JUNE 2005

Coastal investigations technical report

John Sherriff
Resource Investigations Department
Greater Wellington Regional Council

Contents

1. Introduction

The coastal environment of the Wellington region varies greatly in character and provides for a diverse range of human needs. It is also a location where particular types of natural processes and unique ecological values can be found. Balancing the use and the protection of the coastal environment requires careful management.

Our experience has shown us that:

- A variety of human activities, in the coastal environment and further inland, are causing degradation of coastal water quality contamination of sediment and biota, and disruption to natural processes; and

- There is quite limited knowledge of the nature and functioning of coastal ecosystems and coastal processes, particularly in the coastal marine area. The lack of knowledge makes for difficulties when local authorities need to make decisions about the potential effects of sub-division, use and development in the coastal environment whilst providing for the preservation of the natural character of that environment.

At the current time, apart from the recreational water quality monitoring programme, Greater Wellington does not have in place any on-going monitoring programmes specifically targeting the coastal areas of the region. What has occurred is a series of discrete investigations which, in time, may provide the basis for permanent monitoring programmes.

This report provides a summary of the investigations undertaken in the coastal area by Greater Wellington in the period since the last State of the Environment Report in 1999. These investigations have focussed on:

- measuring the quantity of contaminants being discharged in urban stormwater;

- establishing baseline information on the state of contamination in shellfish and marine sediments at selected areas around the Region’s coastline;

- identifying the effects of historical catchment land cover changes on estuary sedimentation in Pauatahanui Inlet; and

- developing an understanding of broad scale habitat at a number of sandy beaches and river estuaries around Wellington Harbour and on the South Coast.

These investigations provide an indication of the present state of the coastal environment and, in the case of the estuary sedimentation, an indication of historical changes in sedimentation rates in Pauatahanui Inlet.

They provide information which can be used to assess the effectiveness of the Regional Policy Statement (Wellington Regional Council 1995) in particular the following objectives relating to the coastal environment.

Objective 1: The natural character of the coastal environment is preserved through:

1. The protection of nationally and regionally significant areas and values;

2. The protection of the integrity, functioning and resilience of physical and ecological processes in the coastal environment;

3. The restoration and rehabilitation of degraded areas; and

4. The management of subdivisions, use and development, and the allocation of resources in the coastal environment so that adverse effects are avoided, remedied or mitigated.

Objective 3: Coastal water quality is of a high standard.

2. Stormwater quality investigations

2.1 Background

Stormwater rules in the Regional Coastal Plan allow stormwater discharges as Permitted Activities subject to the following conditions:

(1) *The discharger shall adopt the best practicable option to ensure that after reasonable mixing the stormwater discharged will not give rise to all or any of the following effects:*

- *the production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials;*
- *any conspicuous change in the colour or visual clarity;*
- *any emission of objectionable odour;*
- *the rendering of fresh water unsuitable for consumption by farm animals;*
- *any significant effects on aquatic life.*

(2) *The stormwater collection systems and pipelines will be constructed and maintained in an efficient operating condition.*

(3) *The stormwater shall be discharged at a rate that does not cause significant erosion.*

It was recognised that at least one of these conditions – that the discharge shall not cause any significant adverse effects on aquatic life – is probably being breached by discharges of urban stormwater in some parts of the Region. For Greater Wellington to establish effective policies for avoiding the adverse environmental effects of such discharges, the quality and effects of stormwater needed to be determined.

To date this issue has been addressed in two parts. In part one Greater Wellington commissioned the preparation of a report synthesising existing information on the effects of urban stormwater discharges on the Region's receiving environments. This work was carried out by the National Institute of Water and Atmospheric Research Limited (NIWA) in conjunction with two sub-consultants, Diffuse Sources Limited and GeoEnvironmental Consultants.

Part two was an investigative programme designed to:

1. Identify the contaminants being discharged in stormwater at selected sites in the Wellington region;
2. Identify the mechanisms by which these contaminants were being transported, i.e., in water or with the sediment; and

3. Assess the likely effects of the discharges through comparisons with relevant environmental guidelines.

2.2 Synthesis of existing data

2.2.1 Methods

This project was a desk-top review. No site inspections were carried out, although one of the authors was familiar with most of the sites discussed. For the purposes of the report, stormwater was regarded as the rainfall runoff from impervious surfaces (roads, paths, roofs, etc.), plus diffuse (i.e., non-point source) discharges of contaminants to that rainfall runoff, which is collected and conveyed through a stormwater reticulation system to be discharged into receiving waters. Discharges of sewage, landfill leachate, industrial/commercial wastewater and spills were considered point-source discharges to the stormwater conduits. Stormwater conduits were generally defined as man-made conduits, usually pipes. Streams, even when re-aligned and/or highly modified (thus effectively acting as part of the stormwater system), were regarded as the receiving environment.

2.2.2 General findings

The main effects of stormwater discharges from urbanised catchments on surface water quality and aquatic environments were considered to be:

- Changes in the flow regime (i.e., increase in peak flow and reduction in base flow)
- Increases in suspended solids
- Channelisation of streams
- Changes to riparian vegetation
- Increases in toxic substances in the water column and sediments
- Increases in nutrients
- Contamination by human pathogens
- Accumulation of litter in waterways
- Effects on the biota

2.2.3 Stormwater effects on marine ecosystems

Microbiological impacts

In general terms, urban stormwater probably reduced the microbiological quality of the Region's marine receiving waters. However, the effects could not be distinguished from other contamination sources using the data existing at that time. Sewage contamination (of stormwater) and diffuse-sourced run-off from rural land were identified as the most probable major factors influencing microbiological levels in the Wellington Region's coastal waters.

Water quality

No studies were found investigating the effects of stormwater discharges on marine water quality in the Wellington Region. However, concentrations of toxic substances in marine waters receiving stormwater discharges were expected to be too low, after dilution, to exceed water quality guidelines. This was because urban outfall discharge volumes are relatively small compared with their marine receiving waters.

Sediment quality

There was compelling evidence of stormwater impacts on the sediments of Wellington Harbour and Porirua Inlet, which have experienced large increases in heavy metal concentrations, specifically:

- High concentrations near the Evans Bay outfalls in Wellington
- High concentrations near the Semple Street drain in Porirua
- High concentrations in stormwater drains in inner Wellington City and Miramar
- A modest increase in Porirua Inlet (in line with urbanisation history)
- A very small impact in Pauatahanui Inlet (in line with the low extent of urbanisation)

The evidence was consistent with a much larger body of evidence from Auckland estuaries, which has demonstrated that urban stormwater is causing an increase in the concentration of zinc, lead, copper, and polycyclic aromatic hydrocarbons, in the sediments of sheltered waters.

Effects on aquatic organisms

There was insufficient information to conclusively demonstrate adverse effects on marine animals from stormwater discharges in the Wellington Region. However, extensive studies in the Auckland region had provided circumstantial evidence linking adverse effects on marine organisms to stormwater discharges.

2.2.4 Conclusions

The report highlighted gaps in the information available on the effects of urban stormwater discharges on the Region's receiving environments. It specifically identified a lack of information about:

- The nature and concentrations of the contaminants (particularly organic compounds) present in urban stormwater discharges in many parts of the Region.

- The relationship of the contaminants present in urban stormwater discharges to catchment characteristics.

- The relative importance of the different phases of urban stormwater (liquid, coarse sediment, fine sediment) in transporting contaminants to the receiving environments.

- The levels of contamination of receiving environments where adverse effects are *likely* due to the degree of urbanisation of the catchment and the characteristics of the receiving environment, but for which there is currently no information.

2.3 Stormwater quality investigative programme

2.3.1 Background

An investigative programme was designed and implemented to fill the information gaps identified in the desk top exercise which comprised Part One of this investigation. The fieldwork was undertaken by Greater Wellington staff and the preliminary analyses and reporting was undertaken by consultants, Kingett Mitchell Ltd. (Kingett Mitchell Ltd. 2005)

2.3.2 Method

Over a period of three years from 2001- 2004 stormwater samples were collected from a total of 11 different sampling sites from a range of different catchments in the Greater Wellington region. Five of these sampling points were at locations where stormwater discharged directly into the coastal environment.

The 11 catchments ranged from newer residential areas through to catchments with well established industrial land. Table 2.1 summarises the land use for each of the sites based upon the general characteristics of the catchments upstream of the sampling sites. Those discharging directly into the coastal environment are italicised.

Table 2.1: Sampling site information.

