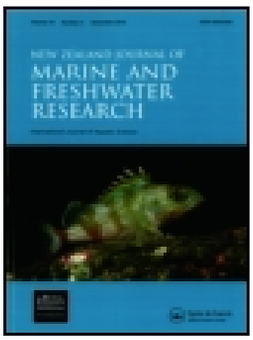

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Short communication

Heavy-metal pollution in Porirua Harbour, New Zealand

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Abstract The <20 μm fractions of 72 sediment samples from Pauatahanui and Porirua Inlets of Porirua Harbour have been analysed for eight elements and the results compared between the two inlets. Co, Ni, Fe, and Mn occur in similar abundances in sediments from the two inlets and show no evidence of contamination. Cr concentration is somewhat higher in sediments from Pauatahanui Inlet and again shows no evidence of contamination. Cu concentration is significantly higher in sediments of Porirua Inlet and two samples taken in the vicinity of Porirua City are in the class uncontaminated to moderately contaminated. Pb and Zn show significantly higher concentrations in sediments from Porirua Inlet. Sediments in the vicinity of Porirua City attain the category moderately to strongly contaminated for Pb and moderately contaminated for Zn. No evidence of heavy-metal contamination is seen in sediments in the vicinity of State Highway 1. Heavy-metal pollution in Porirua Harbour therefore appears to be restricted to Pb, Zn, and, to a lesser extent, Cu, and occurs in Porirua Inlet in the vicinity of Porirua City.

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INTRODUCTION

There is increasing interest in the heavy-metal pollution of estuaries in New Zealand. Studies have recently been undertaken on the heavy-metal contents of sediments from Wellington Harbour (Stoffers et al. 1986) and Manukau and Waitemata Harbours (Glasby et al. 1988). These studies have shown that heavy-metal enrichment in sediments in these harbours is localised and can be traced to specific inputs. In the present paper, we report on heavy-metal analyses of sediment samples taken from Porirua Harbour. The procedures adopted here are identical to those in both studies noted above. In addition, sediment samples have been analysed for several pesticides and halogenated hydrocarbons (Wellington Regional Council unpubl. data).

STUDY AREA

Porirua Harbour

Porirua Harbour is situated on the west coast of the North Island some 20 km north of Wellington and consists of two inlets. Pauatahanui Inlet is a tidal estuary c. 3.5 km long by 2 km wide and lies in an east–west direction. Porirua Inlet lies south-west–north-east and is of an elongate form, 4 km long and 1.3 km wide. The catchment area of Porirua Harbour is 600 km². Both inlets have common access to the sea via a narrow 0.1 km wide entrance opening to the north. Both are shallow with maximum depths of 3 m, except for the inlet connecting them which has a maximum depth of 9 m. (Bathymetry: Irwin (1978a, 1978b, 1978c). Place names mentioned in the text are shown in Fig. 1 and 2.

The harbour was formed by post-glacial drowning of the seaward end of the west-flowing rivers about 10 000–14 000 years ago. It is believed that the 1855 earthquake raised the harbour about 1 m, slightly more in Pauatahanui Inlet and slightly less in Porirua Inlet (Irwin 1976). The tidal estuary of the Pauatahanui Inlet covers a 4.5 km² area and the tidal mud flat area is 1.1 km².

