				
Aotea Lagoon	30	16	471	1,000
Oriental Bay at Freyberg Beach	30	4	300	330
Oriental Bay at Wishing Well	30	8	470	860
Oriental Bay at Band Rotunda	28	6	111	240
Balaena Bay	31	2	480	2,000
Hataitai Beach	31	4	380	650
Shark Bay	35	8	585	1,100
Mahanga Bay	32	4	424	740
Scorching Bay	30	4	419	640
Worser Bay	30	8	260	500
Seatoun Beach at Wharf	32	10	327	400
Seatoun Beach at Inglis Street	29	4	195	420
Breaker Bay	30	3	560	6,400
Lyall Bay at Tirangi Road	31	4	200	460
Lyall Bay at Onepu Road	29	2	156	410
Lyall Bay at Queens Drive	30	2	329	3,400
Princess Bay	28	2	92	920
Island Bay at Reef St Recreation Ground	35	28	1,700	5,400
Island Bay at Surf Club	32	6	1,252	3,800
Island Bay at Derwent Street	36	18	970	4,400
Owhiro Bay	35	12	1,216	4,400
Hutt				
Petone Beach at Water Ski Club	35	12	398	680
Petone Beach at Sydney Street	36	44	1,125	4,300
Petone Beach at Kiosk	33	12	562	1,400
Sorrento Bay	32	10	583	960
Lowry Bay at Cheviot Road	37	40	1,200	1,300
York Bay	29	4	186	690
Days Bay at Wellesley College	29	16	130	820
Days Bay at Wharf	30	12	234	720
Days Bay at Moana Road	31	20	320	480
Rona Bay at N end of Cliff Bishop Park	35	36	683	700
Rona Bay at Wharf	31	20	465	980
Robinson Bay at HW Shortt Recreation Ground	33	20	324	630
Robinson Bay at Nikau Street	35	28	376	980
Wairarapa				
Castlepoint Beach at Castlepoint Stream	27	2	42	150
Castlepoint Beach at Smelly Creek	27	2	72	200
Riversdale Beach Between the Flags	27	2	37	88

Table 3.2: Summary of faecal coliform counts recorded at seven marine shellfish gathering sites monitored between 1 July 2013 and 30 June 2014 inclusive

Site	Total no. of samples	Faecal coliforms (cfu/100 mL)		
		Median	95th percentile	Max
Kapiti Coast				
Otaki Beach at Surf Club	31	35	688	8,800
Peka Peka Beach at Road End	28	13	160	305
Raumati Beach at Tainui Street	34	48	845	1,435
Porirua				
Porirua Harbour at Rowing Club	29	56	856	1,020
Wellington City				
Shark Bay	32	4	672	960
Mahanga Bay	31	4	810	1,760
Hutt				
Sorrento Bay	30	16	369	670

4. Estuary condition

In January 2014, 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 (2014a–h) and the key findings are summarised in Table 4.1.

In broad terms the surveys of the five key estuaries included measurements of Redox Potential Discontinuity (RPD)[1], 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. The monitoring variables and analytical methods are summarised in Appendix 2.

Table 4.1 presents sedimentation rates measured over buried plates for the period January 2013 to January 2014. Mean annual sedimentation rates 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 depositional zones.

Broad scale subtidal habitat mapping was also carried out in Porirua Harbour in January 2014 (Stevens & Robertson 2014c). This is the first subtidal survey of this kind and complements the intertidal habitat surveys undertaken in 2008 and 2013 (Stevens & Robertson 2008, 2013). A summary of the dominant substrate categories and area of seagrass is presented in Table 4.2. Figure 4.1 provides an example of the habitat maps produced from the field data. A more detailed explanation of the methods used to map subtidal substrates and habitats can be found in Appendix 2.