Site	Land use	Sampling Location	Rainfall during sampling (mm)	Catchment area (ha)
Ohiro Stream	residential	open channel	NA	-
Browns Stream	residential	open channel	NA	123
The Parade	residential	pipe	12.0	467
McLeod Park	residential	pipe	13.5	35
Duck Creek	residential	open channel	16.0	869
Te Roto Drive	industrial	pipe	5.0	
Semple Street	mixed	Pipe	8.5	995
Hutt Park Road	industrial	pipe	2.0	323
Waring Taylor Street	commercial	pipe	9.9	52
Parkside Road	industrial	pipe	3.5	
Grassleas Reserve	residential	pipe	NA	210

Sampling was commenced within the first hour of the rainfall event and continued at hourly intervals until six samples had been collected and combined. Water depth was measured continuously using a pressure transducer mounted in a perforated steel pipe standing on the culvert or stream bed. Two to three gaugings were carried out at open channel sites during the rainfall events.

Samples were analysed for:

- Heavy metals
- Total suspended solids
- pH
- Nutrients
- Organic compounds

2.3.3 Results

General stormwater quality

Overall, the pH measured in the Wellington stormwater samples was similar to the pH measured in stormwater in other studies carried out in New Zealand.

The median total suspended solids (TSS) concentration in the Wellington stormwater samples was 76 g/m^3. The median concentration in the residential catchments was lower than in the industrial catchments (59 g/m^3 and 90 g/m^3 respectively). Although the industrial catchment stormwater had a higher total suspended solids (TSS) concentration, the difference between the residential and industrial catchments was not statistically significant ($p=0.053$).

The dissolved organic carbon (DOC) and total organic carbon (TOC) concentrations observed in the stormwater samples collected in the Wellington region appeared similar to concentrations recorded in other studies. Total nitrogen concentrations were elevated (median of 1.6 g/m^3) with samples from the residential catchments having a higher median concentration than the samples from the industrial catchments. The median dissolved reactive phosphorous (DRP) concentration (0.04 g/m^3) was relatively low and similar to data from other locations in New Zealand such as urban Dunedin and Rotorua.

Dissolved elements in stormwater

This study measured the concentration of a range of elements in urban stormwater from residential and industrial/commercial catchments. Table 2.2 summarises the results in relation to the degree of increase in concentration over natural concentrations and identifies whether the concentrations measured exceed the ANZECC (2000)[1] 95% protection trigger for freshwater biota.

The data summary in Table 2.2 indicated that exceedences of the ANZECC trigger values occurred for copper, cobalt, nickel and zinc. In this study concentrations of lead did not exceed the ANZECC (2000) trigger values. Copper and Nickel are additional elements to those identified by Williamson et al. (2001)[2]. The lower concentrations of lead relative to the trigger value may be the result of declining lead concentrations over time since lead was removed from petrol in New Zealand. It should also be noted that dissolved lead concentrations were typically low and although the actual data was not

---

[1] ANZECC 2000: Australian and New Zealand guidelines for fresh and marine water quality 2000. Australian and New Zealand Environment and Conservation Council.

[2] Wiiliamson, B.: Goff, J: Ray, D.: Mills, G.: Berkenbusch, K. 2001: Effects of urban stormwater in the Wellington Region: A synthesis of existing information. Report prepared by NIWA for Wellington Regional Council May 2001

evaluated some older data could have been artificially elevated due to laboratory and sampling errors

It should be noted that comparison with the ANZECC (2000) and identification of exceedence of the trigger values does not constitute a defacto identification of waterborne toxicity. Toxicity is affected by a number of aspects of water chemistry. These need to be evaluated prior to any affirmation of potential toxicity issues.

In addition, the trigger values are based upon a particular ANZECC (2000) data set. The trigger values are subject to change and new data. As such although ANZECC (2000) indicate that exceedence of the trigger values should result in further evaluation of potential toxicity, the trigger values themselves may require further evaluation.

Table 2.2: Dissolved trace elements in urban stormwater in the Wellington region.

Elements	Residential catchments		Industrial catchments	
	Concentration[1]	Exceed ANZECC (2000)	Concentration[1]	Exceed ANZECC (2000)
Aluminium	M	***YES2***	M	***YES2***
Antimony	M	No	M	No
Arsenic	L	No	L	No
Barium	L?	NT	L?	NT
Cadmium	?	No	?	No
Chromium	L	No	L	No
Cobalt	L?	***Yes***	M?	***Yes***
Copper	H	***Yes***	H	***Yes***
Iron	?	NT	?	NT
Lead	M	No	H	No3
Manganese	?	No	?	No
Mercury	?	No	?	No
Nickel	L	No	M	***Yes***
Selenium	?	No	?	No
Strontium	L	NT	L	NT
Silver	L?	No	L?	No
Tin	L	NT	L	NT
Vanadium	L?	No	L?	No
Zinc	H	***Yes***	H	***Yes***

Note: 1 – Relative increase in concentrations compared to natural concentration
– L – low; M – medium; H – High. NT = No trigger value.

In terms of any assessment of effects, the comparison of concentrations in stormwater and the ANZECC (2000) trigger values does not account for any dilution arising from reasonable mixing. When considering reasonable mixing, it is unlikely that stormwater discharges to coastal environments, where reasonable dilution would be expected will result in any waterborne adverse effects as minimal dilution is required for all of the key elements identified in Table 2.2 to bring concentrations below the ANZECC (2000) trigger values.

Of all of the elements, the zinc concentrations measured in Wellington urban stormwater are the most elevated compared to natural concentrations and concentrations were markedly elevated in two samples from industrial catchments. Concentrations were typically higher than ANZECC trigger values but when compared to USEPA (2002)[3] criteria for the protection of aquatic life, most of the samples collected from residential catchments were below the guideline. In industrial catchments most of the samples were above the criteria concentration.

Particulates in stormwater

This study measured the concentration of a range of elements in the particulate material in suspension in urban stormwater from residential and industrial/commercial catchments in the Wellington region. Table 2.3 provides a summary of the results obtained in relation how the concentration compares to natural sediment concentrations and whether the concentrations measured exceed the ANZECC (2000) ISQG-Low and High for the protection of sediment dwelling biota.

The summary indicates that in depositional environments, the elements chromium, copper, nickel, lead, zinc are the elements most likely to result in an increase in sediment contaminant concentration as a consequence of elevated concentrations in urban stormwater particulate material. Based upon the available data, it is evident that urban stormwater will contribute to sediment contamination through the deposition of suspended solids in stormwater. Contributions will also be made by larger particles and by dissolved elements (that are taken out of solution through sorption and removal processes when stormwater enters saline water). Williamson et al. (2001) and Kennedy (2003)[4] discuss sediment quality and effects on benthic biota, the former study summarising examples of elevated concentrations of key elements adjacent to stormwater outfalls in the Wellington region.

[3] USEAP 2002: National recommended water quality criteria: 2002 EPA- 822-R-02-047. Office of Water, Office of Science and Technology, Washington D.C.
[4] Kennedy P.: 2003: The Effects of Road Transport on Freshwater and Marine Ecosystems. Prepared by Kingett Mitchell Ltd for Ministry of Transport, June 1999. Revised October 2003.

Table 2.3: Trace elements in urban stormwater particulates in the Wellington region.

Elements	Residential catchments		Industrial catchments	
	Concentration[1]	Exceed ANZECC (2000)	Concentration[1]	Exceed ANZECC (2000)
Aluminium	NA	NT	NA	NT
Antimony	?	No	?	No
Arsenic	L	NT	L	NT
Barium	M	NT	M	NT
Cadmium	?	?	?	?
Chromium	M	***Some yes***	M	***Some yes***
Cobalt	L	NT	M-H?	NT
Copper	M-H	***Most yes***	H	***Yes***
Iron		NT		NT
Lead	H	***Yes***	H	yes
Manganese	?	NT	?	NT
Mercury	M-H	No	M-H	No
Nickel	M	***Some yes***	M	***Some yes***
Selenium	?	NT	?	NT
Strontium	L	NT	L	NT
Silver	?	No	?	No
Tin	?	NT	?	NT
Vanadium	?	NT	?	NT
Zinc	H	***Yes***	H	***Yes***

Note: 1 – Relative increase in concentrations compared to natural concentration

– L – low; M – medium; H – High. NT = No trigger value.

Organic compounds

This study provided information on the concentration of a number of key groups of organic compounds in dissolved and particulate phases in Wellington urban stormwater.

Dissolved poly cyclic aromatic hydrocarbons (PAH) concentrations were low to non-detectable in residential stormwater from newer catchments that drained to Pauatahanui Inlet and the Owhiro Stream. As expected, PAH concentrations were highest in the stormwater collected from the Hutt Park Rd industrial catchment. In most samples the PAH profile was dominated by heavier PAHs which reflected weathering of the PAH assemblage. In some samples, lighter or more volatile PAHs were identified.