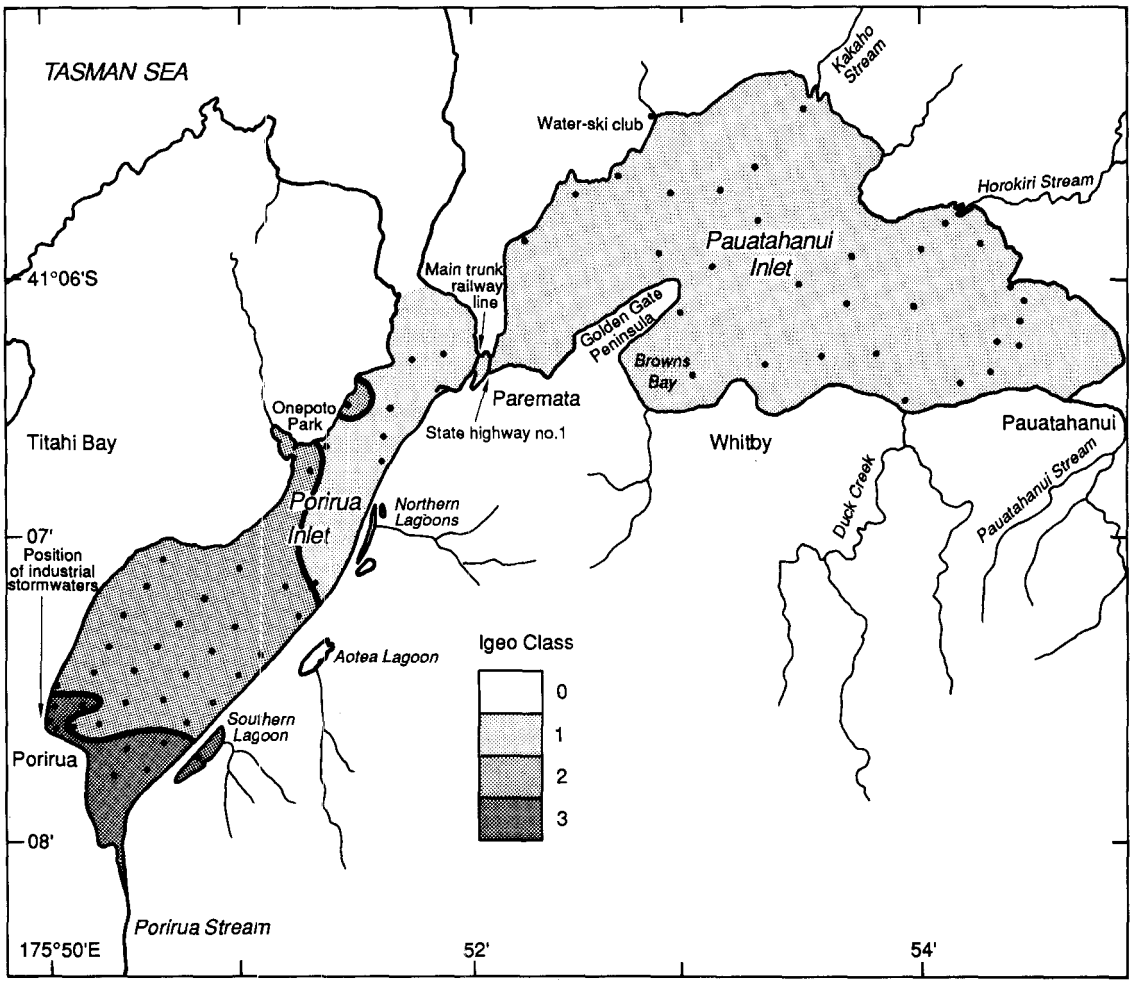

Fig. 1 Schematic map showing the distribution of Igeo class values for Pb in Porirua Harbour.

Pautahanui Inlet

Pauatahanui Inlet was subject to extensive investigations as a part of the 3-year Pauatahanui Environmental Programme which took place in the 1970s (Healy 1980, and references therein). A sediment chart has also been prepared for the inlet (McDougall 1976, 1978) and other studies undertaken (Smith & McColl 1978; Hicks 1988).

Surface sediments in the main channel around Golden Gate Peninsula are very coarse shell and sand. Fine sediments have been sluiced out by strong currents. The other areas of the inlet including the mudflats are predominantly sands and silty sands with some areas of shell beds. The deep area in the centre of the inlet is predominantly silt. The shore-line is rock, gravel, and sand flat. Bedrock is indurated siliceous sandstone with indurated mudstone.

Catchments in the Pauatahanui Inlet were originally covered in native forest and bracken at the time of European arrival. Much of the catchment was converted to pasture following European settlement. Development has occurred predominantly at the seaward end of the inlet this century, with the most recent developments occurring in the Whitby subdivision. Cut-and-fill earthworks were carried out during the 1970s. The small stream which runs through Whitby into Browns Bay carried a great deal of sediment-laden run-off depositing the material in Browns Bay (Healy 1980).

