ADVISORY COUNCIL ON THE ENVIRONMENT
ACE
Room 2006, 20th floor, Murray Building, Garden Road, Central, Hong Kong
Tel: 848 2551 Fax: 845 3489
香港中環花園道美利大廈20樓2006室 • 電話：848 2551 傳真機：845 3489

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for information

Progress Report on the Sha Tin Sludge Marine Disposal Scheme

INTRODUCTION

The purpose of this paper is to brief members on the progress of the 5-year trial of marine disposal of water treatment and sewage treatment works sludges. Results of the preliminary environmental assessment are presented, followed by discussions on the interim measures to be implemented after the cessation of the Scheme.

BACKGROUND

2. In the early 1980's, a Government inter-departmental working group considered and recommended ways of disposing of sludges arising from Hong Kong Government's water treatment and sewage treatment works. With the agreement of the then Environmental Pollution Advisory Committee the Government began in early 1991 to dump the sludge on a trial basis at a point 20 km south east of Port Shelter (Figure 1). The trial was to last for a period of five years.

3. Marine dumping of sewage sludge from the Sha Tin Sewage Treatment Works started in March 1991 with sludge from the Sha Tin Water Treatment Works added some four months later. The sludge-dumping tanker, *the Shatin Prince*, has a sludge holding capacity of 1,400 cu.m. and about 30 tonnes of dry solids are dumped each day. The sludge is released into the water column by its own gravity as the tanker traverses the dump site. Estimates of the total quantities of major constituents dumped between March 1991 and September 1994 are shown in Figure 2.

4. To assess the impacts of sludge dumping on the marine environment, baseline surveys were performed in addition to dumping surveys which were scheduled to be conducted at 2, 5 and 10 years after the commencement of dumping. Four baseline surveys were carried out between 1987 and 1989 and the first series of dumping surveys, also four in number, was conducted between 1992 and 1994.

5. Various special investigations have been conducted to supplement the core monitoring programme. These included tracer studies to determine the way the sludge particles spread on the seabed, sediment toxicity tests to determine potential impacts on benthic organisms, and a special survey on the cadmium level of a bivalve species, *Anadara craticulata* (bloody cockle). The vertical profiles of the sediment at the dump site were investigated visually by deploying a special camera and analytical technique called REMOTS as part of a territory wide survey organized by the Civil Engineering Department.

RESULTS OF THE PRELIMINARY ENVIRONMENTAL ASSESSMENT

Water quality

6. Results for dissolved oxygen levels, 5-day biochemical oxygen demand and suspended solids levels indicated that the sludge dumping operation has not caused any adverse changes of these parameters in the water column. However, nutrient levels have increased when compared with the baseline surveys (Figure 3). The median total phosphorus levels recorded between 1992 and 1994 were 100 and 150% above the baseline for the surface and bottom waters respectively. The median total inorganic nitrogen level in the surface water in summer was 443% above the baseline. However other parts of Hong Kong waters have shown increases in nutrients in recent years thought to be due to increasing local pollution and loads from the Pearl River estuary. The increases at the dump site therefore cannot confidently be ascribed to the dumping activity.

7. Notwithstanding the changes in water quality that have been recorded, routine monitoring data for the years 1992 to 1994 show that the key water quality objectives for the Mirs Bay Water Control Zone (within which the dump site is situated) continue to be met (Figure 4).

Sediment quality

8. Sewage sludge tracers, coprostanol and Clostridium perfringens were recorded in sediment samples. Their distribution showed that sludge solids are reaching the seabed but are generally confined to the dump site itself rather than being spread around. The REMOTS survey however did not identify any sludge deposition layer on the seafloor.

9. There is very clear evidence of an increase in metal contamination at the sampling stations. The main increases are seen in metals which constitute the main contaminants of the sludge. Median levels of aluminium, arsenic, chromium, copper, nickel and zinc in summer were all greater than 50% above the baseline (Figure 5). The scale of change was less marked in winter. The changes are probably due to sludge dumping and based on available information on sediment toxicity in the scientific literature, the levels may have ecological impacts.