Particulate concentrations of PAHs were high with the concentration generally reflecting the concentration measured in the dissolved fraction. The profile identified appeared to reflect the emission of PAHs from motor vehicles.

The examination of stormwater samples for organochlorine compounds detected a range of compounds and the poly chlorinated biphenyls (PCB) congeners present in each sample were similar. PCB concentrations were highest in the samples collected from the industrial Hutt Park stormwater catchment. The concentrations in the stormwater particulates with up to 678 ng/g total PCB measured. The concentrations are high compared to available data for stormwater and road surface particulates.

The evaluation of organochlorine pesticide concentrations showed that compounds such as DDT were present at moderate concentrations with up to 315 ng/g total DDT present in samples from industrial catchments.

Examination of samples for chlorophenol compounds (historically used in timber preservation) showed that samples from the industrial catchments tended to have more chlorophenols than those from residential catchments. The tendency for the industrial catchment samples having higher concentrations compared to residential catchments is likely to be a reflection of the historically higher use of such compounds in those catchments.

The stormwater from the industrial Hutt Park stormwater catchment had elevated concentrations of metals, PAHs, PCBs, organochlorine pesticides (OCPs) and chlorophenols. The elevation in this catchment compared to other catchments is likely to reflect historical use and contamination of soils (or local fill, landfills) and groundwater within the catchment. Given that many of the OCP compounds involved have been withdrawn from use in New Zealand or are not permitted to be used it is unlikely that the cause is current use or land use in the catchment.

2.4 Future steps

Further monitoring of stormwater discharges may be required to provide greater certainty about the nature and degree of contaminants being discharged from urban areas. Further information of this kind will establish whether or not we are justified in using data derived from other areas to represent the quality of stormwater discharges in our region.

Further work is needed to establish a relationship between the quality of stormwater discharges and catchment characteristics.

A major undertaking will be to use the water quality data, together with information about volumes of stormwater being discharged and the sensitivity of receiving environments, to differentiate the risks posed by stormwater discharges across the Region. This work recognises the possibility that future management responses to control stormwater discharges may involve the use of different rules in different places according to the risk they present to the environment.

3. Investigation of chemical contaminants in shellfish

3.1 Background

During 2001 and 2002 Greater Wellington Regional Council measured the levels of a range of chemical contaminants in the tissues of four species of shellfish found around the Region's coastline. The purpose of this research was to:

- assess the use of shellfish monitoring for measuring marine and estuarine water quality with respect to low-level contaminants that are not practical to measure routinely as part of an ambient water quality programme;
- provide a baseline for identifying spatial patterns of contamination, and measuring trends over time in contaminant levels, should a sentinel shellfish monitoring programme be established in the Region;
- contribute regional information on the movement of chemical contaminants into marine food chains; and
- assess the risks to human health resulting from the collection and consumption of feral shellfish from the Region.

The investigation linked to the GWRC stormwater programme, in which the same suite of chemical contaminants was being analysed in the discharges from a variety of urban catchments.

3.2 Method

The species of shellfish studied were black-foot paua (*Haliotis iris*), blue mussel (*Mytilus galloprovincialis*), cockle (*Austrovenus stutchburyi*), and tuatua (*Paphies subtriangulata*). The 21 study sites (Table 3.1) were selected to represent the major biogeographic and ecological divisions of the Region's coastline, as well as areas of the Region where traditional and recreational collection of shellfish for human consumption occurs regularly. Pollution sources were not specifically targeted, nor was a minimum distance from a known pollution source specified. Samples of black-foot paua were collected by diving; the remaining species were collected by hand from the lower intertidal (cockles) or immediate sub-tidal (blue mussels and tuatua). All analyses were conducted by Agriquality New Zealand Limited on homogenised composite samples. Whole shucked shellfish were used for analysis in all cases. The analytes were total lipid, six heavy metals (cadmium, chromium, copper, lead, mercury, and zinc), organochlorines (14 varieties), chlorophenols (18 varieties), polycyclic aromatic hydrocarbons (16 varieties), and polychlorinated biphenyls (40 varieties). The majority of these analytes are US Environmental Protection Agency "Priority Pollutants".

Table 3.1: Location of shellfish samples from the Wellington region used for the analysis of chemical contaminants, 2001/2002.

Locality	Date collected	Grid reference		Species
		Easting	Northing	
Porirua Harbour at Te Hiko Street	20/03/2001	2664306	6007564	cockle
Porirua Harbour at Paremata Railway Station	20/03/2001	2666645	6009635	cockle
Porirua Harbour at Motukaraka Point	20/03/2001	2669325	6010746	cockle
Wellington Harbour at Point Howard	22/03/2001	2669600	5993020	blue mussel
Wellington Harbour at Sunshine Bay	22/03/2001	2669646	5991109	blue mussel
Wellington Harbour at Burdans Gate	22/03/2001	2667482	5986637	blue mussel
Wellington Harbour at Inconstant Point	22/03/2001	2664932	5982542	blue mussel
Wellington south coast at Hue-te-taka Peninsula	26/03/2001	2661470	5983320	blue mussel
Wellington Harbour at Mahanga Bay	26/03/2001	2663547	5989182	blue mussel
Wellington Harbour at Shark Bay	26/03/2001	2662176	5987920	blue mussel
Wellington Harbour at Ferry Terminal	26/03/2001	2660007	5992268	blue mussel
Wellington Harbour at Scorching Bay	6/04/2001	2663480	5988121	blue mussel
Wellington west coast at Green Point	19/02/2002	2661474	6008975	black-foot paua
Wellington west coast at Ohariu Bay	19/02/2002	2653909	5998020	black-foot paua
Wellington south coast at Island Bay	19/02/2002	2658929	5983010	black-foot paua
Wairarapa south coast at Cape Palliser	4/03/2002	2696850	5953303	black-foot paua
Wairarapa east coast at Flat Point	8/03/2002	2758655	5991411	black-foot paua
Wairarapa east coast at Mataikona	8/03/2002	2784826	6037721	black-foot paua
Raumati Beach at Kainui Road	20/03/2001	2676176	6027855	tuatua
Peka Peka Beach at Road End	13/03/2002	2683215	6039608	tuatua
Otaki Beach at Surf Club	13/03/2002	2688601	6050007	tuatua

3.3 Results

The following general observations were made.

3.3.1 Heavy metals

The heavy metals tested were all present at measurable concentrations in the four species of shellfish examined.

- Each heavy metal showed relatively little spatial variation in concentration between samples of individual shellfish species.
- Some differences in heavy metal concentrations between shellfish species appeared to be the result of factors unrelated to anthropogenic inputs.
- In the late summers of 2001 and 2002 none of the heavy metals were present in the shellfish tested at concentrations which exceeded the New Zealand Food Safety Authority guidelines for edible tissue, where such guidelines exist. <u>This was not interpreted as meaning other species of shellfish, or examples of the tested species taken from within the mixing zones of point sources, were also within the guidelines.</u>

3.3.2 Organochlorines

- Organochlorines were not detected in paua, but a number of these compounds were present at measurable concentrations in all the samples of cockles, mussels, and tuatua.

- In the late summers of 2001 and 2002 none of the organochlorines were present in the shellfish tested at concentrations which exceeded the New Zealand Food Safety Authority guidelines for edible tissue, where such guidelines exist. This was not interpreted as meaning other species of shellfish, or examples of the tested species taken from within the mixing zones of point sources, were also within the guidelines.

3.3.3 Chlorophenols

- Chlorophenols were not detected in paua, but compounds from this group were present at measurable concentrations in all the samples of cockles, mussels, and tuatua, with the range of compounds generally decreasing with distance from urban areas.

- There are no specified safe levels for chlorophenols in shellfish for human consumption.

3.3.4 Polycyclic aromatic hydrocarbons (PAHs)

- Polycyclic aromatic hydrocarbons were only detected in some cockle and mussel samples, generally those close to urban areas.

- There are no specified safe levels for polycyclic aromatic hydrocarbons in shellfish for human consumption.

3.3.5 Polychlorinated biphenyls (PCBs)

- A range of polychlorinated biphenyls were present at measurable concentrations in all the samples of cockles, mussels, and tuatua. PCBs were not detected in paua except for the sample at Island Bay. All but one of the PCBs in this paua sample were also detected in urban stormwater samples taken in Island Bay in August 2002.