The Pauatahanui Stream enters the inlet at its eastern end and is surrounded by a protected mud

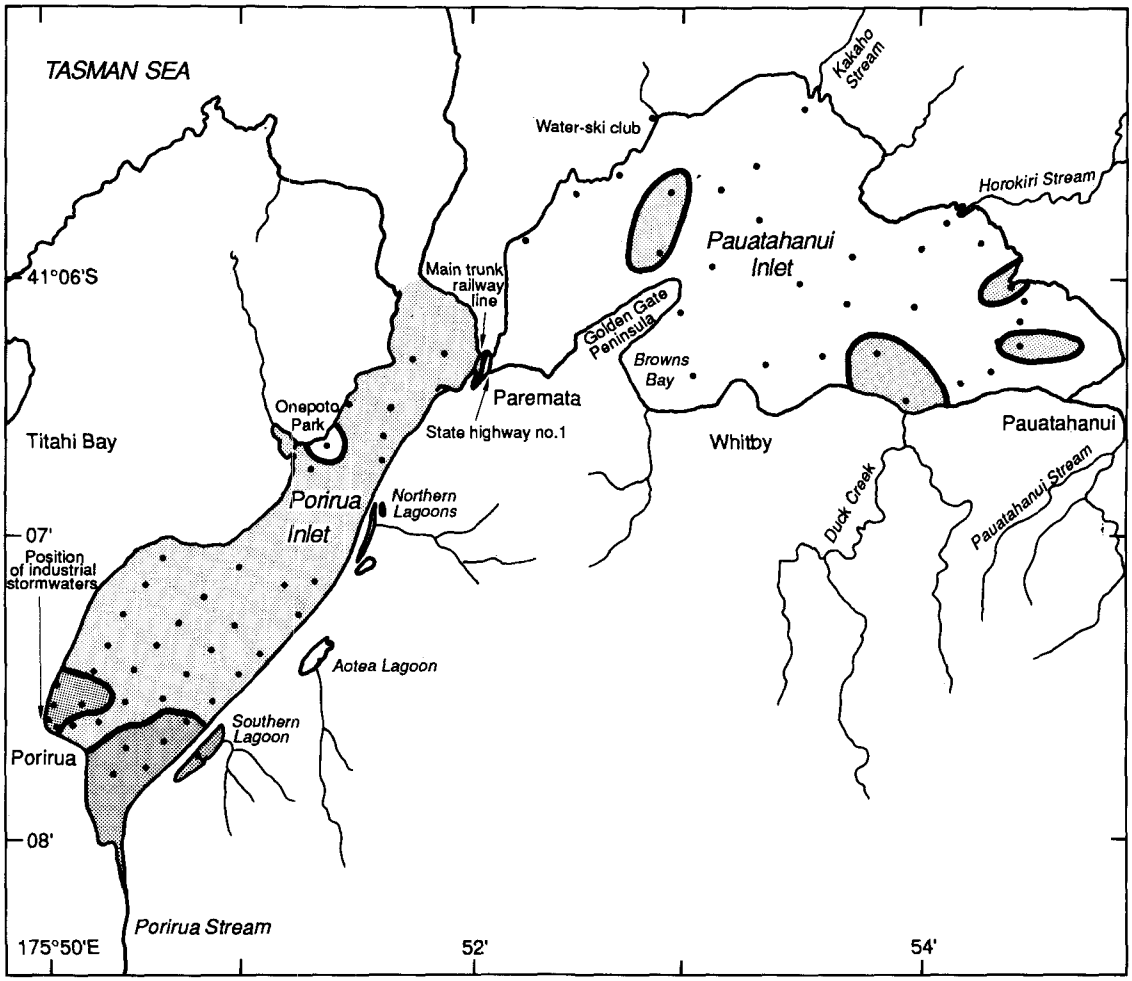

Fig. 2 Schematic map showing the distribution of Igeo class values for Zn in Porirua Harbour.

flat area established with weirs to retain water during summer months. Catchment cover of this stream is predominantly pastoral with pockets of bush and scrub. A sawmilling plant operates within the Pauatahanui Stream catchment.

The Horokiri Stream enters the northern side of the inlet. Catchment cover is pastoral with some gorse and scrub. Previous land use includes a domestic waste landfill and dairy farming. A small piggery is operating at present.