10. Results of the sediment toxicity tests suggested that the sediments had a low reactivity and toxicity potential. No spatial variations in toxicity were identified.

Tissue contaminant levels

11. As regards the accumulation of metals some species actually showed a reduction in metals whereas other showed an increase. Overall, of the eight species of biota sampled, decreases in tissue metals outnumbered increases for the ten metals monitored (Figure 6). Aluminium, copper, manganese and zinc appear to have accumulated in the tissues of some species in both summer and winter. This may be linked to sludge dumping but the toxicological and ecological significance is unclear. It is not clear either why some samples showed a depletion rather than an accumulation of metals.

12. One particular species of biota out of the eight species sampled, *Anadara craticulata* (bloody cockle) collected around the dump site, had high cadmium levels. Samples collected from southern waters (at 3-9 km south of Lamma Island, 40 km west of the sludge dump site) and from local markets also have median levels above the statutory limit of 2 parts per million stated under the Food Adulteration (Metallic Contamination) Regulations. The wide occurrence of high cadmium levels in this species indicates that this is a species specific phenomenon and is unlikely to have been caused by the dumping operation.

Population of the bottom-living organisms

13. There have been changes in the community structure. Fish (in summer) and shrimp populations have decreased, while the mollusc (e.g., bivalves and gastropods) has increased (Figure 7). Overall, the biomass of the bottom-living community (in terms of the total wet weight per station) has increased by 56%. The changes are not indicative of large scale degradation. Because of their widespread nature and because benthic communities are notoriously patchy and subject to large fluctuations with time, it is not possible to conclude that these have been due to sludge dumping.

FUTURE ARRANGEMENTS FOR SLUDGE DISPOSAL

14. The current contract for the marine disposal of the combined sludges will expire at the end of February 1996. The government has therefore conducted a review of the arrangements for disposal of these sludges, to determine whether a new long-term contract should be let. In conducting the review the following key issues have been taken into account:

(i) the international trends regarding dumping of wastes at sea;

(ii) the environmental costs and benefits of the various options available; and

(iii) the economic costs and benefits of the various options available.

15. As regards (i), there is a clear trend towards the banning of disposal of industrial waste at sea. At its meeting in 1993, the Consultative Committee of the London Convention reached a resolution that marine disposal of industrial waste should be banned starting from 1 January, 1996. Recent indications from the International Maritime Organisation are that water treatment works sludge should be considered to be an industrial waste.

16. As regards (ii), the only two feasible options are dewatering of the sludges followed by disposal at landfill, and continued disposal at sea. While there is no clear evidence that disposal at sea is harmful, there is little doubt that disposal at properly constructed landfills will minimise the potential for environmental damage.

17. As regards (iii), an economic analysis has shown that if water treatment works sludge is to be dewatered and disposed of at landfill there is no advantage in continuing to dispose of the sewage sludge by dumping at sea. Rather both types of sludge should be disposed of in the same way.

18. In view of the foregoing it has been decided to replace the current arrangements with a three-year contract to co-dewater the sludges at Sha Tin sewage treatment works followed by disposal at landfill. The contract will be put in place as soon as possible after February 1996. It may be necessary to extend the current dumping contract by a few months to ensure a smooth transition.

19. Because of the scarcity of landfill space in Hong Kong the new contract will be a three year service contract rather than a permanent long-term solution. During the period of the contract the situation will be kept under review and the sludge dumping ground will continue to be monitored to provide valuable information on changes that take place following the cessation of dumping. This will feed into the decision-making process, should there be a need to reconsider dumping at sea as a disposal option, following changes either in international trends or local circumstances.

CONCLUSIONS

20. The preliminary impact assessment of the marine sludge disposal scheme has indicated changes in sediment quality, and possibly in levels of contamination of biota, which may be due to dumping. The toxicological and ecological implications of these changes are unclear.

21. In view of these findings, and international trends relating to disposal of wastes at sea, the current arrangements are to be replaced by a service contract for dewatering of the sludges at the Sha Tin sewage treatment works followed by disposal at landfill. The sludge disposal site will continue to be monitored to consolidate information on impacts and to track changes on cessation of dumping. The information so gathered will be used to assist future decisions about disposal options.