- In the late summers of 2001 and 2002 total PCB concentrations in all the shellfish samples tested were below the US Food and Drug Administration guideline for PCBs in shellfish for human consumption. This was not interpreted as meaning other species of shellfish, or examples of the tested species taken from within the mixing zones of point sources, were also within the guidelines.

3.4 General findings

The concentrations of organic compounds such as PAHs and PCBs in the shellfish tissues were considered to represent the balance between the uptake and elimination of these compounds by the shellfish over periods of up to several weeks. In contrast, the concentrations of metals in the shellfish tissues were considered to represent the balance between the uptake and elimination of metals by the shellfish over periods of months to years.

3.5 Conclusions

Shellfish in waters adjacent to the Region's urban areas in particular appear to be being exposed to anthropogenic sources of at least some of the contaminants measured. Preliminary results from the GWRC stormwater investigation suggest that urban stormwater is the most likely source of these contaminants.

The shellfish tests are just one contribution to a much needed broader assessment of the environmental effects of the Region's urban stormwater. This assessment should include studies of contaminant levels in other components of marine food chains such as crabs, fin-fish, and sediment-dwellers, as well as further surveys of contaminant concentrations in harbour sediments.

4. Porirua marine sediment quality investigation

4.1 Background

Stormwater investigations provided evidence that there were a number of chemical contaminants in the Region's urban stormwater and in runoff from agricultural land, particularly some heavy metals and DDT, which were probably having, or through long-term accumulation could eventually have, significant adverse effects on the aquatic ecosystems of the depositional zones in Wellington Harbour and Porirua Harbour. In response to these findings Greater Wellington Regional Council contracted consultants NIWA to undertake an investigation of marine sediments in the Porirua Harbour in an attempt to establish the degree and extent of contamination.

The investigation linked to the GWRC study of chemical contaminants in stormwater systems and urban streams, and the development of event mean concentration pollution runoff models for urban catchments to permit estimation of typical annual contaminant loads to receiving environments.

4.2 Results

The investigation was carried out in May 2004 at two sub-tidal sites in each arm of the Porirua Harbour (Figure. 4.1). The sites were selected to be:

1. representative of the area of concern;
2. likely to accumulate contaminants in a manner that reflects accumulation over the area;
3. unlikely to change markedly, particularly in their sediment texture, over time periods of decades; and
4. likely have a relatively high proportion of mud in the sediment.

Figure 4.1: Map of Porirua Harbour showing the marine sediment quality sampling sites.

4.2.1 Particle size analysis

Sediments at the sites in the Onepoto Arm had a higher proportion of mud (63–98%) than the sediments of the sites in the Pauatahanui Arm (31–71%).

4.2.2 Total organic carbon (TOC)

The sediment at the site off Browns Bay in the Pauatahanui Arm had a slightly lower TOC content than the sediments of the other sites (Figure 4.2). Variability in TOC content was low at three of the four sites. However, at the site off Duck Creek in the Pauatahanui Arm TOC content was quite variable and may mean that trend detection will not be as sensitive at this site as it will be at the others, at least for the organic contaminants.

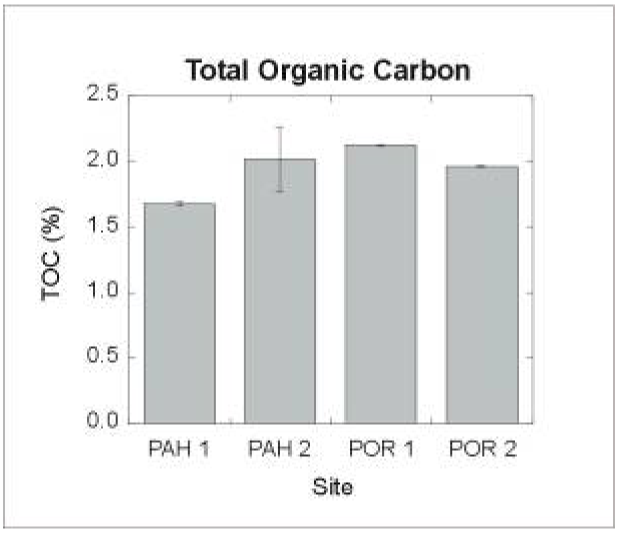

Figure 4.2: Total organic carbon content of the sediments at sites in the Porirua Harbour.

4.2.3 Heavy metals

The concentrations of the nine metals tested, with the exception of cadmium, were higher in the sediments of the sites in the Onepoto Arm than in the sediments of the sites in the Pauatahanui Arm (Figures 4.3, 4.4 and 4.5). The mud fraction metals data showed low variability, which means that monitoring will be able to detect relatively small changes in concentration over time.

The concentrations of copper and lead in the sediments of both sites in the Onepoto Arm exceeded the Auckland Regional Council's Environmental Response Criteria (ARC ERC) amber "trigger level", while the concentrations of zinc exceeded the ARC ERC red "trigger level". The concentration of zinc in the sediment of the southern site in the Onepoto Arm also exceeded the ANZECC (2000) ISQG-Low "trigger level".

The concentrations of copper, lead, and zinc in the sediments of the sites in the Pauatahanui Arm were all below ARC ERC and ANZECC (2000) ISQG "trigger levels", although the concentration of copper in the sediment of the site off Browns Bay was very close to the ARC ERC amber "trigger level".

The concentrations of arsenic, cadmium, chromium, mercury, nickel, and silver in the sediments of the sites in both arms of the harbour were all below ANZECC (2000) ISQG "trigger levels". However, mercury approached the ISQG-Low "trigger level" in the sediments of both sites in the Onepoto Arm.

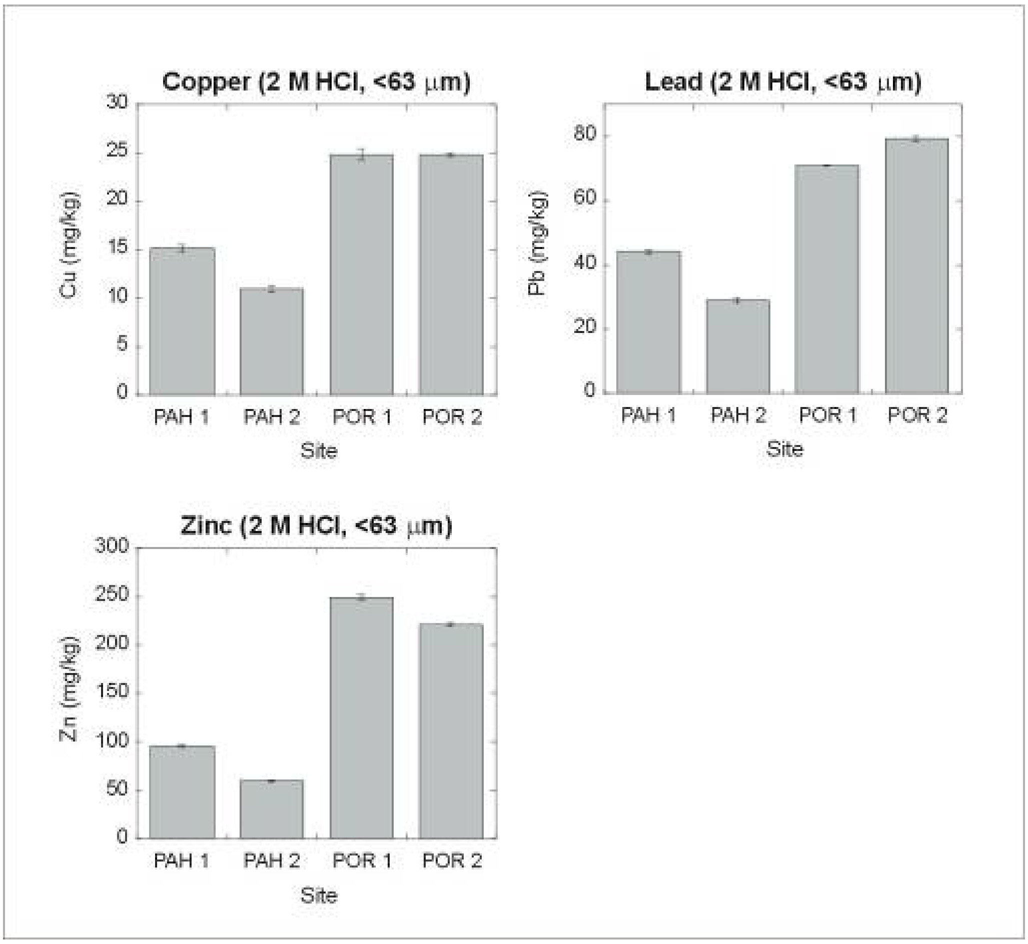

Figure 4.3: Concentrations of copper, lead, and zinc in the mud fraction of the sediments at sites in the Porirua Harbour