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

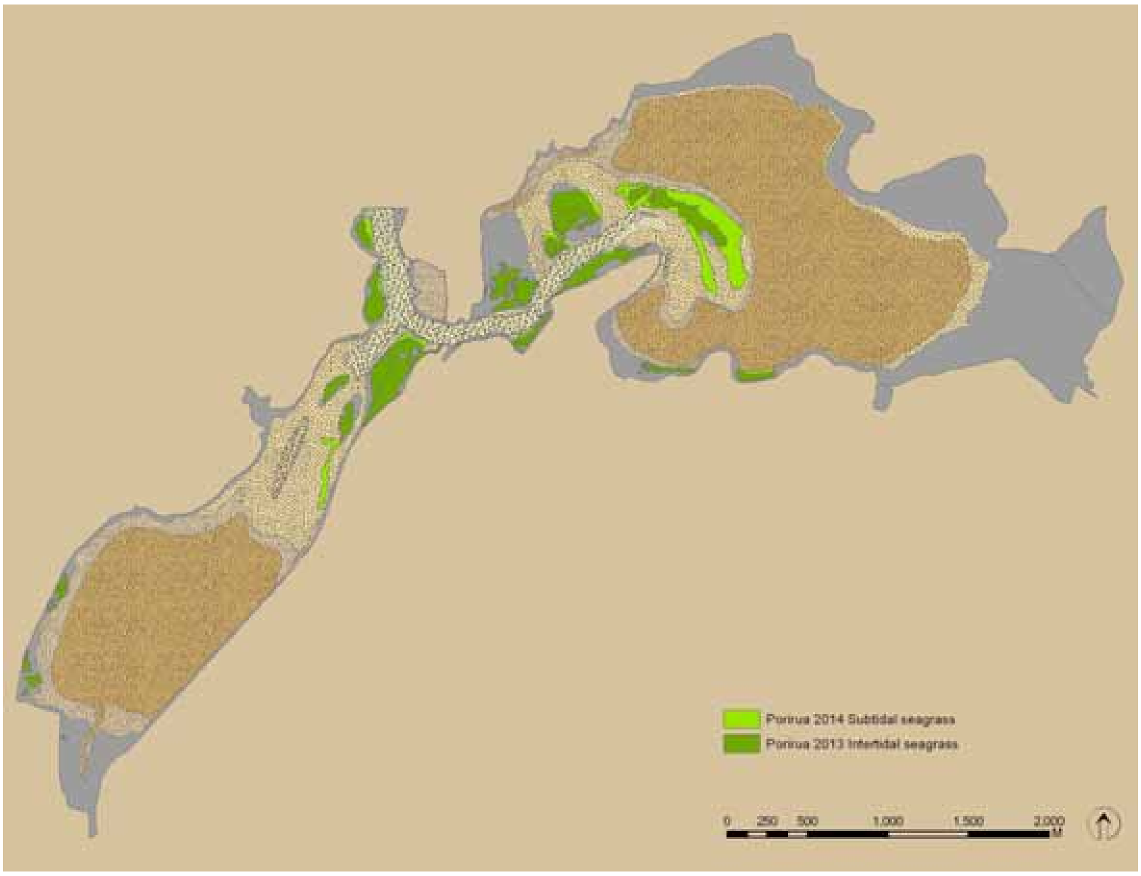
Table 4.1: Sedimentation and eutrophication indicator results for estuaries monitored in early 2014. Porirua Harbour cells shaded in light blue and dark blue equate to intertidal and subtidal sites, respectively

		Sedimentation				Eutrophication	
		Sedimentation rate (2013/14)	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		19.0	26.4	4	1.5	0.1 (very low)	<1% (very low)
Hutt Estuary		-9.3	-4.2	4	1.5	4.8 (high)	52% (very high)
Whareama Estuary		20.0	11.2	6	1	Not assessed	Not assessed
Porirua Harbour							
Onepoto Arm	1	-4.3	1.4	6	1.5	1.6	15.5%
	2	-0.3	6.0	2	3		
	3	1.8	2.3	6	1		
	S6	0.0	0.0	1	1		Not assessed
	S7	-6.0	-6.0	1	3		
	S8	-8.0	-8.0	1	5		
	S9	0.0	-2.7	6	5		
Pauatahanui Arm	6	-2.0	0.3	5	3	2.7	1.4%
	7	-4.0	2.6	2	2		
	8	-2.5	-0.3	2	1		
	9	4.5	0.8	6	1.5		
	10	14.8	5.9	2	3		
	11	-30.0[1]	-30.0	1	3		
	S1	6.6	6.6	1	1		Not assessed
	S2	26.4	26.4	1	1		
	S3	8.0	8.0	1	1		
	S4	11.0	11.0	1	3		
	S5	9.2	9.2	1	3		

[1] Change attributable to localised movement of intertidal sands and does not reflect a significant change in sedimentation.

Table 4.2: Summary of dominant subtidal substrate categories and area of seagrass determined from broad scale subtidal habitat mapping of Porirua Harbour in January 2014. The numbers in brackets represent the area of intertidal substrate or habitat type recorded in a 2013 survey (see Stevens & Robertson 2013)

Habitat/substrate category	Pauatahanui Arm	Onepoto Arm	Whole estuary
Substrate			
Firm sand (ha)	16.5 (17.0)	20.8 (0.6)	37.3 (17.7)
Firm mud/sand (ha)	103.3 (103.2)	87.1 (32.8)	190.4 (136)
Very soft mud (ha)	215.5 (16.5)	113.1 (3.3)	328.7 (19.8)
TOTAL	*335.3 (136.7)*	*221(36.7)*	*556.4 (173.5)*
Habitat			
Seagrass (ha)	15.2 (22.2)	3.1 (15.2)	18.3 (37.4)