Environmental Protection Department
July 1995

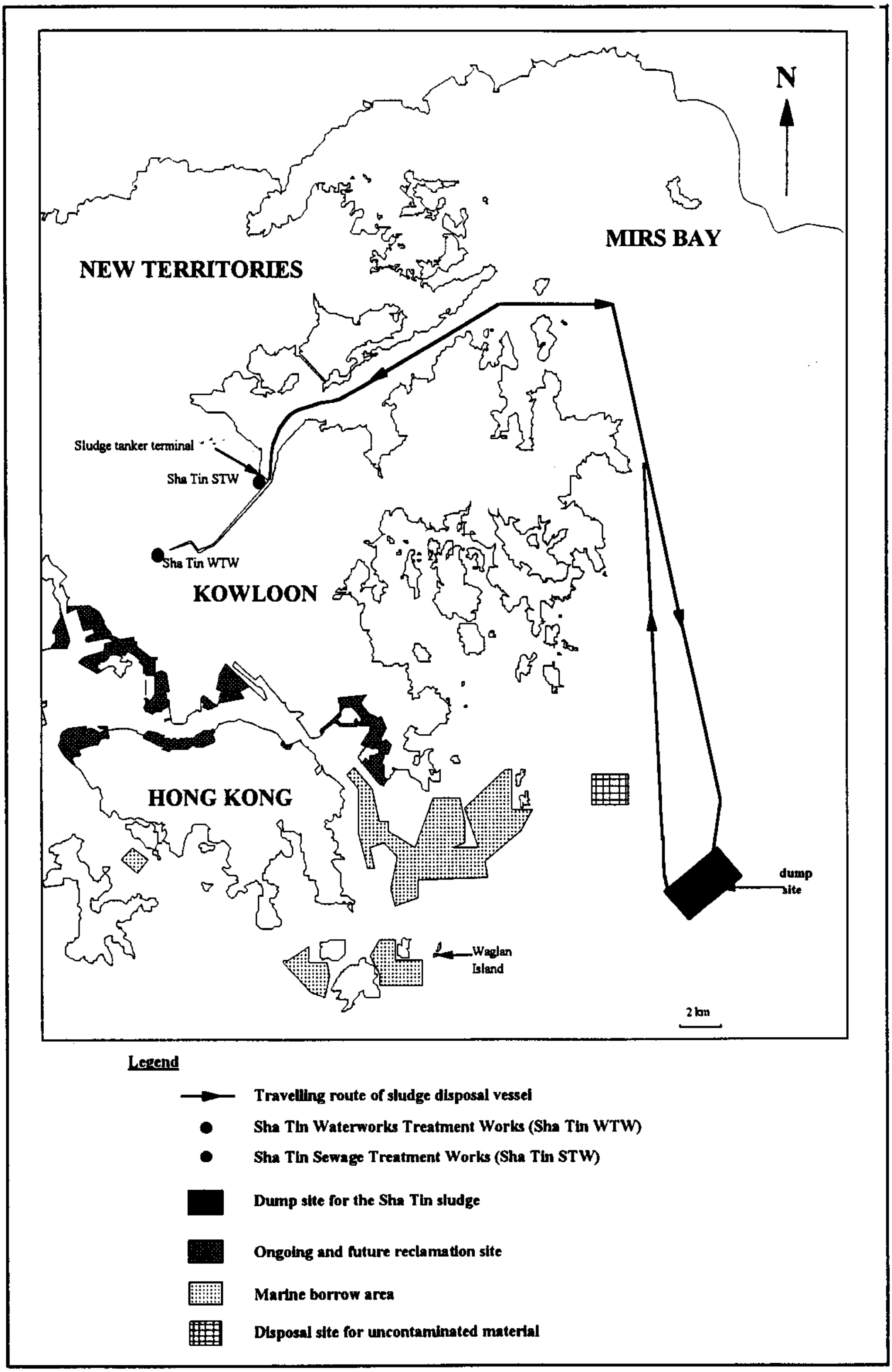