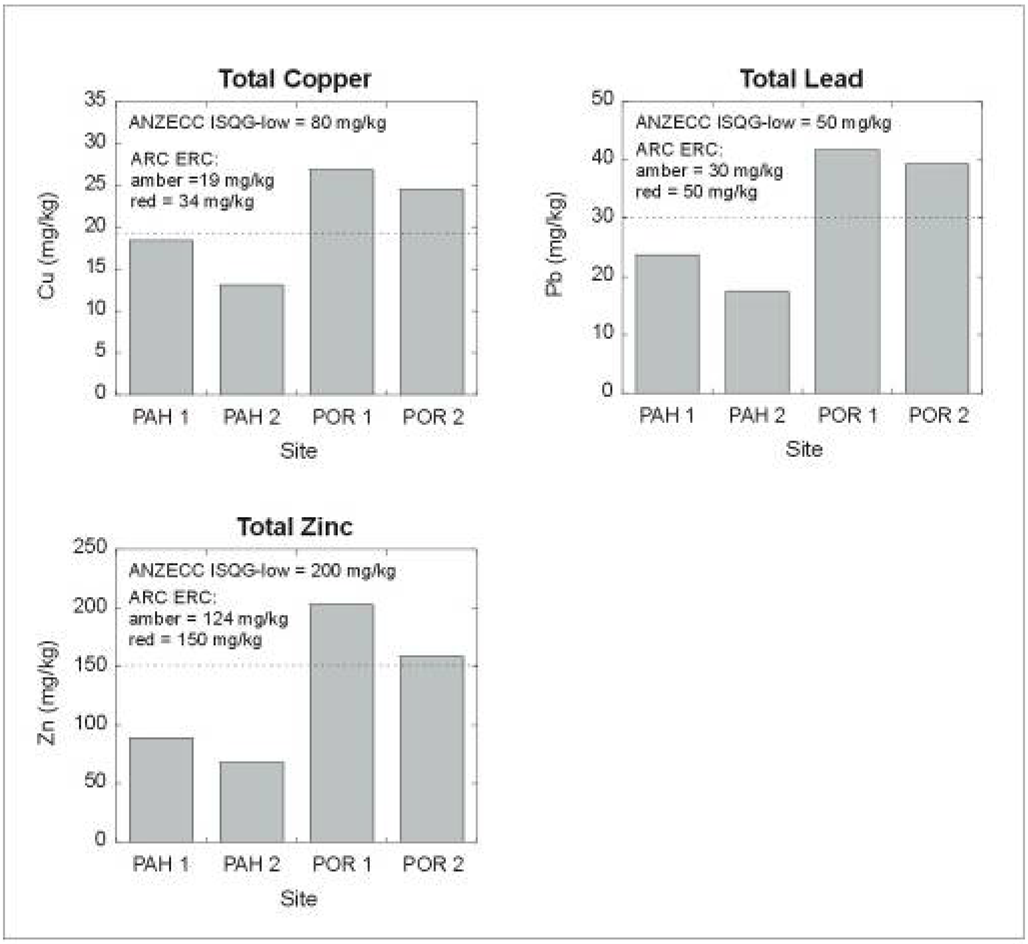

Figure 4.4: Concentrations of total copper, lead, and zinc in the sediments at sites in the Porirua Harbour.

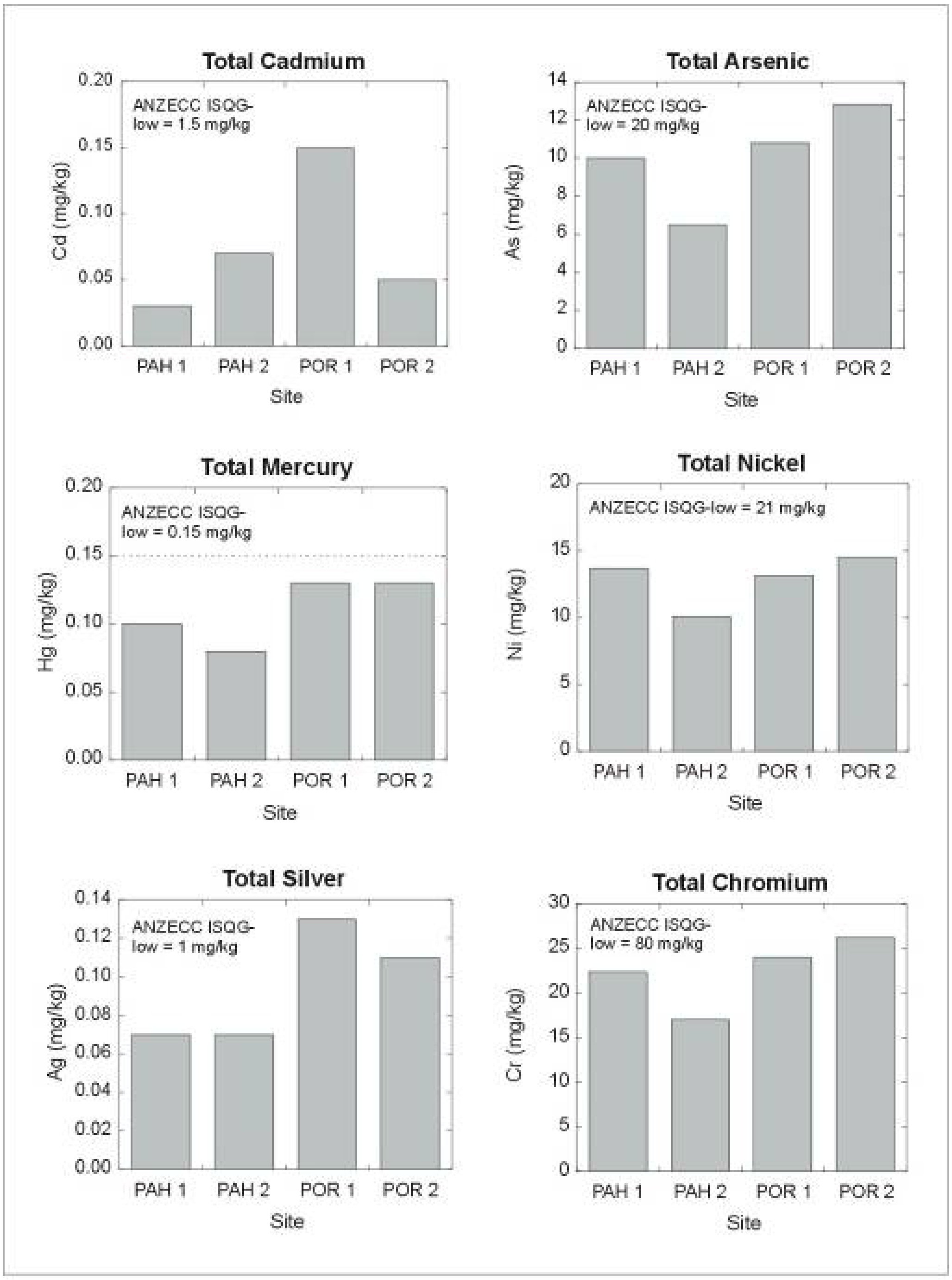

Figure 4.5: Concentrations of total cadmium, arsenic, mercury, nickel, silver, and chromium in the sediments at sites in the Porirua Harbour

4.2.4 Polycyclic aromatic hydrocarbons (PAHs)

Total PAH and high molecular weight PAH concentrations were both higher in the sediments of the sites in the Onepoto Arm than in the sediments of the sites in the Pauatahanui Arm (Figure 4.6). In sediment quality guidelines the concentrations are expressed as “normalised to 1% TOC” – the concentration equivalent to that which would be present in sediment of 1% TOC, to allow better comparison of potential toxicity between sediments with different TOC levels. “Normalised” total PAH and HMW PAH concentrations were well below ARC ERC and ANZECC (2000) ISQG "trigger levels" in the sediments of all sites in both arms of the harbour.