(Source: Stevens & Robertson 2014c)

Figure 4.1: Habitat map showing the location of intertidal and subtidal seagrass beds recorded during the 2013 and 2014 broad scale surveys of Porirua Harbour

4.1 Additional monitoring

During 2013/14, three monitoring stations collected continuous turbidity data in the lower reaches of the Porirua, Pauatahanui and Horokiri streams. These streams drain the three largest subcatchments of Porirua Harbour and were identified via CLUES[2] modelling as the greatest contributors of sediment to the harbour. This monitoring is being carried out to support the actions of the Porirua Harbour and Catchment Strategy and Action Plan (PCC 2012).

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

During 2013/14 discrete wet weather water sampling was also carried out with a focus on suspended sediment (and to a lesser extent nutrients and *E. coli*) from the subcatchments of Porirua Stream.

The results of the continuous turbidity monitoring and wet weather sampling are reported in Morar et al. (2014) and Milne and Morar (in prep), respectively.

[2] 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. Beach sediment quality/condition

In January 2014, Wriggle Coastal Management carried out surveys of Castlepoint and Peka Peka beaches. The surveys are documented in full in Robertson and Stevens (2014a,b) and the key findings are summarised in Table 5.1.

The beach surveys included assessments of the following key condition indicators: sediment oxygenation, sediment grain size, beach, macrofauna and beach morphometry. A baseline assessment was carried out at Castlepoint Beach in 2008 and 2009 (Robertson & Stevens 2008a, 2009) and this current survey represents the first assessment since the baseline was established. Peka Peka Beach was selected for annual baseline assessment over the next two to three years as an example of a dissipative[3] beach on the region's west coast.

Table 5.1 presents the Redox Potential Discontinuity depth (an indicator of sediment oxygenation), the sediment mud content and the macroinvertebrate enrichment index as an indicator of the risk of organic enrichment. Other fine scale indicators relating to eutrophication and sediment contamination are not monitored at Castlepoint or Peka Peka beaches because these beaches have no major nutrient or toxic contaminant inputs.

Table 5.1: Summary of beach condition risk indicator results from the January 2014 beach surveys

Site	RPD depth (cm)	% mud	Macroinvertebrate enrichment index
Peka Peka Beach	>15	0.3–1.1	1.2–3.3 (Low)
Castlepoint Beach	>15	0.3–1.4	1.2–3.3 (Low)

[3] Dissipative beaches are characterised as being high energy beaches with a wide surf zone and a low-sloping and wide beach face consisting of fine sand.

6. Wellington Harbour subtidal sediment quality

6.1 Introduction and background

In late 2011 GWRC commissioned the second survey of sediment quality and benthic community health at 16 subtidal sites in Wellington Harbour; ten of these sites were previously sampled in 2006 and six sites were new (Figure 6.1). In addition, sediment samples from the stormwater catchpits of five Wellington city catchments were collected for PAH source reconciliation (Figure 6.2). The survey was jointly funded by GWRC and Wellington City Council.

Laboratory analyses of the 2011 samples were largely complete by late 2012. However, inconsistencies in the sediment particle size data necessitated re-analysis of the samples from both the 2006 and 2011 surveys. These repeated analyses were carried out in 2013 and final reporting was completed in early 2014. Full details of the survey are reported in Oliver (2014) and the key findings are summarised here. See Appendix 2 for a summary of the methods.