Another sawmilling plant operates in the Kakaho Stream catchment. Vegetation cover in this catchment is grassland with patches of scrub, bracken, and fern.

Vegetation cover in the Duck Creek catchment is grassland with bracken, fern, and scrub. Land in this catchment is used for recreational purposes.

The entire inlet is encircled by a road which carries a moderately high traffic volume as it is the major route from the Hutt Valley to Porirua. The main trunk railway line and State Highway 1 cross the Inlet at the south-western corner. Evidence of pollutants from vehicles, probably from exhaust gases and oil, might be expected in the shoreline sediments.

Rural catchments have been substantially topdressed in the past. It is possible that residual Cd, Cu, Co, Mn, Mo, Fe, Zn, and B have run-off into the inlet.

Porirua Inlet

Porirua City lies on the southern and western banks of the Inlet and has a population of c. 43 000. The

area is not highly industrialised, the major industry being an automotive assembly factory employing some 900 staff. Other industry includes hosiery and wallpaper manufacture together with many smaller industries producing all manner of products from foodstuffs to sheet metal products.

The eastern catchments of the Porirua Stream were extensively farmed and have been heavily topdressed over the years. In general, the catchments around the Porirua Inlet are significantly more developed than in the Pauatahanui area. This is because Porirua City surrounds a major part of the inlet.

Several stormwaters discharge into the inlet along the western shore flowing from the northern suburbs of Porirua. Stormwaters flowing from the industrial area of Porirua discharge into the south-western corner of the inlet. Around the mouth of the Porirua Stream, stormwater discharges are derived from the commercial area of Porirua.

The Porirua Stream flows into the inlet at its southern end. Over the last year, major earthworks have been carried out with the construction of the Mungavin Interchange on the urban motorway. Some silt build-up has occurred in the lower reaches of the Porirua Stream following the collection of samples for this study.

The urban motorway and main trunk railway line run parallel with the eastern shore of the inlet. Several tidal lagoons have formed on the eastern side of the motorway which drain under the road into the Inlet.

METHODS

In all, 72 samples from 82 stations were analysed for 8 elements by atomic absorption spectrometry (AAS). Analyses were carried out on the <20 μm size fraction of the sediment. Separation of the <20 μm fraction was carried out by wet-sieving using standard plastic sieves. The analytical method has previously been described by Stoffers et al. (1986). Co was analysed by AAS (graphite furnace). The precision of the data is ± 5–10% depending on the individual element. A set of international rock standards was used for calibration. Overall accuracy of the data is ± 5%. Several samples taken from the channel between the two inlets consisted entirely of shells and had no fine fraction to analyse.

To compare present-day heavy-metal concentration with pre-European background values, we have used the index of geoaccumulation (Igeo) as introduced by Müller (1979); see also Stoffers et al. (1986). This index is defined as :

$$\text{Igeo} = \log_2 \frac{C_n}{1.5B_n}$$

where C_n is the measured concentration of the element in the <20 μm fraction of a sediment, and B_n represents the background concentration of the element. The background concentration is taken from Turekian & Wedepohl (1961). The Igeo value is therefore a measure of heavy-metal contamination and is defined in the following scale:

Igeo class	Designation of sediment quality
6	Extremely contaminated
5	Strongly to extremely contaminated
4	Strongly contaminated
3	Moderately to strongly contaminated
2	Moderately contaminated
1	Uncontaminated to moderately contaminated
0	Uncontaminated

RESULTS

Analytical data for Pauatahanui Inlet and Porirua Inlet as well as background average shale values (Turekian & Wedepohl 1961) are given in Table 1.

The data show that, on average, Co, Ni, Fe, and Mn occur in similar abundances in the two inlets and that all samples are Igeo Class 0. Cr is somewhat higher in sediments of Pauatahanui Inlet, possibly reflecting differences in sediment provenance, but again all samples are in Igeo Class 0. Cu shows notably higher concentrations in sediments from Porirua Inlet. However, all but two samples taken immediately adjacent to Porirua are in Igeo Class 0; the other two samples are in Igeo Class 1.