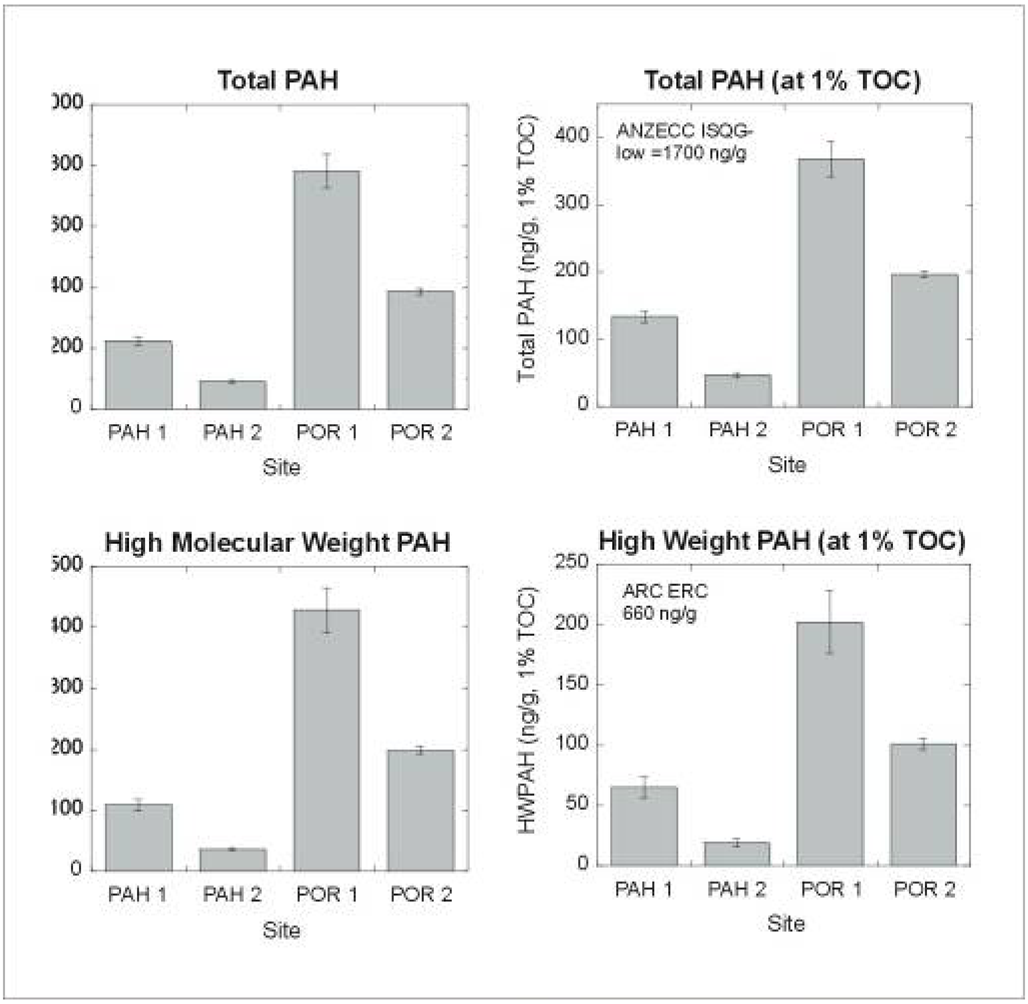

Figure 4.6: Concentrations of PAH in the sediments at sites in the Porirua Harbour. Concentrations are in nanograms/gram in the < 0.5 mm fraction.

4.2.5 Organochlorine pesticides

Of the 23 organochlorine pesticides analysed, only DDT and its derivatives were consistently detected in the sediments. Total DDT concentrations were similar at all the sites, these being above the ARC ERC red "trigger level", and well above the ANZECC (2000) ISQG-Low "trigger level" (Figure 4.7). DDE is the main contributor to the totals, particularly in the Pauatahanui Arm, which is consistent with an aerobically weathered DDT source, e.g., agricultural soils (Figure 4.8). Higher proportions of DDD and DDT in the Onepoto Arm sediments possibly reflect less weathered sources, such as urban stormwater and in-situ anaerobic transformation of DDT to DDD.

Dieldrin was detected in the sediments of the site off Duck Creek in the Pauatahanui Arm, and of both sites in the Onepoto Arm, at concentrations above the ANZECC (2000) ISQG-Low "trigger level", but this is set extremely low (0.02 nanograms/gram at 1% TOC). The ARC ERC-red "trigger level" for dieldrin is 0.72 nanograms/gram at 1% TOC and the Porirua Harbour sediments had dieldrin concentrations that were all well below this level.

Hexachlorobenzene (HCB) was detected in the sediments of the site off Browns Bay in the Pauatahanui Arm and of the southern site in the Onepoto Arm at concentrations close to its detection limit of 0.3 nanograms/gram. There is no “trigger level” for HCB in the ANZECC (2000) interim sediment quality guidelines.

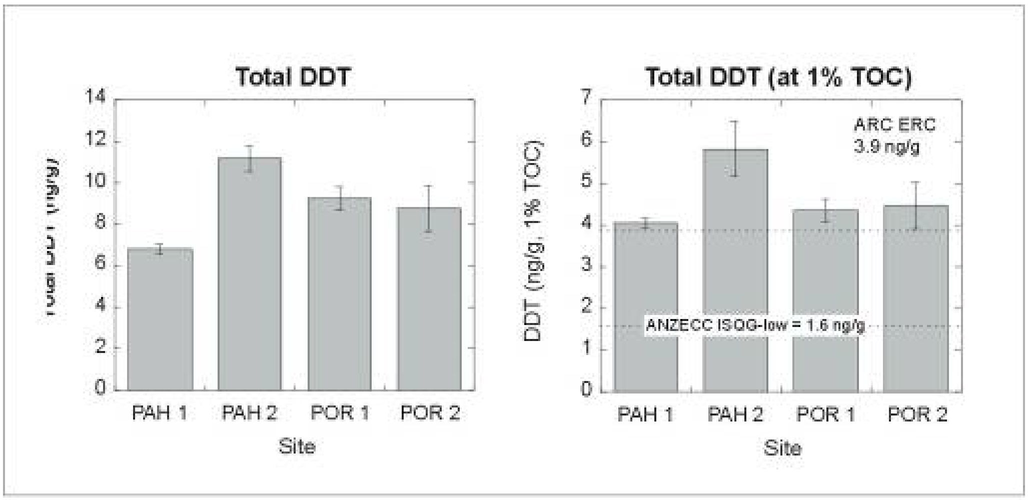

Figure 4.7: Concentrations of DDT in the sediments at sites in the Porirua Harbour.

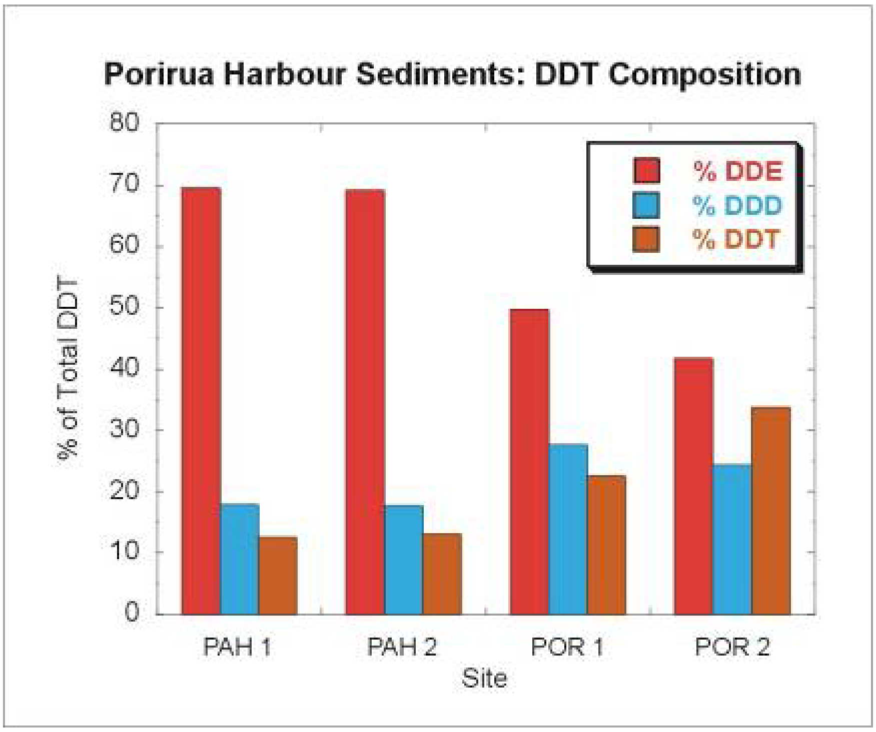

Figure 4.8: DDT composition in the sediments at sites in the Porirua Harbour. Values are means from each site (n = 5).

4.2.6 Organotin compounds

All of the four organotin compounds analysed were below detection limits in the sediments of both sites in the Onepoto Arm. In the Pauatahanui Arm, dibutyltin (DBT) was detected in the sediments of both sites and tributyltin (TBT) in the sediments of the site off Duck Creek. The TBT concentration was below the ANZECC (2000) ISQG-Low "trigger level".