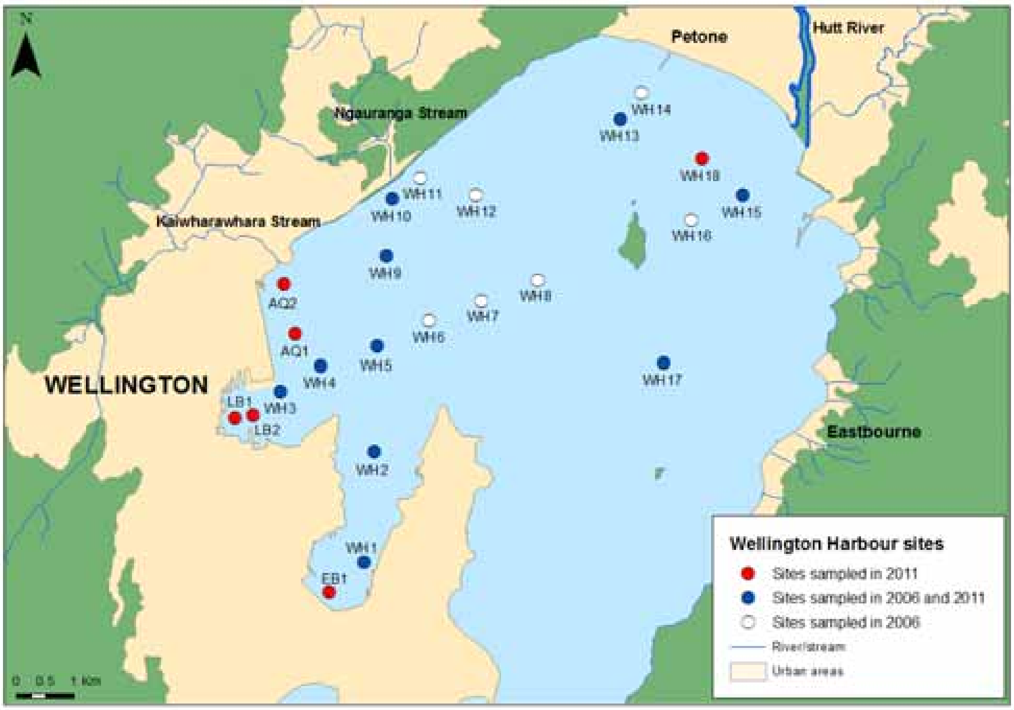


Figure 6.1: Map of Wellington Harbour showing the subtidal locations sampled in 2006 and 2011. Sample collection and analyses at sites EB1, WH1–5, LB1–2, AQ1–2 and WH10 were funded by Wellington City Council

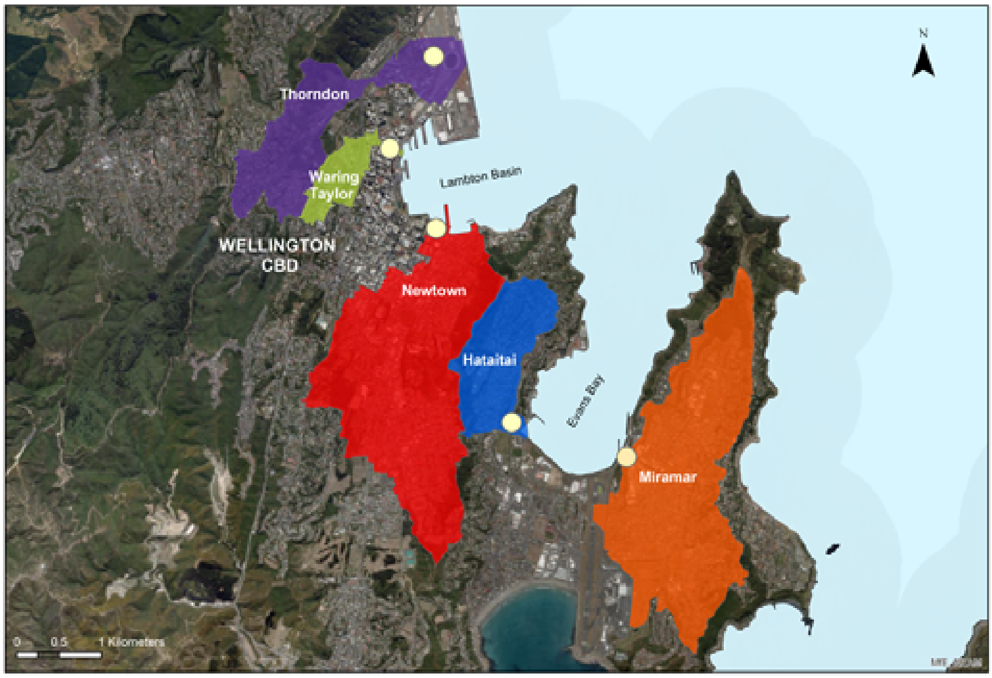


Figure 6.2: Map of Wellington city showing the stormwater catchments (coloured areas) and location of roadside catchpit samples (yellow circles) collected in September 2011

6.2 Key findings

A selection of the metal and organic contaminants found in both harbour and catchpit sediment samples are presented in Table 6.1 and 6.2, respectively. The key findings of the 2011 survey, summarised from Oliver (2014), were:

- Concentrations of total copper, lead, zinc and mercury exceeded nationally recognised 'early warning' (ie, ARC (2004) ERC[4]-amber or ANZECC[5] (2000) ISQG-Low) sediment quality guidelines at several sites throughout Wellington Harbour;
- There was evidence of a contaminant gradient extending offshore with some of the highest concentrations of copper, lead, zinc and mercury found at the inner harbour sites adjacent to Wellington city;
- Concentrations of high molecular weight polycyclic aromatic hydrocarbons (HMW PAHs) exceeded ARC ERC-red and ANZECC ISQG-Low sediment quality guidelines at all of the inner harbour and Evans Bay sampling sites, although PAH source analysis indicates that much of this contamination is historic;
- The insecticide DDT remains a ubiquitous legacy contaminant throughout the harbour with total DDT concentrations being highest at the inner harbour sites where they exceeded the ARC ERC-red threshold;
- A total of 124 invertebrate taxa were identified in the 2011 survey, with polychaete worms, crustaceans, sipunculids and bivalves the most abundant invertebrates present; and

[4] Auckland Council (ARC) Environmental Response Criteria (ERC) (ARC 2004).