Figure 1 Location of the sludge dump site

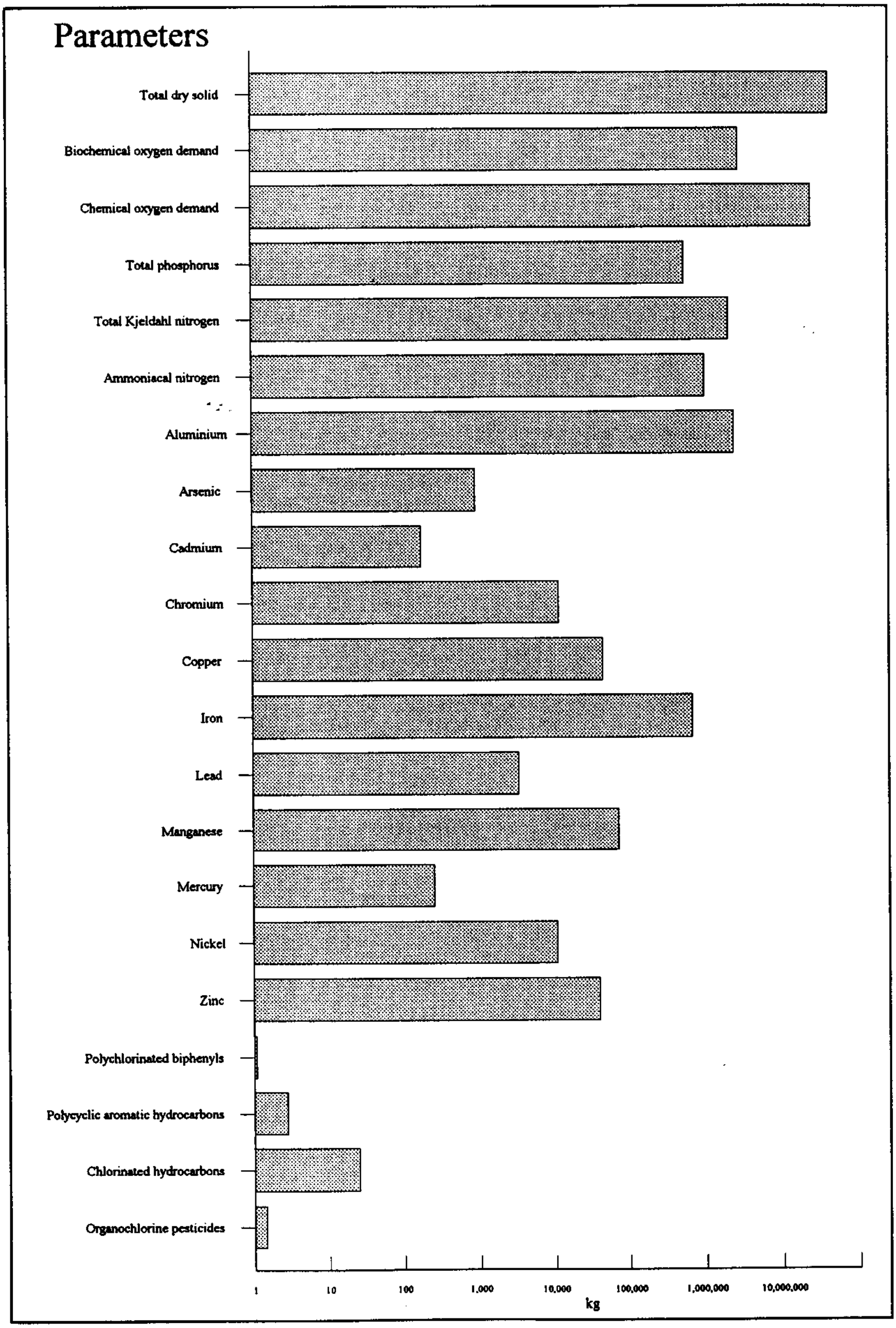
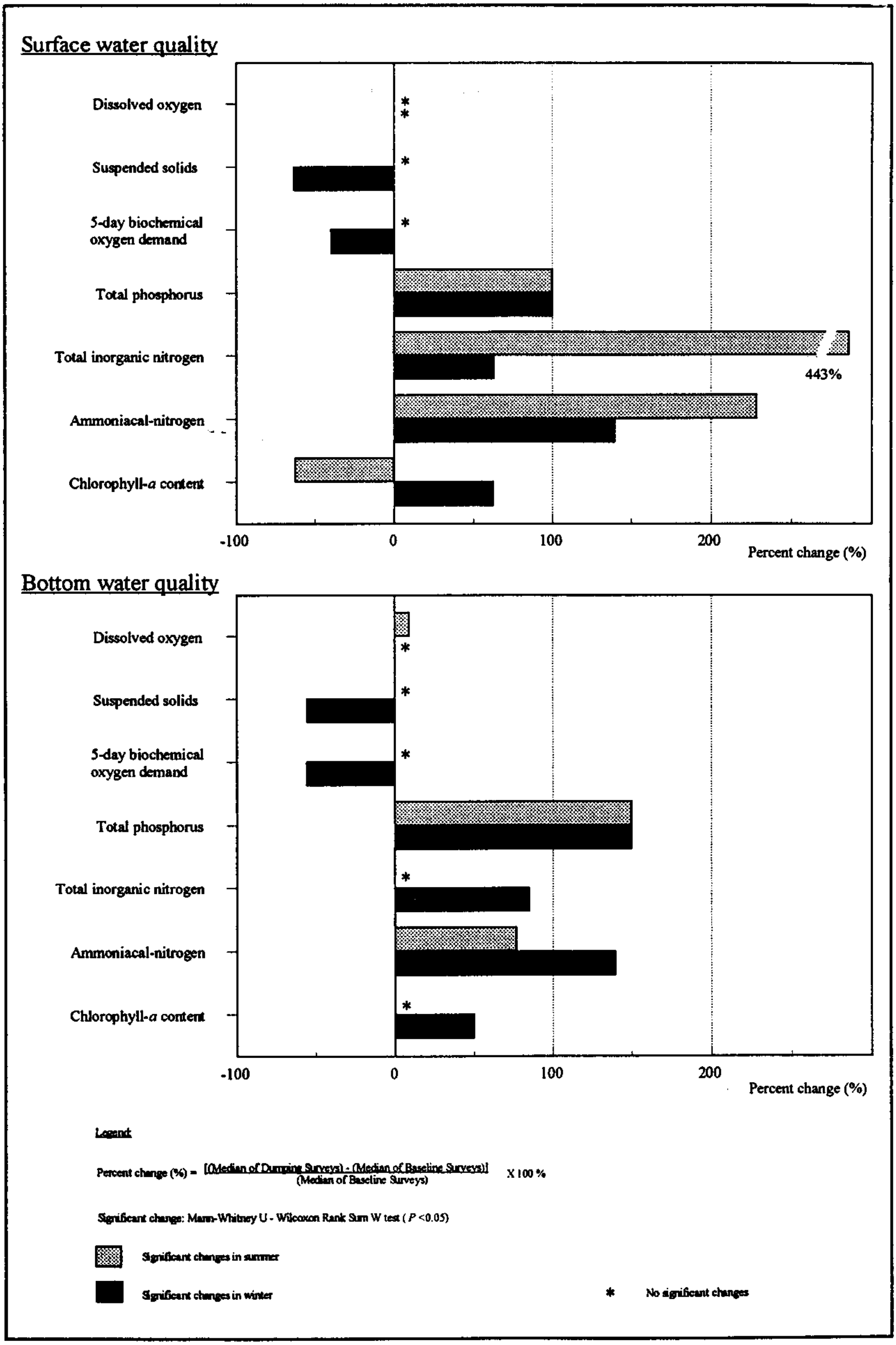


