Report on Ocean Dumping R and D Pacific Region Department of Fisheries and Oceans 1984-1985

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RESUME

Woods, S.M. (ed.) 1986. Rapport sur la R et D sur l'immersion en mer dans la région du Pacifique. Ministère des Pêches et Océans, 1984-85. Rep. Can. pour les Contrats, Hydrog. Sci. de la mer 26. 43p.

Les recherches sur l'immersion de déchets en mer effectuées en 1984-1985 ont été examinées lors d'un atelier tenu à l'Institut des sciences de la mer; les compte rendus de cet atelier ont été abrégés pour publication sous forme de résumé étoffé. Les études financées par le RODAC et présentées lors de l'atelier portaient sur la séparation du cadmium et du plomb des sédiments contaminés, les effets des déchets de bois sur le recrutement benthique, l'évaluation de microorganismes pour l'appréciation de la toxicité et de la biodisponibilité des contaminants dans les déblais de dragage et un examen du Programme national d'assurance de la qualité. Le dégagement de cadmium et de plomb par les sédiments riches en métaux et en matière organique semblait dépendre de la nature et de l'ampleur du mélange de la masse d'eau sus-jacente ainsi que de la concentration de matière particulaire en suspension. A l'intérieur de la communauté benthique influencée par le dépôt de déchets de bois, l'on observait une diminution uniforme des nombres d'espèces à mesure qu'augmentait l'épaisseur de déchets de bois alors que l'abondance moyenne totale était la plus élevée dans les substrats renfermant des épaisseurs intermédiaires de bois. L'étude des microorganismes comme indicateurs de la toxicité des sédiments concluait que les algues conviennent comme indicateurs de la biodisponibilité éventuelle de certains métaux à tout le moins, alors que les ciliés sont des organismes indicateurs plus utiles et ne sont pas sujets aux problèmes de stimulation par les éléments nutritifs que l'on observe dans le cas des algues. Quoique le Programme national d'assurance de la qualité en soit encore au stade de l'évaluation préliminaire des méthodes de laboratoire et d'étalonnage, la préparation et l'analyse des agents d'étalonnage devraient commencer au début de 1986. Dans le domaine de la recherche en gestion écologique l'approche tripartite prévoit une combinaison de travaux sur le terrain et en laboratoire pour l'obtention de renseignements sur les sources de pollution de l'environnement, les intensités des dommages causés et les agents responsables, ainsi d'être une méthode permettant de déterminer le degré de respect et l'efficacité des mesures de contrôle. Suite à ce survol national des recherches sur la LIDM, les objectifs futurs seront une meilleure connaissance des relations de cause à effet associées à l'élimination en mer des matériaux de dragage ainsi que l'explication et la mise à jour des exigences en renseignements et en normes de la LIDM.

L'on a examiné la réglementation concernant les emplacements de déversement et les cas individuels de dragage et d'élimination dans le bras de mer Puget. L'on a discuté les sujets de recherche pour lesquels le financement par le RODAC est suggéré en 1986-1987.

Mots-clés: immersion en mer, effets sur l'environnement.

ABSTRACT

Woods, S.M. (ed.). 1986. Report on Ocean Dumping R and D Pacific Region. Department of Fisheries and Oceans, 1984-85. Can. Contract. Rep. Hydrogr. Ocean Sci. 26. 43p.

Ocean dumping research conducted during 1984-1985 was reviewed at a workshop held at the Institute of Ocean Sciences; the proceedings have been summarized in extended abstract form for publication. RODAC-funded studies presented at the workshop include partitioning of cadmium and lead from contaminated sediments, effects of wood wastes on benthic recruitment, evaluation of micro-organisms for assessing toxicity and bio-availability of contaminants from dredge-spoils and a review of the national quality assurance programme. The release of cadmium and lead from metal- and organic-rich sediments appeared to be dependent upon the nature and extent of mixing of the overlying water mass, as well as on the concentration of suspended particulate matter. In the experimental study of macrobenthic communities affected by wood-waste deposition, species richness decreased with increasing thicknesses of wood waste, while total mean abundance was highest in substrate containing intermediate thicknesses of wood. In the study of micro-organisms as indicators of sediment toxicity it was concluded that algae are suitable as indicators of potential bioavailability of at least some metals, while ciliates are more useful test organisms and are not subject to nutrient stimulation problems exhibited with the algal tests. Although the National Quality Assurance Programme is still at the stage of preliminary evaluation of laboratory procedures and calibration methods, preparation and analysis of check calibrants should commence early in 1986. In the area of environmental management research, the Threefold Path outlines a combination of field work and laboratory testing to provide information on the source of environmental pollution, the degree of damage and the causative agent and also to act as a method of determining compliance to and effectiveness of controls. As a result of the national roll-up of ODCA research, future goals are to understand cause-effect relationships associated with ocean disposal of dredged material and to clarify and update ODCA information requirements and standards. Regulatory procedures used for permitting disposal sites and individual dredging and disposal activities in Puget Sound were reviewed. Suggested research topics for 1986-87 Pacific RODAC funding were discussed.

