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Porirua Harbour

Sediment Plate Monitoring 2013/14

Prepared for
Greater Wellington Regional Council
May 2014

Cover Photo: Pauatahanui Inlet - measuring intertidal sediment plates, Jan. 2014.

Porirua Harbour, Onepoto Arm - intertidal flats by Paremata railway station.

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Prepared for
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by

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Porirua Harbour Estuary

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Vulnerability Assessment
Identifies issues and recommends monitoring and management. Completed in 2007 (Robertson and Stevens 2007)

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Porirua Estuary Issues
Moderate eutrophication
Excessive sedimentation
Habitat Loss (saltmarsh, dune and terrestrial margin)

↓

Monitoring

Broad Scale Mapping
Sediment type
Saltmarsh
Seagrass
Macroalgae
Land margin

5 -10 yearly
Undertaken in 2008, 2013.
Repeat survey 2018.

Fine Scale Monitoring
Grain size, RPD, Organic Content
Nutrients, Metals, Invertebrates, Macroalgae, Sedimentation,

4yr Baseline then 5 yearly
Next survey 2015.
Sedimentation annually
Next survey 2015.

↓

Condition Ratings
Area soft mud, Area saltmarsh, Area seagrass, Area terrestrial margin, RPD depth, Benthic Community, Organic content, N and P, Toxicity, Sedimentation rate.

Other Information
Previous reports, Observations, Expert opinion

↓

ESTUARY CONDITION
Moderate Eutrophication
Excessive Sedimentation
Low Toxicity
Habitat Degraded (saltmarsh, terrestrial margin)

↓

Recommended Management

- Limit intensive landuse.
- Set nutrient, sediment guidelines.
- Margin vegetation enhancement.
- Manage for sea level rise.
- Enhance saltmarsh.
- Manage weeds and pests.

Soil erosion is a major issue in New Zealand and the resulting suspended sediment impacts are of particular concern in estuaries because they act as a sink for fine sediments or muds. The main intertidal flats of developed estuaries (e.g. Porirua Harbour) are usually characterised by sandy sediments reflecting their exposure to wind-wave disturbance, and are hence relatively low in mud content (2-10% mud).

Recent monitoring (e.g. Robertson and Stevens 2008, 2009, 2010) showed Porirua Harbour Estuary had low-moderate intertidal sedimentation rates and a benthic invertebrate community dominated by species that prefer sand or a little mud. However, the sand dominated sediments had an elevated mud content, showed a general trend of increasing muddiness, and sediments were not very well oxygenated. Based on these findings, in 2011 Greater Wellington Regional Council (GWRC) decided to undertake annual monitoring of sedimentation rates, grain size, and RPD depth at existing intertidal sites in the estuary (e.g. Stevens and Robertson 2011).

In addition to intertidal areas, Porirua Harbour has also been identified as being particularly at risk from subtidal sedimentation because 65% of the estuary is subtidal, and the main subtidal basins are rapidly infilling (Gibb and Cox 2009). Gibb and Cox (2009) predict that both estuary arms are highly likely to rapidly infill and change from tidal estuaries to brackish swamps within 145-195 years if rates of deposition over the last ~30 years continue. The dominant sediment sources to the estuary were identified as discharges of both bed-load and suspended load from the various input streams (most notably Pauatahanui, Horokiri and Porirua Streams). Elevated inputs of nutrients from the same streams are also causing symptoms of moderate eutrophication (i.e. poor sediment oxygenation and moderate nuisance macroalgal cover) in the estuary (Stevens and Robertson 2013, Robertson and Stevens 2008, 2009, 2010).

In response to these concerns, GWRC convened a technical workshop in April 2011 which drew on expert scientific advice, combined with existing catchment and estuary models, to highlight the areas of greatest predicted deposition. A key output was the recommendation to increase the number of intertidal plates within areas influenced by priority catchments, and to determine suitable methods and locations for the establishment of subtidal sediment plates which is where the greatest sediment deposition in the estuary is expected to occur. In response, four additional intertidal sites were established in February 2012 (3 in Pauatahanui Arm and 1 in the Onepoto Arm - Figure 1), with an additional nine sites established in Jan 2013 (1 intertidal and 5 subtidal sites in the Pauatahanui Arm and 3 subtidal sites in the Onepoto Arm - Figure 1). Following a second technical workshop on sediment issues in the estuary in March 2013, GWRC contracted Wriggle Coastal Management to map broad scale subtidal habitat, and assess key indicators of sediment condition (e.g. grain size, organic carbon, total sulphur, sediment oxygenation). This work, undertaken in January 2014, is presented in Stevens and Robertson (in press 2014).