Figure 2 Total quantities of sludge constituents dumped (March 1991 to September 1994)



$$\text{Percent change (\%)} = \frac{[(\text{Median of Dumping Surveys}) - (\text{Median of Baseline Surveys})]}{(\text{Median of Baseline Surveys})} \times 100\ \%$$

Significant change: Mann-Whitney U - Wilcoxon Rank Sum W test ($P < 0.05$)

Figure 3 Temporal changes in water quality with the dumping of sludge

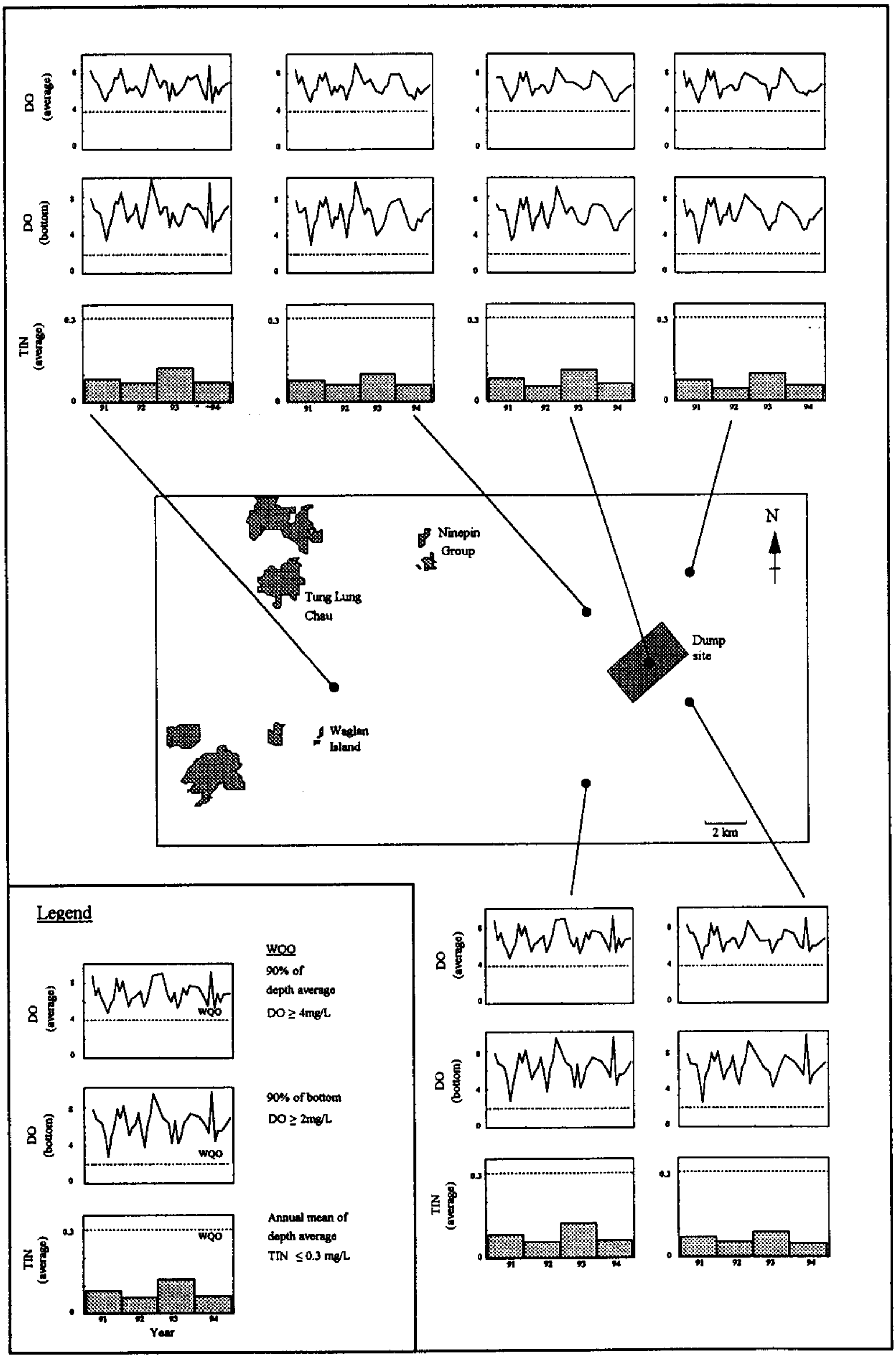
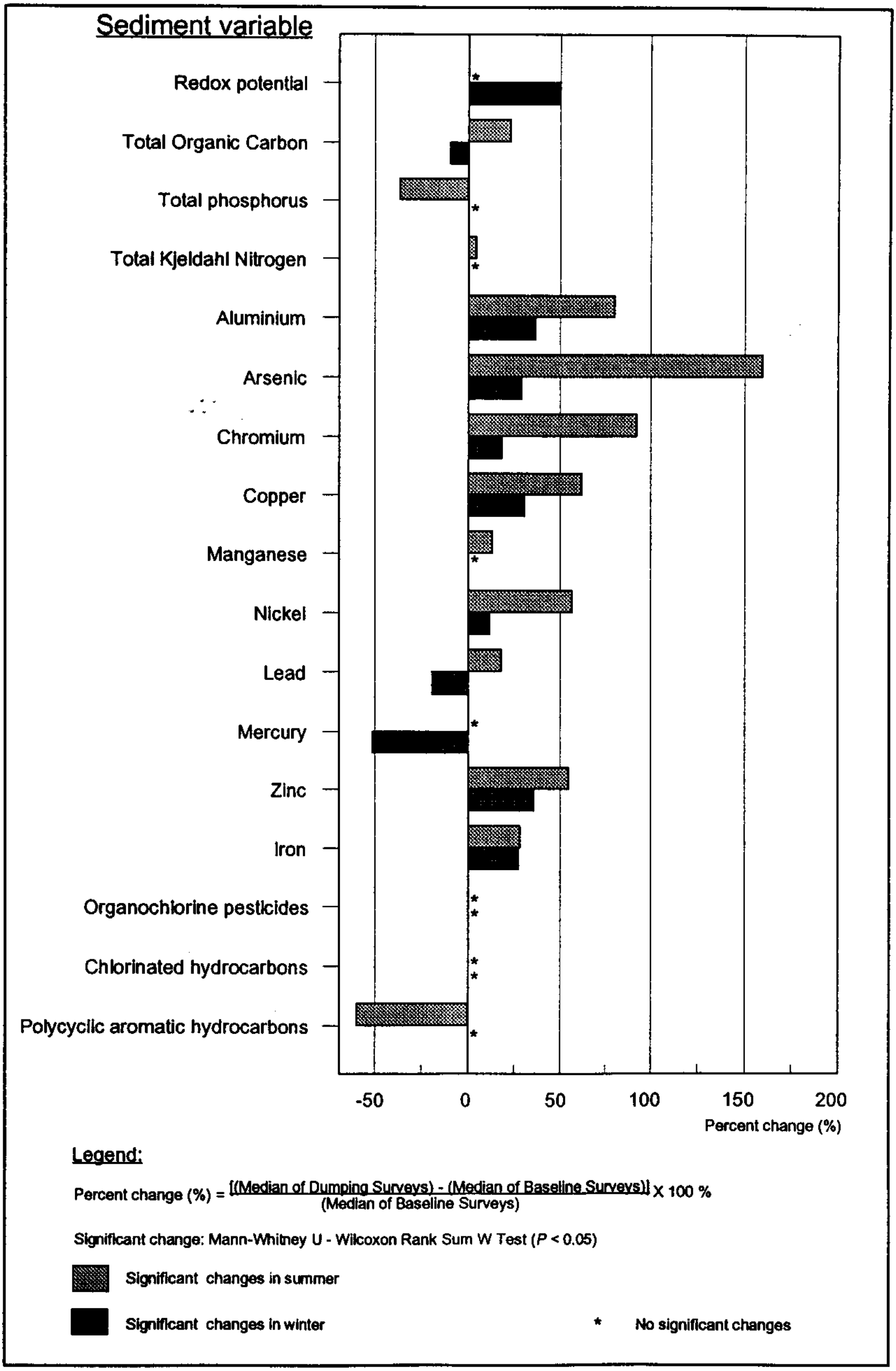