4.3 Discussion

The measured concentrations of contaminants were compared against both the Auckland Regional Council Environmental Response Criteria (ARC ERC) for estuarine environments (ARC 2002) and the interim sediment quality guidelines (ISQG) of ANZECC (2000). These are not "pass" or "fail" values, but the concentrations which experimental and/or field evidence suggests are likely to result in impacts on aquatic life. They signal the need for further investigation to confirm whether or not impacts on aquatic life are occurring.

The heavy metals copper, lead, and zinc had already accumulated in the sub-tidal sediments of the Onepoto Arm to concentrations where impacts on aquatic life may begin to occur. Mercury was approaching ecologically significant concentrations in the sub-tidal sediments of the Onepoto Arm, as was copper in the sub-tidal sediments of Browns Bay in the Pauatahanui Arm. Inputs of heavy metals to the harbour sediments were believed to be on-going. This had been confirmed by studies of urban stormwater in the catchments.

DDT had accumulated in the sub-tidal sediments of both arms of the Porirua Harbour to concentrations where impacts on aquatic life may begin to occur. Inputs of DDT to the harbour sediments were believed to be on-going. This has been confirmed by studies of stream bed sediments and urban stormwater in the catchments.

The results of the investigation showed that adverse effects on aquatic life were unlikely to occur as a result of PAH or organotin contamination of sub-tidal sediments. The use of butyltins as antifoulants on small boats was banned in 1989, but inputs of PAHs to the harbour sediments were believed to be on-going. This was confirmed by studies of stream bed sediments and urban stormwater in the catchments.

4.4 Conclusions

The marine sediments in both arms of the Porirua Harbour were contaminated with toxic substances derived from the surrounding catchments, and some of these substances had accumulated to concentrations likely to result in adverse effects on aquatic life.

The investigation provided a valuable dataset from which to assess future trends in contaminant concentrations. The variability in the results was generally low, especially for the key metals (zinc and copper), so trend detection should be sensitive.

The results suggested that the permitted activity standards for stormwater in the Regional Freshwater Plan and the Regional Coastal Plan are likely to be being exceeded since contaminants in the discharges clearly have the potential to cause significant adverse effects on aquatic ecology of the receiving environment.

4.5 Further steps

This investigation provided a measure of the level of contamination in the marine sediment in Porirua Harbour. Further monitoring will be necessary to determine whether the concentration of chemical contaminants in sediments are increasing, static or decreasing.

A fifth sediment core was taken from the north of Pauatahanui Inlet at the time of sampling and put into storage. This has subsequently been sent for analyses but no results have yet been received.

Further monitoring will also enable the identification of the rate at which contamination is changing and, if an increasing trend is identified, to estimate when critical levels will be reached (e.g., when contaminants will have significant ecosystem effects).

If some form of management response is set in motion to address the sources of contamination, then further monitoring will allow us to assess the effectiveness of this response.

The following programme of on-going investigation was proposed:

1. Analyse the biological collections taken in October 2004 adjacent to the sediment chemistry monitoring sites in order to define the current status of sub-tidal benthic communities in relation to sediment chemistry. This was completed in May 2005.

2. Repeat the sediment chemistry and biological sampling in October 2005. Analysis of these samples will begin trend detection for the key contaminants and help define inter-annual variability in sub-tidal benthic communities, a prerequisite for detecting changes which may be associated with changes in contaminant concentrations in the future.

3. Repeat the sediment chemistry sampling in May 2007. Analysis of these samples will continue trend detection for the key contaminants, and possibly provide the first clear indication of the direction and rate of change.

5. Pauatahanui marine sedimentation investigation

5.1 Background

Greater Wellington has recognised the importance of the Pauatahanui Inlet by partnering a community based programme with Porirua City Council to ensure its sustainable management. In 2000 Greater Wellington and the Porirua City Council adopted the Pauatahanui Inlet Action Plan and provided resources for its implementation. A number of jointly funded projects fulfilling the objectives of the plan have been completed. The latest work to be undertaken looked at the issue of sedimentation build up in the Inlet.

One of the most significant threats to the Inlet is sediment accumulation. While all inlets receive the products of erosion in their catchments and fill up over time, human activities, such as earthworks, can accelerate this process. Accelerated sedimentation results in premature aging of an inlet with a subsequent loss of ecological and amenity values. While there had been anecdotal evidence that the rate of sedimentation in Pauatahanui Inlet was increasing, it was difficult for management agencies to develop policy responses without "hard" evidence.

In 2004 Greater Wellington and the Porirua City Council commissioned two interrelated studies to quantify and understand the impacts that land use has had, and continues to have, on sedimentation rates in the Inlet. These were:

1. An analysis of historical catchment land use and land use change in the Pauatahanui Inlet catchment over the last 150 years. This work was undertaken by the Institute of Nuclear and Geological Sciences Ltd (IGNS).

2. A reconstruction of the sedimentation of the Inlet, which was then related to the findings of the land use study. The specific objectives of this study were to:

    - quantify changes in sediment accumulation rates (SAR) due to deforestation and subsequent conversion to pasture and the effects of urban development;
    - quantify any spatial variations in SAR, particle size and heavy metal profiles between urban and rural sub-catchment outlets and the central mud basin;
    - relate observed sediment profiles to landcover history;
    - determine the rate of annual sediment accumulation; and
    - provide an assessment of potential future SAR over the next 50 years based on present day landcover and land management practices.

This work was undertaken by the National Institute of Water and Atmospheric Research Limited (NIWA).

5.2 Methodology

5.2.1 Historical land use and land use change

The land-use history and change record was constructed from a combination of historical records and sequential aerial photography. This work was undertaken at a sub-catchment level (e.g. Horokiri Stream catchment, Duck Creek catchment etc) and then combined to produce a whole catchment picture.

5.2.2 Sedimentation history

This study involved the extraction of sediment cores from 9 locations within the Inlet. The cores were then analysed using radioisotope and pollen dating techniques, allowing a chronology of sedimentation rates to be established. For instance, as a result of atmospheric nuclear weapon testing in the 1950s, Cesium was deposited in trace quantities over New Zealand, and was first detected in 1953. Where Cesium first occurs in the sediment columns from Pauatahanui Inlet, is known to be 1953. Similarly, the date radiata pine was first widely planted in the catchment is known. Pollen from these trees can be identified in the sediment sample providing another benchmark date. The study then related the rates of sedimentation at these and other identifiable dates to the corresponding land use at the time.

5.3 Summary of results[5]

The studies demonstrated that the rate of sediment accumulation in Pauatahanui Inlet has increased over time. Pre-human ("natural") rates are estimated to have averaged 1 mm per year. As a result of the impacts of forest removal, conversion to pasture and other human activities the sediment accumulation rate has steadily increased and is estimated to be about 4.6 mm per year currently.

It was noted that the quantity of sediment entering the Inlet is likely to higher than this figure. Two processes have worked in the Inlet's favour to prevent the accumulation rate being higher. Firstly, as a result of the strength and frequency of winds experienced at Pauatahanui and the particular depth of the Inlet, there is considerable "stirring up" and re-suspension of sediment. Secondly, the Inlet has strong tidal flushing with the total volume of water in the Inlet changing every 4 days. The scientists suspected that the combination of these two factors resulted in a proportion of sediment being exported from the Inlet. This factor may be the Inlet's "saving grace" that has prevented a more rapid accumulation of sediment. In addition, there had been a sea level rise of about 1.8 mm per year in the Wellington Harbour since 1891. It was assumed that a similar rise has taken place at Pauatahanui Inlet and this will have offset the effects of sediment build-up to some degree.

The study also showed that the rate of accumulation appeared to be continuing to increase and that there may be variations between sub-catchments.

[5] The results presented are from the final draft report on the Pauatahanui Sedimentation study and was yet to include changes arising from feedback.

The study concluded that the fact that sediment accumulation rates have increased in recent decades suggested that the rate of sediment input now exceeded the capacity of the estuary to flush sediment.

5.4 What did this mean?

While the study appeared to confirm the anecdotal evidence that sedimentation was increasing within the Inlet, it did not provide easy answers to the question of where the sediment is coming from. This was because:

- it could take some time (years) for sediment to travel from its source to the Inlet;
- sediment that is generated by slips, landslides and landuses does not always travel immediately to a waterway. It may be "stored" in the system and mobilised some years later as a result of an extreme weather event;
- within the Inlet there appears to be considerable redistribution of sediments from one site to another. For instance, the scientists suspected that sediment deposited in the Inlet from Duck Creek is mobilised and moved away. Correspondingly, it appeared that Browns Bay is a sediment 'sink" where sediment from other parts of the Inlet accumulates.