The current report presents sedimentation rates measured in January 2014 at the intertidal and shallow subtidal sites established in Porirua Harbour (Figure 1). Sediment grain size and RPD were measured at all sites, and risk indicator ratings developed for Wellington's estuaries were used to rate the condition of the estuary,

Installing and checking subtidal plates in the Pauatahanui Arm, January 2013.

1. Introduction and Methods (Continued)

Installing and levelling a sediment plate in Browns Bay, January 2013.

Measuring frame and probe used to measure shallow subtidal plates.

Sediment RPD - Brown (oxic) sediment overlying grey (reduced oxygen) sediment.

Detailed descriptions of existing sampling sites and methods are provided in Robertson and Stevens (2008, 2009, 2010), Stevens and Robertson (2011), and are briefly summarised below.

Sedimentation Rate

To measure the sedimentation rate from now and into the future, concrete plates were buried in December 2007 at 4 intertidal sites and 1 subtidal site in the estuary. An additional 4 intertidal sites (16 plates) were added in January 2012, and 1 intertidal and 8 subtidal plates (30cm diameter concrete pavers) added in January 2013 (Figure 1, see also Appendix 1). Subtidal plates were positioned in soft mud deposition zones by wading from the shore until firmer sediments transitioned to soft muds. These areas were consistently encountered ~1-1.5m below low water depth.

Each plate was positioned and relocated using a handheld Trimble GeoXH differential GPS (post-processing accuracy 10-50cm). Because the subtidal plates were located in very soft muds, a probe was used to carefully locate each plate without disturbing the overlying sediments. A measuring frame (comprising a tube fixed to an aluminium cross piece - see middle sidebar photos) was then aligned over the plate and allowed to settle. A measuring rod was then pushed down through the vertical tube to measure the depth of the plate below the sediment surface. To account for irregular sediment surfaces, 3-5 replicate measures per plate were taken, and averaged to determine the mean annual rate of sedimentation at each site.

Grain Size

To monitor changes in the mud content of sediments, a single composite sample of the top 20mm of sediment was collected from adjacent to each sediment plate site. Samples were analysed by Hill Laboratories for grain size (% mud, sand, gravel). It is recommended that triplicate sampling be undertaken in conjunction with 5 yearly fine scale monitoring to provide a check on within-site sample variability, but that single composite analyses be analysed in intervening years to enable a greater spatial spread of samples to be collected from throughout the estuary within the existing budget.

Redox Potential Discontinuity (RPD) depth

To assess sediment oxygenation, the mean depth to the visually apparent RPD was determined at each intertidal site by repeatedly digging down from the surface with a hand trowel until the mean RPD transition level was located. The same approach was used at subtidal sites, although representative sediment cores were first collected and brought to the surface where the RPD depth was determined.