[5] Australia and New Zealand Environment and Conservation Council (ANZECC) Interim Sediment Quality Guidelines (ISQG) (ANZECC 2000).

- Stormwater catchpit sediment samples contained significant concentrations of copper, lead and zinc.

Table 6.1: Percentage of mud particles (<63 µm) and summary of concentrations (mg/kg dry weight) and variability (co-efficient of variation [c.v., %], *n*=5[1]) of selected total recoverable metals and organic contaminants in sediments of 16 sites sampled in Wellington Harbour in 2011 (<500 µm fraction). Cells highlighted in orange exceed the ARC (2004) ERC amber threshold and cells in red exceed the ARC (2004) ERC red threshold and/or ANZECC (2000) ISQG-Low trigger value

Site	% mud	Copper	Mercury	Lead	Zinc	HMW PAH @ 1% TOC[2]	DDT @ 1% TOC[2]
EB1	2 (9)	4.9	0.21	27	47	812 (8.5)	2.6 (10)
WH1	35 (6)	22	0.69	68	121	1,992 (3.9)	6.4 (4.6)
WH2	64 (10)	16	0.60	51	104	1,053 (1.2)	3.6 (3.8)
LB1	17 (16)	39	0.56	62	114	1,959 (6.1)	14.9 (16)
LB2	37 (15)	38	0.63	67	133	1,668 (5.3)	7.9 (9.9)
WH3	68 (3)	26	0.63	60	122	1,496 (2.6)	16.9 (82)
WH4	65 (8)	19	0.45	49	111	779 (3.2)	3.9 (5.6)
AQ1	58 (14)	19	0.50	47	105	981 (5.9)	6.5 (6.3)
AQ2	25 (5)	17.4	0.44	65	104	1,034 (6.1)	5.9 (9.7)
WH5	78 (4)	12.9	0.29	37	90	462 (2.7)	2.6 (5.8)
WH9	89 (9)	13.5	0.24	36	96	334 (2.5)	1.9 (6.7)
WH10	90 (4)	16.2	0.27	45	109	457 (3.6)	3.0 (6.1)
WH13	82 (5)	15.2	0.20	39	102	257 (20.3)	1.7 (4.4)
WH18	81 (5)	14.7	0.16	35	95	180 (3.0)	1.9 (5.8)
WH15	62 (5)	14.7	0.16	31	90	139 (6.1)	1.7 (2.7)
WH17	45 (5)	11.0	0.12	29	80	242 (3.4)	1.4 (5.5)

[1] For percentage of particles, PAH and DDT concentrations only.

[2] ANZECC (2000) requires concentrations of organic contaminants to be normalised to 1% total organic carbon (TOC).

Table 6.2: Summary of mean concentrations of total organic carbon (TOC), total metals, total petroleum hydrocarbons (TPH) and total polycyclic aromatic hydrocarbons (PAHs) in catchpit sediments (<500 µm fraction) of five Wellington city stormwater catchments sampled in September 2011

Analyte	*n*	Site				
		Thorndon	Waring Taylor	Newtown	Hataitai	Miramar
TOC (%)	2	3.0	4.1	7.3	9.1	5.4
% <63 µm	1	3.5	32	8.0	7.4	6.7
Copper (mg/kg)	2	129	189	335	285	250
Lead (mg/kg)	2	144	255	196	420	215
Mercury (mg/kg)	2	0.064	0.33	0.076	0.076	0.091
Zinc (mg/kg)	2	870	895	885	715	810
Total TPH (mg/kg)	1	1,940	1,220	2,300	460	940
Total PAH (µg/kg)	2	4,300	8,241	9,411	3,794	2,796

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 microbiological water quality summary statistics.

Dr Barry Robertson, Leigh Stevens and Ben Robertson of Wriggle Coastal Management Ltd undertake the estuarine, beach and habitat mapping fieldwork and reporting.