The results of the study suggested that the Inlet was approaching, or perhaps had reached, the point at which it is able to cope with the quantity of sediment it receives.

5.5 Next steps

This project was an important step in understanding the current state of the Inlet. It was one of a series of projects that had been undertaken over the last three to four years as part of implementing the Pauatahanui Inlet Action Plan.

It was considered timely to review the work undertaken to date and develop an "issues and options" report to chart the future direction of the Pauatahanui Project.

The 'issues and options' report will be jointly prepared by Greater Wellington and Porirua City Council officers (reflecting the collaborative nature of this on-going project) and will have the following objectives:

1. to briefly review the information we have assembled as a result of the various studies undertaken and what this information tells us about the present state of the Inlet;
2. to provide comment on the adequacy of current controls on land use within the Pauatahanui catchment, and the areas in which these might be improved. It should be noted that Porirua City Council are about to commence a review of the rural zone of their District Plan.
3. to identify gaps in our understanding of the Inlet and how these might be rectified by formulating a research and monitoring strategy for the Inlet;

4. to review the various programmes and projects currently underway and how they contribute to the objectives of the Pauatahanui Inlet Action Plan and to identify any gaps.

6. Marine biodiversity investigations

6.1 Background

In 2004 Greater Wellington contracted the Cawthron Institute to map the substrate and vegetation of 13 sandy beaches and 3 river estuaries within Wellington Harbour and the adjoining South Coast (Figure 6.1). The purpose was to provide an overview of the health of these intertidal habitats, which provide significant amenity and environmental value. These sites were also under pressure due to their locations adjacent to densely populated urban areas. The information arising from this investigation will assist coastal management and add to the knowledge of Wellington's coastal resources.

Figure 6.1 Sample locations

6.2 Method

The following methods were used:

6.2.1 Broad scale habitat mapping

The aim of broad scale habitat mapping is to describe the inter-tidal environment according to dominant habitat types based on surface features of substrate characteristics (mud, sand, cobble, rock etc.) and vegetation type (eelgrass, salt marsh, coastal plant species etc.) in order to develop a baseline map. This procedure involves the use of aerial photography together with detailed ground-truthing and digital mapping using GIS technology. Once a baseline map has been constructed, habitat information can be used to indicate the potential sensitivity of different areas to identified pressures such as beach grooming, vehicle use, stormwater discharges etc. or to identify areas where further information may be needed to improve resource management. It also provides an indication of the organisms likely to be present in different substrate types, an aspect that can be confirmed through fine scale sampling.

Repeating this exercise in time, the information can be used to evaluate the implications of natural and induced changes on the structure and function of the inter-tidal ecosystem.

6.2.2 Fine scale assessment

The reports authors describe fine scale assessment involves measuring environmental characteristics that are known to be indicative of estuary or coastal conditions, and are likely to provide a means for detecting habitat degradation, as well as providing a measure of subsequent change. The environmental characteristics assessed usually include a suite of commonly used benthic indicators.

In this investigation sediment samples were taken and analysed for the following physical and chemical parameters:

- Grain size
- Ash free dry weight
- Total nitrogen
- Total phosphorus
- Cadmium
- Chromium
- Copper
- Lead
- Nickel
- Zinc
- Macroinvertebrate abundance and diversity.

6.3 Results

6.3.1 Environmental pressures

A summary of the environmental pressures identified at each site, and a subjective assessment of the level of concern for each, is provided in Table 6.1 Blank cells indicate that the identified pressure is not considered significant/relevant, while a "?" indicates that the pressure may be present but needs confirmation.

Bacterial contamination was excluded from this assessment as it is monitored and addressed elsewhere through GWRC water quality monitoring.

Introduced weeds were widely present but their spatial coverage was often limited to the extent that they were not recorded under the broad scale mapping in this study. In many instances, introduced plantings may provide important protection for the establishment of native species, or may have been introduced for their amenity or functional value. For example, marram grass carries out an important dune stabilisation role. No attempt was made to assess their likely influence or recovery as their impact is species and location specific. A subjective assessment of the degree of modification to the beach area has also been included, such as the construction of seawalls, reclamations, stream culverts, building developments, *etc.* to provide an indication of "naturalness".

Table 6.1: Summary of identified pressures at each site and level of concern.

	Owhiro Bay	Island Bay	Houghton Bay	Lyall Bay	Breaker Bay	Seatoun	Worser Bay	Petone	Lowry Bay	Days Bay	Eastbourne	Camp Bay	Fitzroy	Kaiwharawhara	Korokoro	Hutt River
Flooding								C4	D4	D4	D4			D3	D3	C3
Gravel/Sand Extraction								D1					C1			
Grooming				?			?	C3	C3	C3	?					
Landfill Leachate			D2													
Nutrient Enrichment																
Shellfish collection	?	?	?	?	?	?	?	D3	D3	?	?					
Stormwater	D3	D3	D3	D3		D3	D3	D2	D3	D3	D3			D3	D3	D2
Vehicles	D3			?				D3		D3	?		D3			
Introduced weeds	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓
Degree of modification*	H	H	H	H	L	M	H	H	VH	VH	M	L	L	VH	H	VH

*VH=Very High, H=High, M=Moderate, L=Low

This information was not intended to provide a complete or detailed assessment of pressures, but was a broad overview of the activities that may be influencing the environmental quality at each site, and to provide some indication of their likely significance.

6.3.2 General findings

Overall, all of the sites were found to be in a healthy condition. Some localised impacts are present, but across the majority of the habitat at all of the sites, the intertidal sediment quality was high. At the fine scale sites, which were selected to provide a picture of the areas most likely to be affected, sediment analyses found no signs of adverse nutrient enrichment or chemical contamination. All sites supported biological communities typical of other New Zealand beaches and estuaries in good condition.

The results of the survey will be useful for our work in both consents management and policy development as the habitat information can be used to indicate the sensitivity of different areas to pressures such as beach grooming, vehicle use and stormwater discharges. In addition, the work done provides an indication of the organisms likely to be present in different substrate types, allowing us to make some assumptions about what organisms should be present in certain areas.

The survey was successful in gaining immediate public attention and a number of groups and agencies are waiting for the results with interest. The information will be slotted into the Greater Wellington's GIS system and will be available as baseline state of the environment information.

Figure 6.2: An example of the broad scale assessment, Petone Beach.

6.4 Future direction

Greater Wellington is proposing to continue with biological surveys of river estuaries and sandy beaches in other parts of the Region's coast. In particular, the Wairarapa coast has a high number of small river estuaries that contain coastal wetland sequences which we know very little about. The Kapiti and Wellington coasts have larger and only slightly better understood river estuaries. Work in these areas would complement the work done in the Wellington Harbour and in the Pauatahanui Inlet.

Staff will also be working on a Marine Biodiversity Action Plan. This approach is consistent with other action plans being developed as part of Greater Wellington's biodiversity programme. The Action Plan will develop the options and detail the work to be carried out, budgets and timeframes. It will be developed with the following criteria in mind:

- The work is linked to improving our ecological understanding of marine biodiversity;
- Communities may become involved in marine biodiversity work;
- The work can progress within the allocated budget;
- The work will assist with our information requirements for state of the environment reporting and coastal plan review;
- The work will assist in providing information for consents management decision-making; and
- If possible, work will be linked to other biodiversity programmes.

References

Kingett Mitchell Ltd. 2005: Assessment of Urban Stormwater Quality in the Greater Wellington Region.

Stephenson, G. 2005: Porirua Harbour Long-term Baseline Monitoring Programme: Identification of Sub-Tidal Benthos from the November 2004 Survey. Coastal Marine Ecology Consultants

Stevens, L, Robertson, B, Robertson, B. 2004: Broad Scale Habitat Mapping of Sandy Breaches and River Estuaries – Wellington Harbour and South Coast, Cawthron Institute.

Swales A et al. 2005: Pauatahanui estuary: effects of historical catchment landcover changes on estuary sedimentation. National Institute of Water & Atmospheric Research Ltd

Williamson et al. 2001: Effects of urban stormwater in the Wellington region: a synthesis of existing information, National Institute of Water & Atmospheric Research Ltd.

Williamson, B, Olsen G, Green, M. 2004: Greater Wellington Regional Council Long-term Baseline Monitoring of Marine Sediments in Porirua Harbour, National Institute of Water & Atmospheric Research Ltd.

Wellington Regional Council: 1995: Regional Policy Statement