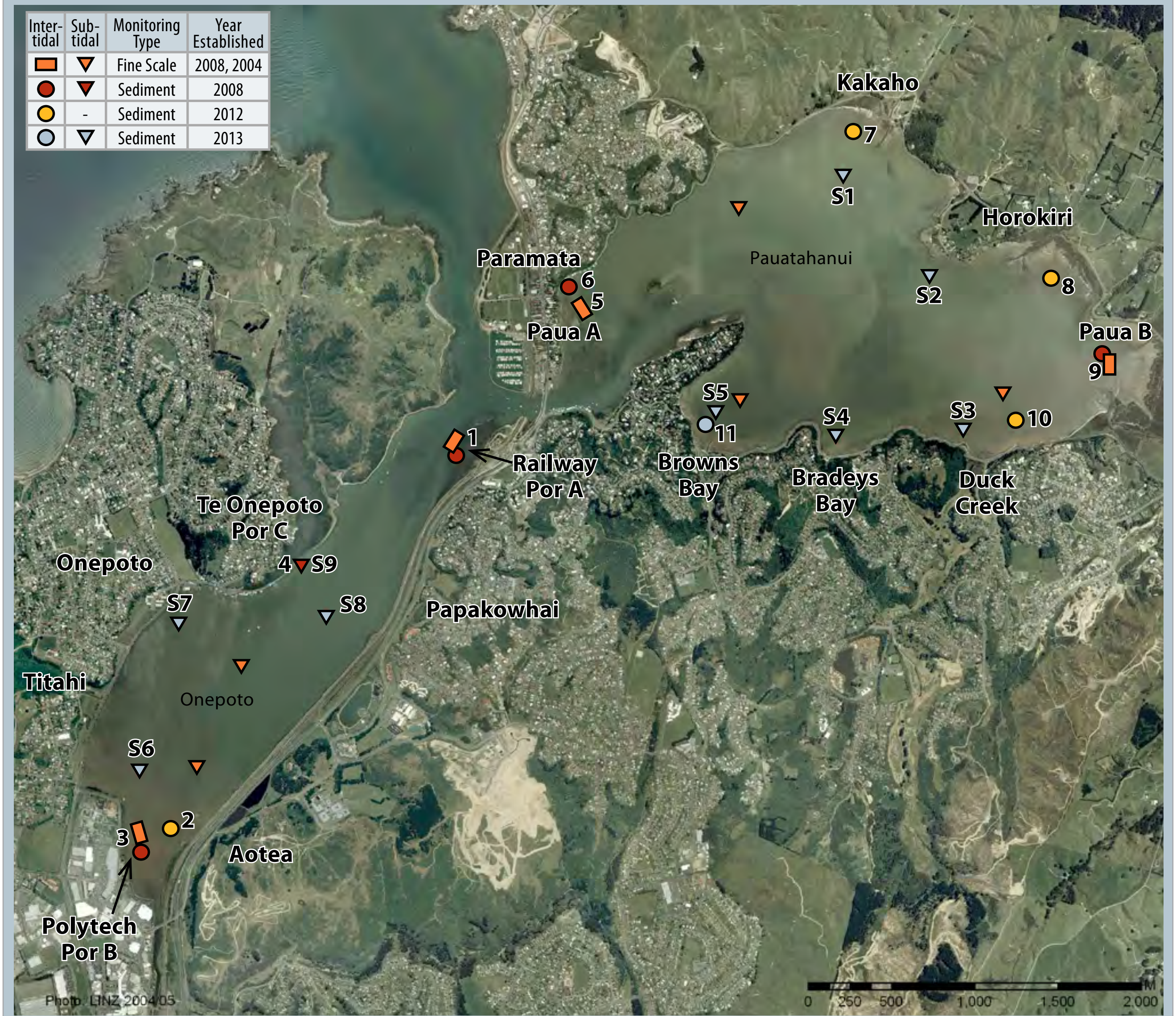


Figure 1. Location of fine scale sites and buried sediment plates established in 2007/8, 2012, and 2013 in Porirua Harbour.

Pauatahanui Inlet looking east toward Horokiri (left) and Duck Creek (right)

2. RISK INDICATOR RATINGS

The National Estuary Monitoring Protocol (NEMP, Robertson et al. 2002), and subsequent additions (e.g. Robertson and Stevens 2006, 2007, 2012), recommend a defensible, cost-effective monitoring design for assessing the long term condition of shallow, intertidally-dominated, NZ estuarine systems. The design is based on the use of indicators that have a documented strong relationship with water or sediment quality. The approach is intended to help quickly identify the likely presence of the predominant issues affecting NZ estuaries (i.e. eutrophication, sedimentation, disease risk, toxicity and habitat change). In order to facilitate this process, "risk indicator ratings" have been proposed that assign a relative level of risk of adversely affecting estuary conditions (e.g. very low, low, moderate, high, very high) to each indicator (see examples below). Each risk indicator rating is designed to be used in combination with relevant information and other risk indicator ratings, and under expert guidance, to assess overall estuary condition in relation to key issues. When interpreting risk indicator results we emphasise:

- The importance of taking into account other relevant information and/or indicator results before making management decisions regarding the presence or significance of any estuary issue.
- That rating and ranking systems can easily mask or oversimplify results. For instance, large changes can occur within a risk category, but small changes near the edge of one risk category may shift the rating to the next risk level.
- Most issues will have a mix of primary and secondary ratings, primary ratings being given more weight in assessing the significance of indicator results.
- Ratings for most indicators have not been established using statistical measures, primarily because of the extensive additional work and cost this requires. In the absence of funding, professional judgment, based on our wide experience from monitoring >300 NZ estuaries, has been used in making initial interpretations. Our hope is that where a high level of risk is identified, the following steps are taken:
    1. Statistical measures be used to refine indicators and guide monitoring and management for priority issues.
    2. Issues identified as having a high likelihood of causing a significant change in ecological condition (either positive or negative) trigger intensive, targeted investigations to appropriately characterise the extent of the issue.
    3. The outputs stimulate discussion regarding what an acceptable level of risk is, and how it should best be managed.

The indicators and risk ratings relevant to the Porirua Harbour sediment monitoring programme are presented in Table 1 below:

Table 1. Risk indicator ratings for sedimentation rate, sediment mud content, and RPD depth.

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.

3. RESULTS, RATING AND MANAGEMENT

The indicators used to assess sedimentation in 2014 were: sedimentation rate, grain size, and RPD depth.

Sedimentation Rate. A total of 42 sedimentation plates have now been buried at 18 sites in Porirua Harbour since December 2007 (Figure 1). Plate depths were measured in January 2014, with results summarised in Table 2 (full details are presented in Appendix 1).