Pb and Zn, on the other hand, show notably higher concentrations in the Porirua Inlet samples compared to the Pauatahanui Inlet samples. The distributions of Igeo class values for these two elements are shown in Fig. 1 and 2. These diagrams indicate that the Pb content of the sediments varies from Igeo Class 3 to Igeo Class 1 whereas Zn content varies from Igeo Class 2 to Igeo Class 0 with increasing distance from Porirua City. There is no evidence of elevated Pb contents in the sediments adjacent to State Highway No. 1 as might have been expected from the density of motor vehicle traffic there. The close association of Pb and Zn in the Porirua Inlet sediments is indicated by the very high correlation coefficient ($r = +0.95$) of these elements in samples from this inlet.

Table 1 Mean, minimum, and maximum concentrations of elements in sediments from Pauatahanui Inlet and Porirua Inlet. All analyses in ppm, except Fe (in %).

	Cu	Co	Cr	Ni	Pb	Zn	Fe	Mn
Pauatahanui Inlet (30 samples)								
Mean	29	13	38	21	36	133	2.85	208
Minimum	20	9	19	14	27	97	2.31	167
Maximum	66	20	101	42	47	241	3.70	443
Porirua Inlet (42 samples)								
Mean	48	12	20	20	93	259	3.11	224
Minimum	35	10	7	15	42	136	2.59	169
Maximum	93	20	33	27	170	435	3.53	966
Average background shale (Turekian & Wedepohl 1961)	45	19	90	68	20	95	4.72	850

The distribution of the data would suggest that there are two sources of anthropogenic elements in Porirua Inlet; one from Porirua city and one from Porirua Stream. The data indicates that Pb, Zn, and, to a lesser extent, Cu in the sediments of Porirua Inlet immediately adjacent to Porirua city are derived directly from Porirua itself. The concentrations of Pb and Zn are comparable to, although slightly less than, those found in parts of Wellington and Auckland Harbours (Stoffers et al. 1986; Glasby et al. 1988).

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REFERENCES

Glasby, G. P.; Stoffers, P.; Walter, P.; Davis, K. R.; Renner, R. M. 1988: Heavy-metal pollution in Manukau and Waitemata Harbours, New Zealand. *New Zealand journal of marine and freshwater research 22*: 595–611.

Healy, W. B. *co–ord* 1980: Pauatahanui Inlet—an environmental study. *DSIR information series 141*. 198 p.

Hicks, G. R. F. 1988: Sediment rafting: a novel mechanism for the small-scale dispersal of intertidal estuarine meiofauna. *Marine ecology–progress series 48*: 69–80.

Irwin, J. 1976: Morphological stability of Pauatahanui Inlet, Porirua Harbour. *New Zealand journal of marine and freshwater research 10*: 641–650.

Irwin, J. 1978a: Pauatahanui Inlet bathymetry. *New Zealand Oceanographic Institute miscellaneous series chart 47* (1:5 000).

Irwin, J. 1978b: Porirua Inlet bathymetry. *New Zealand Oceanographic Institute miscellaneous series chart 48* (1:5 000).

Irwin, J. 1978c: Porirua Harbour bathymetry. *New Zealand Oceanographic Institute miscellaneous series chart 49* (1:10 000).

McDougall, J. C. 1976: Distribution of surface sediments of Pauatahanui Inlet. *New Zealand Oceanographic Institute oceanographic field report 7*. 7 p.

McDougall, J. C. 1978: Pauatahanui Inlet sediments. *New Zealand Oceanographic Institute miscellaneous series chart 50* (1:5 000).

Müller, G. 1979: Schwermetalle in den Sedimenten des Rheins—Veränderungen seit 1971. *Umschau 79*: 778–783.

Smith, A. P. D.; McColl, R. H. S. 1978: Sediments of Pauatahanui Inlet: Nutrient status and role in water quality. *New Zealand Soil Bureau scientific report 37*. 52 p.

Stoffers, P.; Glasby, G. P.; Wilson, C. J.; Davis, K. R.; Walter, P. 1986: Heavy metal pollution in Wellington Harbour. *New Zealand journal of marine and freshwater research 20*: 495–512.

Turekian, K. K.; Wedepohl, K. H. 1961: Distribution of the elements in some major units of the earth's crust. *Bulletin of the Geological Society of America 72*: 175–192.