Figure 4 Compliance with key water quality objectives of the Mirs Bay Water Control Zone



Legend:

$$\text{Percent change (\%)} = \frac{[(\text{Median of Dumping Surveys}) - (\text{Median of Baseline Surveys})]}{(\text{Median of Baseline Surveys})} \times 100\ \%$$

Significant change: Mann-Whitney U - Wilcoxon Rank Sum W Test ($P < 0.05$)

▨ Significant changes in summer

■ Significant changes in winter

* No significant changes

Figure 5 Temporal changes in sediment quality

Baseline versus dumping (in summer)

Organisms	Cd	Cr	Hg	Pb	Ni	Fe	Mn	Zn	Cu	Al
Apogon quadrifasciatus (cardinal fish)		⇩	⇩		⇩		⬆	⬆		⬆
Saurida tumbil (lizard fish)	⬆	⇩	⇩		⇩	⇩	⬆	⇩		⬆
Pseudorhombus oligodon (flounder fish)		⇩					⇩			
Metapenaeopsis barbata (penaeid shrimp)		⇩			⇩	⇩	⇩	⬆	⬆	
Oratosquilla oratoria (mantis shrimp)		⇩	⇩		⇩			⇩	⬆	
Charybdis vadorum (portunid crab)	⇩	⇩	⇩	⇩			⬆	⇩	⇩	⬆
Anadara craticulata (bloody cockle)		⇩	⇩	⇩	⇩	⇩	⇩		⇩	
Bursa rana (frog snail)	⬆	⇩		⇩						

Sediment		⬆		⬆	⬆	⬆	⬆	⬆	⬆	⬆

Baseline versus dumping (in winter)

Organisms	Cd	Cr	Hg	Pb	Ni	Fe	Mn	Zn	Cu	Al
Apogon quadrifasciatus (cardinal fish)		⇩		⬆	⇩	⇩		⬆	⬆	⬆
Saurida tumbil (lizard fish)										
Pseudorhombus oligodon (flounder fish)	⇩	⇩					⇩		⬆	
Metapenaeopsis barbata (penaeid shrimp)		⇩			⇩			⬆	⬆	⬆
Oratosquilla oratoria (mantis shrimp)							⬆		⬆	
Charybdis vadorum (portunid crab)	⇩	⇩			⇩		⬆		⬆	⬆
Anadara craticulata (bloody cockle)		⇩		⬆	⇩	⇩	⇩		⬆	⇩
Bursa rana (frog snail)										

Sediment		⬆	⇩	⇩	⬆	⬆		⬆	⬆	⬆

Legend

⬆	Median value of dumping surveys > median value of baseline surveys
⇩	Median value of dumping surveys < median value of baseline surveys

Note

Presence of an arrow indicates the "within-block" difference are significant at $P < 0.05$ levels (Mann-Whitney U - Wilcoxon Rank Sum W Test).

Figure 6 Changes in the sediment and tissue metal levels

Baseline versus dumping (in summer)

Parameter	Whole community	Fish population	Crustacean population	Mollusc population
No. of individual		⇩	⇩	⬆
Total wet weight				⬆
No. of species			⬆	⇩
Diversity index	⬆		⬆	⇩
Eveness index	⬆	⬆	⬆	⇩

Baseline versus dumping (in winter)

Parameter	Whole community	Fish population	Crustacean population	Mollusc population
No. of individual			⇩	⬆
Total wet weight	⬆			⬆
No. of species			⬆	
Diversity index	⬆			⇩
Eveness index	⬆			⇩

Legend

⬆ median value of dumping surveys > median value of baseline surveys

⇩ median value of dumping surveys < median value of baseline surveys

Note

Presence of an arrow indicates the "within-block" differences are significant at $P < 0.05$ level
(Mann-Whitney U-Wilcoxon Rank Sum W Test)

Figure 7 Changes in the population of bottom-living organisms