Because of the variable length of monitoring, and particularly the very recent establishment of the subtidal plates which require at least a 5 year annual monitoring period before being used in any trend analyses, it is necessary to interpret the early results of this monitoring programme with caution.

The 2014 results show a mean annual intertidal sedimentation rate across all sites of 1.9mm/yr in the Pauatahanui Arm, and 3.2mm/yr in the Onepoto Arm. The Onepoto rate has been elevated by recent deposition of coarse sands at Site 2 (Aotea), which are expected to dissipate over time. The results reflect "low" and "moderate" risk indicator ratings respectively.

The subtidal sediment plate monitoring, while very preliminary, shows mean deposition of +12.2mm/yr in the Pauatahanui Arm, and -4.2mm/yr in the Onepoto Arm. Gibb and Cox (2009) estimated overall sedimentation rates for the Harbour (for the 1974-2009 period) to be 9.1mm/yr in the Pauatahanui Arm, and 5.7mm/yr in the Onepoto Arm. The combined intertidal and subtidal sediment plate results are consistent with this estimate in the Pauatahanui Arm, but the Onepoto Arm results, which indicate sediment loss, are not. For the Onepoto Arm this is thought to reflect:

i. expected small scale temporal and spatial redistribution of sediment over the buried plates that will even out as the monitoring record extends, and

ii. the location of two of the four sites in the lower estuary which has strong tidal flushing and does not appear to be accumulating fine sediment.

The preliminary subtidal plate data indicate a "high" to "very high" risk rating in the Pauatahanui Arm, and a "very low" risk rating in the Onepoto Arm.

In conjunction with the sediment plate data, a proposed repeat in 2014 of the comprehensive bathymetric survey of the Harbour undertaken by Gibb and Cox (2009) will provide a clear picture of major changes over the entire estuary over the past 5 years.

Table 2. Mean sediment plate depths (2007-2014), and 2014 condition rating, Porirua Harbour.

Site		No	Name	Calendar Year Baseline Commenced	Site Mean (mm/yr)							Mean Annual Sedimentation since baseline (mm/yr)	2014 Sedimentation Rate Risk Indicator Rating
					2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014		
Onepoto Arm	Intertidal	1	Por A Railway (FS)	2008	Baseline	0.8	2.3	-4.5	-0.3	14.3	-4.3	1.4	Low
Onepoto Arm	Intertidal	2	Aotea	2012					Baseline	12.3	-0.3	6.0	High
Onepoto Arm	Intertidal	3	Por B Polytech (FS)	2008	Baseline	7.0	0.5	2.0	0.3	4.3	1.8	2.3	Moderate
Onepoto Arm	Subtidal	S6	Titahi	2013						Baseline	0.0	0.0	Very Low
Onepoto Arm	Subtidal	S7	Onepoto	2013						Baseline	-6.0	-6.0	Very Low
Onepoto Arm	Subtidal	S8	Papakowhai	2013						Baseline	-8.0	-8.0	Very Low
Onepoto Arm	Subtidal	S9	Te Onepoto	2008	Baseline	-2.5	-2.5	3.0	-1.0	-14.0	0.0	-2.7	Very Low
Pauatahanui Arm	Intertidal	6	Boatsheds	2008		Baseline	0.5	-0.8	0.3	3.5	-2.0	0.3	Very Low
Pauatahanui Arm	Intertidal	7	Kakaho	2008					Baseline	9.3	-4.0	2.6	Low
Pauatahanui Arm	Intertidal	8	Horokiri	2009					Baseline	2.0	-2.5	-0.3	Very Low
Pauatahanui Arm	Intertidal	9	Paua B (FS)	2008	Baseline	2.3	3.8	0.3	-5.3	-0.8	4.5	0.8	Very Low
Pauatahanui Arm	Intertidal	10	Duck Creek	2012					Baseline	-3.0	14.8	5.9	High
Pauatahanui Arm	Intertidal	11	Browns Bay	2013						Baseline	-30.0	-30.0*	Very Low
Pauatahanui Arm	Subtidal	S1	Kakaho	2013						Baseline	6.6	6.6	High
Pauatahanui Arm	Subtidal	S2	Horokiri	2013						Baseline	26.4	26.4	Very High
Pauatahanui Arm	Subtidal	S3	Duck Creek	2013						Baseline	8.0	8.0	High
Pauatahanui Arm	Subtidal	S4	Bradeys Bay	2013						Baseline	11.0	11.0	Very High
Pauatahanui Arm	Subtidal	S5	Browns Bay	2013						Baseline	9.2	9.2	High

*change attributable to localised movement of intertidal sands and does not reflect a significant change in sedimentation Value excluded from calculation of means.