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Appendix 1: Monitoring sites

Tables A1.1 to A1.9 list coastal sites monitored or reported on during 2013/14. 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: Waikanae Estuary intertidal sampling locations

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

Table A1.3: 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 A1.4: 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)

Table A1.5: Porirua Harbour sediment plate locations

Sampling site	Location	NZTM co-ordinates Easting	NZTM co-ordinates 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 A1.6: Peka Peka Beach sampling locations

Sampling site	NZTM co-ordinates Easting	NZTM co-ordinates Northing
Peka Peka Beach A	1772686 (High shore) 1772620 (Low shore)	5477096 (High shore) 5477156 (Low shore)
Peka Peka Beach B	1772657 (High shore) 1772585 (Low shore)	5477060 (High shore) 5477120 (Low shore)

Table A1.7: Castlepoint Beach sampling locations

Sampling site	NZTM co-ordinates Easting	NZTM co-ordinates Northing
Castlepoint Beach A	1871628 (High shore) 1871669 (Low shore)	5469783 (High shore) 5469777 (Low shore)
Castlepoint Beach B	1871614 (High shore) 1871641 (Low shore)	5469730 (High shore) 5469710 (Low shore)

Table A1.8: Site location and sample collection details for the Wellington Harbour sediment quality survey carried out over October to December 2011 (sites sampled in 2006 only are also listed)

Site	Location	Sample date	NZTM co-ordinates Easting	NZTM co-ordinates Northing	Depth (m)
WH1 WH1B	Southern Evans Bay	12/11/2011 14/11/2011	1751530 1751492	5425348 5425333	19
WH2 WH2B	Northern Evans Bay	12/11/2011 12/11/2011	1751710 1751744	5427288 5427271	19
WH3 WH3B	Lambton Basin entrance	14/11/2011 05/12/2011	1750056 1750055	5428340 5428303	18
WH4 WH4B	~ 0.7 km NW of Point Jerningham	14/11/2011 05/12/2011	1750763 1750775	5428789 5428760	20
WH5 WH5B	~ 1.2 km NNE of Point Jerningham	14/11/2011 14/11/2011	1751748 1751743	5429138 5429104	21
WH6 WH6B	≈ 1.25 km NW of Point Halswell	Sampled in 2006 only	1752665 1752646	5429581 5429560	22
WH7 WH7B	≈ 1.5 km N of Point Halswell	Sampled in 2006 only	1753581 1753604	5429932 5429907	22
WH8 WH8B	≈ 1.5 km SW of Matiu/Somes Island	Sampled in 2006 only	1754566 1754571	5430282 5430310	23
WH9 WH9B	~ 1.5 km SSE of Ngauranga Stream mouth	30/11/2011 30/11/2011	1751921 1751975	5430708 5430747	20
WH10 WH10B	~ 0.5 km SSE of Ngauranga Stream mouth	30/11/2011 30/11/2011	1752012 1752008	5431724 5431740	20
WH11 WH11B	≈ 0.5 km E of Ngauranga Stream mouth	Sampled in 2006 only	1752508 1752541	5432084 5432099	20
WH12 WH12B	≈ 1.5km E of Ngauranga Stream mouth	Sampled in 2006 only	1753480 1753516	5431786 5431804	21
WH13 WH13B	~ 1.25 km S of Petone Wharf	12/11/2011 28/10/2011	1756023 1756061	5433121 5433126	16
WH14 WH14B	≈ 0.65 km S of Petone Wharf	Sampled in 2006 only	1756382 1756422	5433576 5433553	12
WH15 WH15B	~ 1.1 km SW of Seaview (Hutt River mouth)	28/10/2011 28/10/2011	1758160 1758176	5431778 5431750	16
WH16 WH16B	≈ 2.1 km SW of Seaview (Hutt River mouth)	Sampled in 2006 only	1757243 1757129	5431336 5431335	19
WH17 WH17B	~ 1.6 km NNW of Makaro/Ward Island	28/10/2011 28/10/2011	1756770 1756793	5428847 5428858	21
WH18 WH18B	~1.75 km WSW of Seaview (Hutt River mouth)	12/11/2011 28/10/2011	1757450 1757460	5432426 5432435	16
EB EB B	SW Evans Bay ~250 m from shore (Cobham Drive)	12/11/2011 12/11/2011	1750921 1750920	5424829 5424860	7
LB1 LB1B	Lambton Harbour ~ 250 m from shore (FK Park)	30/11/2011 30/11/2011	1749263 1749262	5427887 5427872	10
LB2 LB2 B	Lambton Harbour ~ 500 m from shore (FK Park)	30/11/2011 14/11/2011	1749576 1749541	5427939 5427940	14
AQ1 AQ1 B	~ 0.5 km ENE of Aotea Quay east	05/12/2011 05/12/2011	1750317 1750331	5429346 5429374	20
AQ2 AQ2 B	~ 0.5 km ENE of Aotea Quay west	05/12/2011 05/12/2011	1750125 1750133	5430214 5430254	16

Table A1.9: Catchments and location of the Wellington city catchpits sampled in September 2011

Catchment	NZTM co-ordinates	
	Easting	Northing
Thorndon	1749358.23	5429342.68
Waring-Tayor St	1748886.66	5429274.71
Newtown	1749358.23	5427400.92
Hataitai	1750148.81	5425098.54
Miramar	1751743.83	5424793.40

Appendix 2: Monitoring variables and methods

Microbiological water quality

Microbiological water quality monitoring is undertaken in accordance with the 2003[6] 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 (2014) for full details of GWRC's microbiological water quality monitoring methods.