It is recommended that all plates continue to be monitored annually to assess the impacts of predicted land disturbance from impending forest harvesting, urban development, and road construction (in particular Transmission Gully) in the catchment. Comprehensive reporting of results, including plots of sedimentation trends, is recommended 5 yearly (e.g. next scheduled for 2018), or annually if there is major land disturbance or unexpected results occur.

Grain Size. Grain size (% mud, sand, gravel) is a key indicator of both eutrophication and sediment changes. Increasing mud content signals a deterioration in estuary condition and can exacerbate eutrophication symptoms.

Grain size monitoring at intertidal sites (Table 2, Figure 2) shows that sandy sediments dominate the sites. Mud content ranged from 2-11%, with a mean of 5.8% in the Pauatahanui Arm and 7.2% in the Onepoto Arm, a risk indicator rating of "moderate". The highest intertidal mud contents were generally recorded from the lower estuary sites (e.g. fine scale 'A' sites, Boatsheds, Kakaho). Replicate samples show within-site variability is relatively low, and for the intertidal sites monitored annually for the past 7 years, the mean mud content has remained relatively stable with no clear trend of increase. However, inter-annual variability is evident and most likely reflects localised sorting of sediments by wave action. Field observations over the past 6 years suggest intertidal mud deposits are predominantly event related (e.g. pulsed deposits from stream inputs), with fine sediments relatively quickly re-mobilised by wind generated waves and tidal streams.

For subtidal sites, significantly more mud was present than at intertidal sites (Table 3, Figure 3). Mud content ranged from 8-46% in the Onepoto Arm, with a mean of 18% and 20-66% in the Pauatahanui Arm, with a mean of 49%, risk indicator ratings of "high" and "very high" respectively. All subtidal sites in the Pauatahanui Arm, and the Titahi site in the Onepoto Arm, showed an increase in mud content from 2013. These results clearly indicate most of the muddy sediment entering the Harbour is deposited and retained in the deeper subtidal basins. Subtidal sediments in the estuary have recently been comprehensively addressed as part of broad scale subtidal habitat mapping (see Stevens and Robertson 2014).

Table 3. Sediment grain size and RPD depth results, Porirua Harbour (January 2014).

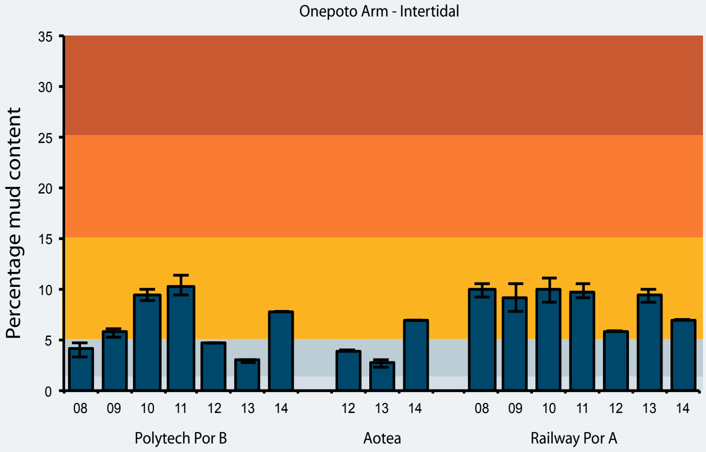
Site		No	Name	Site Mean				2014 RPD Risk Indicator Rating
				% Mud (g/100g dry wt)	% Sand (g/100g dry wt)	% Gravel (g/100g dry wt)	RPD depth (cm)	
Onepoto Arm	Intertidal	1	Por A Railway (FS)	7	92	1	1.5	Moderate
Onepoto Arm	Intertidal	2	Aotea	6.9	92.3	0.8	3	Low
Onepoto Arm	Intertidal	3	Por B Polytech (FS)	7.8	90	2.2	1	Moderate
Onepoto Arm	Subtidal	S6	Titahi	9.9	90	< 0.1	1	Moderate
Onepoto Arm	Subtidal	S7	Onepoto	11.8	84.9	3.3	3	Low
Onepoto Arm	Subtidal	S8	Papakowhai	45.9	52.5	1.6	5	Low
Onepoto Arm	Subtidal	S9	Te Onepoto	7.9	91	1.1	5	Low
Pauatahanui Arm	Intertidal	5	Paua A (FS)	6.1	92.7	1.1	2	Moderate
Pauatahanui Arm	Intertidal	6	Boatsheds	11.1	87.7	1.2	3	Low
Pauatahanui Arm	Intertidal	7	Kakaho	8.2	87.4	4.4	2	Moderate
Pauatahanui Arm	Intertidal	8	Horokiri	5.4	90.9	3.7	1	Moderate
Pauatahanui Arm	Intertidal	9	Paua B (FS)	2.7	95.4	1.9	1.5	Moderate
Pauatahanui Arm	Intertidal	10	Duck Creek	2.0	98.0	< 0.1	3	Low
Pauatahanui Arm	Intertidal	11	Browns Bay	5.1	81.8	13.1	3	Low
Pauatahanui Arm	Subtidal	S1	Kakaho	65.8	34.2	< 0.1	1	Moderate
Pauatahanui Arm	Subtidal	S2	Horokiri	50.7	49.2	0.1	1	Moderate
Pauatahanui Arm	Subtidal	S3	Duck Creek	46.2	53.5	0.3	1	Moderate
Pauatahanui Arm	Subtidal	S4	Bradeys Bay	20.3	79.5	0.3	3	Low
Pauatahanui Arm	Subtidal	S5	Browns Bay	60.0	37.2	2.8	3	Low

Note grain size results are based on a single composite sample comprising 5 sub-samples collected from each site. RPD depth is based on 10 replicate measures at each site.

Redox Potential Discontinuity (RPD). The depth to the RPD boundary is a critical estuary condition indicator in that it provides a direct measure of sediment oxygenation. This commonly shows whether nutrient enrichment in the estuary exceeds levels causing nuisance anoxic conditions in the surface sediments, and also reflects the capacity of tidal flows to maintain and replenish sediment oxygen levels.

In well flushed sandy intertidal sediments, tidal flows typically oxygenate the top 5-10cm of sediment. However, when fine muds fill the interstitial pore spaces, less re-oxygenation occurs and the RPD moves closer to the surface.

In 2014, the measured RPD depths (Table 2) were relatively shallow (1-3cm at intertidal sites and 1-5cm at subtidal sites), a "low" or "moderate" risk indicator rating.



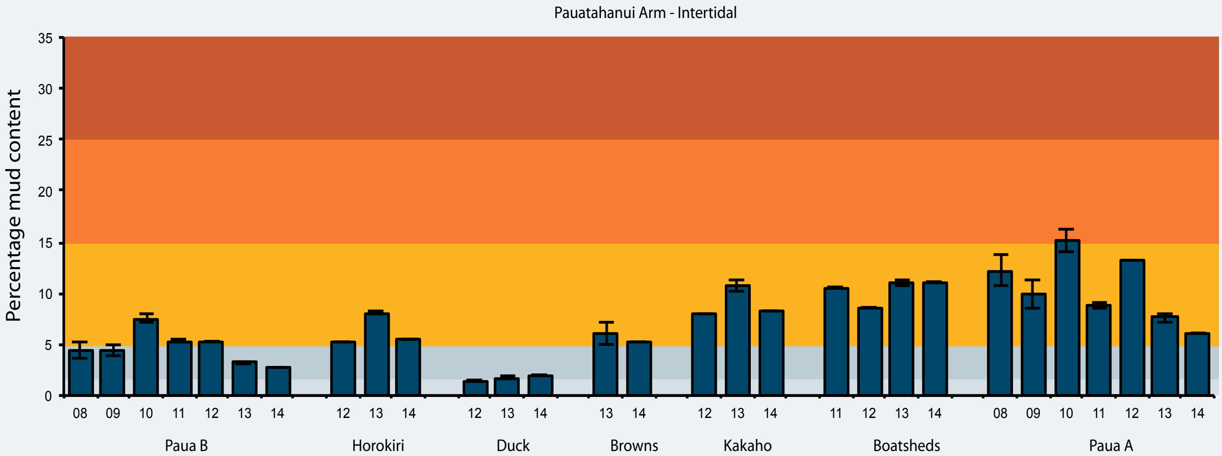
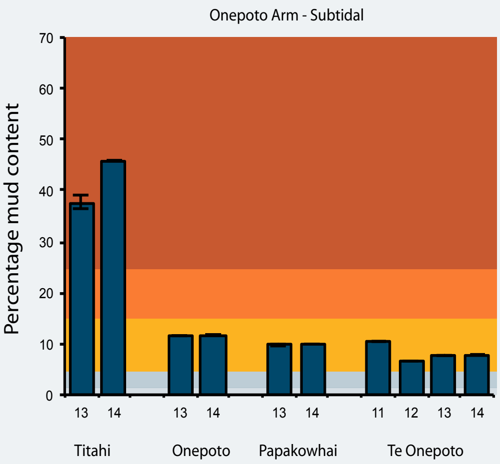


Figure 2. Mean sediment mud content (+/-SE) at Porirua Harbour intertidal sites, (2008-2014).