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 2008b; 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 A2.1). 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 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 A2.1) (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.

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

Table A2.1: 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 (2008b), Stevens & Robertson (2008))

<table>
<tr><th>Issue</th><th>Indicator</th><th>Indicator type</th><th>Rationale</th></tr>
<tr><td rowspan="4">Sedimentation</td><td>Soft mud area</td><td>BS</td><td rowspan="3">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.</td></tr>
<tr><td>Sediment composition (% mud)</td><td>FS</td></tr>
<tr><td>Sedimentation rate</td><td>FS</td></tr>
<tr><td>Diversity of benthic fauna</td><td>FS</td><td>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.</td></tr>
<tr><td rowspan="5">Eutrophication (nutrient enrichment)</td><td>Nuisance macroalgae cover</td><td>BS</td><td>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.</td></tr>
<tr><td>Organic content</td><td>FS</td><td>High sediment organic content can result in anoxic sediments and bottom water, release of excessive nutrients, and adverse impacts on biota.</td></tr>
<tr><td>Sediment nutrient concentrations:
• Nitrogen
• Phosphorus</td><td>FS</td><td>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).</td></tr>
<tr><td>Sediment oxygenation (RPD depth)</td><td>FS</td><td>Surface sediments need to be well oxygenated to support healthy invertebrate communities (anoxic sediments contain toxic sulphides and very little aquatic life).</td></tr>
<tr><td>Diversity of benthic fauna</td><td>FS</td><td>Soft sediment macrofauna can be used to represent benthic community health and classify estuary condition.</td></tr>
<tr><td rowspan="2">Toxic contamination</td><td>Sediment contamination – eg, concentrations of:
• heavy metals
• PAHs
• pesticides</td><td>FS</td><td>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.</td></tr>
<tr><td>Diversity of benthic fauna</td><td>FS</td><td>Soft sediment macrofauna can be used to represent benthic community health and classify estuary condition.</td></tr>
<tr><td rowspan="3">Habitat loss</td><td>Saltmarsh area</td><td>BS</td><td rowspan="3">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.</td></tr>
<tr><td>Seagrass area</td><td>BS</td></tr>
<tr><td>Vegetated terrestrial buffer</td><td>BS</td></tr>
</table>

A series of interim fine and broad scale estuary 'condition ratings' (reproduced as Tables A2.2–A2.4) 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 and 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).

Table A2.2: Interim fine scale estuary 'condition ratings' used to assess estuaries in the Wellington region

(Source: Stevens & Robertson (2014e))

RISK INDICATOR RATING	SEDIMENTATION RATE[1]	MUD CONTENT[2]	RPD DEPTH[3]
Very Low	<1mm/yr	<2%	>10cm
Low	>1-2mm/yr	2-5%	3-10cm
Moderate	>2-5mm/yr	>5-15%	1-<3cm
High	>5-10mm/yr	>15-25%	0-<1cm
Very High	>10mm/yr	>25%	Anoxic at surface

NOTES:

[1]**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. Note the very low risk category is based on a typical NZ pre-European average rate of <1mm/year, which may underestimate sedimentation rates in soft rock catchments.

[2]**Sediment Mud Content:** In their natural state, most NZ estuaries would have been dominated by sandy or shelly substrates. Fine sediment is likely to cause detrimental and difficult to reverse changes in community composition (Robertson 2013), can facilitate the establishment of invasive species, increase turbidity (from re-suspension), and reduce amenity values. High or increasing mud content can indicate where changes in land use management may be needed.

[3]**Redox Potential Discontinuity (RPD):** RPD depth, the transition between oxygenated sediments near the surface and deeper anoxic sediments, is a primary estuary condition indicator as it is a direct measure of whether nutrient and organic enrichment exceeds levels causing nuisance (anoxic) conditions. Knowing if the 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 support very little aquatic life.

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. The tendency for sediments to become anoxic is much greater if the sediments are muddy.

Table A2.3: Visual rating scale for percentage cover estimates for macroalgae (top) and seagrass (bottom)

(Source: Stevens & Robertson (2013))

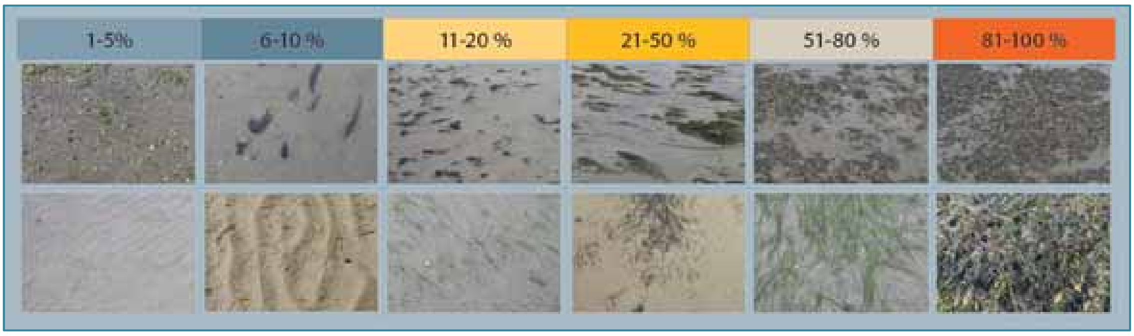

Table A2.4: Broad scale 'condition ratings' for areas of low and high density macroalgae cover (Source: Stevens & Robertson (2013))

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

Sandy beach condition

There is currently no nationally recognised protocol for ecological monitoring of sandy beaches. The monitoring methods employed at Castlepoint and Peka Peka beaches were devised by Robertson and Stevenson (2008a) 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 or Peka Peka beaches as they have no major nutrient or toxic contaminant inputs.

A series of interim fine scale beach condition risk ratings (reproduced as Table A2.5) from reports prepared for GWRC by Wriggle Coastal Management) are proposed for Castlepoint and Peka Peka beaches. The ratings have been established to provide a defensible, cost-effective way to help identify environmental pressures and to assess changes in the long-term condition of beach ecosystems. The design is based on the use of primary indicators that have a documented strong relationship with water or sediment quality. Each rating is designed to be used in combination with other ratings and under expert guidance to assess overall beach condition and to make appropriate monitoring and management recommendations.

Table A2.5: Summary of beach condition risk indicator ratings

(Source: Stevens & Robertson (2014b))

INDICATOR	RISK RATING				
	Very Low	Low	Moderate	High	Very High
Redox Potential Discontinuity (aRPD, cm)	>10cm depth below surface	3-10cm depth below sediment surface	1-<3cm depth below sediment surface	0-<1cm depth below sediment surface	Anoxic conditions at surface
Sediment Mud Content (% mud)	<2%	2-5%	5-15%	15-25%	>25%
Macroinvertebrate Enrichment Index (AMBI)	0-1.2 Intolerant of en-riched conditions	1.2-3.3 Tolerant of slight enrichment	3.3-5.0 Tolerant of moderate enrichment	5.0-6.0 Tolerant of high enrichment	>6.0 Azoic (devoid of invertebrate life)

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. Table A2.6 summarises the analytical methods.

Table A2.6: Subtidal sediment quality analytical methods (see Oliver (2014) and Oliver and Conwell (2014) for further details of analytical test suites and detection limits, including analytical test methods for organotin compounds)

Determinant	Method	Detection limit
Invertebrate identification	Core samples were washed through a 500 µm screen, the retained material preserved in 5% formalin in seawater and then identified to lowest taxonomic level and enumerated under a stereo microscope.	–
Sediment particle/grain size	Eyetech laser particle size analyser, <500 µm fraction.	–
Total organic carbon	Acid pre-treatment to remove carbonates if present, Elementar Combustion Analyser	0.05 g/100 g dry wt
Total recoverable Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Sb and Zn	Dried sample, <500 µm fraction, Nitric/Hydrochloric acid digestion ICP-MS, trace level. US EPA 200.2.	Various
Extractable copper	2M HCl extraction (Solid:Liquid 1:50 w/v), <63 µm fraction, ICP-MS. ARC Tech Publication No 47, 1994.	1 mg/kg dry wt
Extractable lead	2M HCl extraction (Solid:Liquid 1:50 w/v), <63 µm fraction, ICP-MS. ARC Tech Publication No 47, 1994.	0.2 mg/kg dry wt
Extractable zinc	2M HCl extraction (Solid:Liquid 1:50 w/v), <63 µm fraction, ICP-MS. ARC Tech Publication No 47, 1994.	2 mg/kg dry wt
Polycyclic aromatic hydrocarbons (PAHs)	Sonication solvent extraction and GC-MS in selected ion mode.	Various
Organochlorine pesticides (OCPs)	Sonication solvent extraction and GC-MS in selected ion mode.	Various