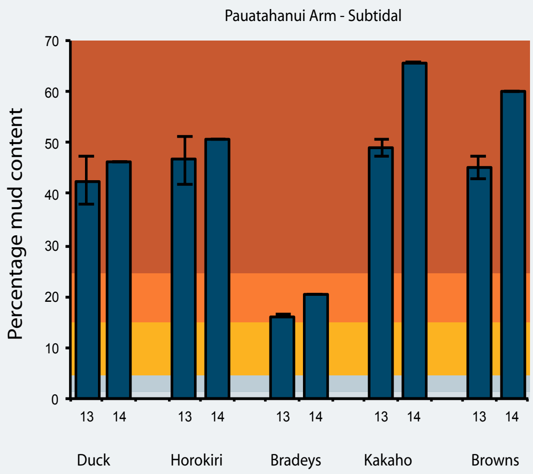


Figure 3. Mean sediment mud content (+/-SE) at Porirua Harbour subtidal sites, (2008-2014).

3. Results, Rating and Management (Continued)

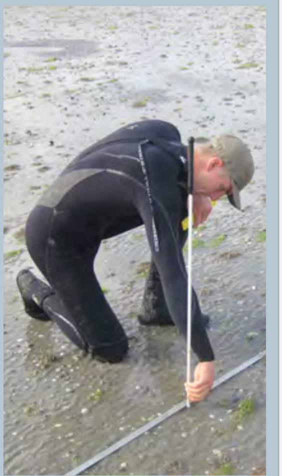
SUMMARY

Sediment plate monitoring, first established in 2007/08 at strategic intertidal sites within the Porirua Harbour, indicates a mean annual intertidal sedimentation rate across all sites of 1.9mm/yr in the Pauatahanui Arm, and 3.2mm/yr in the Onepoto Arm, fitting the "low" and "moderate" risk indicator ratings respectively.

Sediment plates have been established within the subtidal basins of both estuary arms where the greatest rates of sedimentation are predicted. While these values require at least a 5 year annual monitoring period before being used in any trend analyses, preliminary results after 1 year indicate very high deposition in the Pauatahanui Arm, and slight erosion in the Onepoto Arm.

The moderate sediment RPD depth, and elevated sediment mud content results, particularly at the subtidal sites, highlight continuing issues related to mud deposition within the estuary.

RECOMMENDED MONITORING



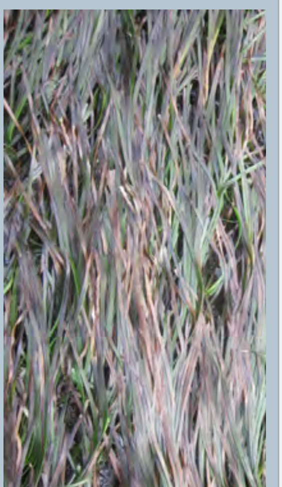
It is recommended that monitoring continue as outlined below:

Annual Sediment Monitoring (both intertidal and subtidal). To assess sediment derived changes in the estuary, annually monitor sedimentation rate, RPD depth and grain size at the existing intertidal and shallow subtidal sites (and at new offshore subtidal sites recommended in the 2014 broad scale subtidal survey (Stevens and Robertson 2014). Next monitoring due in January 2015. To optimise reporting, it is recommended that results be fully reported every 5 years (first 5 year review due in 2018 after 5 years of annual subtidal monitoring).

Fine Scale Monitoring (both intertidal and subtidal). To assess intertidal estuary condition it is recommended that a "complete" fine scale monitoring assessment be undertaken at 5 yearly intervals (next scheduled for Jan-Feb 2015). To assess subtidal estuary condition it is recommended that subtidal fine scale monitoring be undertaken according to the reviewed design recommended in 2014 broad scale subtidal survey (Stevens and Robertson 2014).

Broad Scale Habitat Mapping (both intertidal and subtidal). It is recommended that broad scale intertidal and subtidal habitat mapping be integrated, and repeated every 5 years (next monitoring due in January 2018).

RECOMMENDED MANAGEMENT



The sediment indicators monitored in 2014 reinforce the 2008 to 2010 fine scale monitoring results about the need to manage fine sediment inputs to the estuary.

In particular, limiting catchment sediment inputs to more natural levels that will not cause excessive estuary infilling and will improve harbour water clarity. To achieve this, interim and long term targets have been prepared by and approved by the joint councils (Porirua City Council, Wellington City Council and Greater Wellington Regional Council), Te Runanga Toa Rangatira and other key agencies with interests in Porirua Harbour and catchment, as follows:

- Interim – Reduce sediment inputs from tributary streams by 50% by 2121
- Long-term – Reduce sediment accumulation rate in the harbour to 1mm per year by 2031 (averaged over whole harbour)

Greater Wellington's ongoing catchment and sediment transport modelling will help determine the catchment suspended sediment load inputs and the target reductions required to reduce in-estuary sedimentation rates. GWRC and PCC have also undertaken desktop assessments to determine the likely sediment input loads from different landuses, including the Transmission Gully motorway development, and modelled the zones of deposition within the estuary. Strategies to determine the best options for managing sediment within the catchment are currently being developed.

3. Results, Rating and Management (Continued)

ACKNOWLEDGEMENTS Many thanks to Megan Oliver (GWRC) for her support and feedback on the draft report, and to Ben Robertson for help with the field component.

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APPENDIX 1

ANALYTICAL METHODS

Indicator	Laboratory	Method	Detection Limit
Grain Size	R.J Hill	Wet sieving (2mm and 63µm sieves), gravimetry (calculation by difference).	0.1 g/100g dry wgt

DETAILED RESULTS

Sediment Plate Depths, Onepoto Arm, Porirua Harbour (2007-2014).

	No.	Site	PLATE	NZTM EAST	NZTM NORTH	**13/12/07**	**15/1/09**	**20/1/10**	**18/1/11**	**21-24/2/12**	11/1/2013	20-21/1/2014
Onepoto Arm - Intertidal	1	Por A Railway (fine scale site)	1	1756505.7	5447788.6	168	164	159	155	160	183	181
			2	1756477.9	5447784.8	150	152	158	156	151	150	160
			3	1756478.8	5447762.7	152	155	163	150	145	174	148
			4	1756508.1	5447755.8	93	95	95	96	100	106	107
	2	Aotea	1	1754771.8	5445520.0					138	145	140
			2	1754770.5	5445521.2					108	126	128
			3	1754768.3	5445523.1					103	118	116
			4	1754767.3	5445523.9					100	109	113
	3	Por B Polytech (fine scale site)	1	1754561.9	5445430.3	237	237	240	242	245	243	243
			2	1754577.9	5445403.8	230	244	242	244	244	256	256
			3	1754561.6	5445529.5				110	110	109	112
			4	1754559.9	5445528.6				75	73	81	85
Subtidal	S6	Titahi	1	1755704.1	5446797.6						191	191
	S7	Onepoto	1	1754811.3	5446762.9						194	188
	S8	Papakowhai	1	1754580.9	5445864.0						183	175
	S9	Te Onepoto	1	1755551.8	5447105.3	120	-	115	115	118	104	104

APPENDIX 1

DETAILED RESULTS

Sediment Plate Depths, Pauatahanui Arm, Porirua Harbour (2007-2014).

	No.	Site	PLATE	NZTM EAST	NZTM NORTH	13/12/07	15/1/09	20/1/10	18/1/11	21-24/2/12	11/1/2013	20-21/1/2014
Pauatahanui Arm - Intertidal	5	Paua A (fine scale site)	-	1757243.0	5448644.0							
	6	Boatsheds	1	1757267.5	5448785.8		171	172	165	166	172	166
			2	1757265.6	5448785.2		213	213	215	216	221	222
			3	1757263.6	5448784.7		232	232	233	234	233	232
			4	1757262.0	5448784.1		234	235	236	234	238	236
	7	Kakaho	1	1758885.4	5449747.8					73	89	85
			2	1758884.9	5449746.0					100	106	104
			3	1758884.4	5449744.2					90	103	92
			4	1758884.0	5449742.3					92	94	95
	8	Horokiri	1	1760040.2	5448827.6					106	104	104
			2	1760039.8	5448825.5					108	111	113
			3	1760039.6	5448823.5					118	124	124
			4	1760039.1	5448821.5					98	99	87
	9	Paua B (fine scale site)	1	1760333.9	5448378.8	181	182	186	186	181	180	187
			2	1760349.2	5448355.8	215	218	228	233	228	225	229
			3	1760375.1	5448366.9	182	186	183	183	181	182	182
			4	1760362.3	5448391.9	176	177	181	177	168	168	175
	10	Duck Creek	1	1759829.3	5447944.8					134	121	136
			2	1759828.7	5447946.7					108	108	117
			3	1759828.1	5447948.7					122	122	146
			4	1759827.6	5447950.6					88	89	100
	11	Browns Bay	1	1757971.4	5447956.8						220	190
Subtidal	S1	Kakaho	1	1758810.9	5449470.5						165	172
	S2	Horokiri	1	1759325.4	5448867.9						176	202
	S3	Duck Creek	1	1759529.0	5447896.3						194	202
	S4	Bradeys Bay	1	1758763.2	5447865.0						124	135
	S5	Browns Bay	1	1758040.6	5448015.1						179	188