Key words: Ocean dumping, Environmental effects.

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I would like to express my gratitude to the speakers and other workshop participants who contributed to the successful outcome of the day's proceedings and to the contents of this report. Special acknowledgement is accorded to R. Kussat (EPS, West Vancouver), M. Waldichuk (DFO, West Vancouver) and R. Wilson (DFO - IOS) for chairing the workshop and to our guest speakers - R.O. Brinkhurst (DFO - IOS), A. Chevrier (EPS, Ottawa) and C. Kassebaum (EPA, Seattle). My appreciation is extended also to L. Giovando (DFO - IOS) for his review of the report manuscript.

1. SUMMARY AND CONCLUSIONS

RODAC-funded research contracts for 1984-85 were reviewed at a workshop held on 29 November 1985 at the Institute of Ocean Sciences, Sidney, B.C. The studies included partitioning of cadmium and lead from contaminated sediments, effects of wood wastes on benthic recruitment, an evaluation of micro-organisms for assessing the toxicity and bioavailability of contaminants from dredge-spoils and a review of the national quality assurance programme. Guest speakers presented an approach to environmental management research, the national ocean dumping research strategy and a review of dredged-material disposal in Puget Sound. A discussion on suggested research topics for 1986-87 Pacific RODAC funding concluded the proceedings. This report summarizes the material presented at the workshop.

In order to resolve the discrepancy regarding concentrations of soluble cadmium and lead in surface waters of False Creek, Vancouver, B.C., as indicated by oceanographic studies and expected by a laboratory release study, two experiments were designed to measure the flux of cadmium and lead from metal- and organic-rich False Creek sediments. False Creek sediments, alluvial sediments and False Creek sediments capped with alluvial material were tested; the capped-sediment combination was designed to determine whether a cleaner sediment cap could inhibit the flux. It was concluded that the release of cadmium and lead appeared to be dependent upon the nature and extent of mixing of the overlying water mass, as well as upon the concentration of suspended particulate matter. The release of soluble cadmium from an alluvial material containing approximately 0.3 $\mu g.g^{-1}$ cadmium equalled or exceeded that of the trace-metal-rich False Creek sediments. The relatively small amount of lead released appeared to be scavenged by the large algal growth prompted by the nutrient-rich, alluvial sediment. For False Creek sediments, relatively high concentrations of cadmium and lead were observed in the water column: these maxima could be explained by leaching of less than 0.2% of the cadmium and 0.001% of the lead bound in the sediment.

The effects of different thicknesses of fine wood waste on the recruitment of marine macrobenthic communities were experimentally assessed using <u>in situ</u> settlement trays. Species richness showed a consistent decrease with increasing thicknesses of wood waste, while total mean abundance was highest in the substrate containing an intermediate thickness of wood. Common indicators of marine organic pollution were included in those species associated with greater wood-waste thicknesses. Multivariate analysis differentiated distinct groupings of species and samples related to the different thicknesses of wood waste tested. Increasing amounts of wood waste were also reflected in a progressive increase in percent total organic carbon. Sediment redox potential was shown to be a reliable, quantitative indicator of the wood-waste thickness present. Anoxia within the substrate was considered to be a major factor affecting the recruitment of macrobenthic species.

The growth of two algal species and one ciliate were used to evaluate the utility of these types of micro-organisms as indicators of sediment toxicity. As a companion measure to growth, mutagenicity of neutral, basic and acid fractions of methanol-dichloromethane extracts of the test sediments was assessed with the Ames strains of bacteria. It was concluded that, while algae were not the most useful indicators of sediment toxicity in short-term growth tests, they are suitable in chronic tests as indicators of potential bioavailability of at least some metals. Ciliates are more useful test organisms and are not subject to the nutrient st .mulation problems that complicate algal tests. Mutagenicity c chemicals in sediments to bacteria is not uniformly expressed as growth-pattern alteration in algal and ciliate test cultures. More than one species is needed for toxicity assessments with contaminated sediments. Nutrient enrichment effects can mask contaminant effects with algae.

The National Quality Assurance Programme is presently stalled in Phase 1 (the preliminary evaluation of laboratory procedures and calibration methods). For perhaps the majority of labs it is clear that quality objectives have not been formulated, and there is no plan to control and measure quality to show that it satisfies objectives. Since it is not yet possible to extract sufficient detail on "current" digestion procedures and on preparation and running of calibrants, check calibrants have not been prepared. These will be tailor-made for each lab in order to match individual laboratory calibrants, rather than providing identical material to each lab. This process should commence early in 1986.

'The Threefold Path' attempts to define and evaluate approaches to the problem of preventing and ameliorating damage to the environment due to human activity in physical construction, waste disposal of all kinds and product use and abuse. These lead to a need for information on the source, degree of damage and causative agent where these are unknown or unpredicted, a scientifically-based body of control legislation and methods of determining both compliance to and effectiveness of controls in order to retain ecological integrity. It is suggested that field work be used in pre-development impact assessment and that toxicology be combined with field studies to make risk-assessments and predictions. Field work, backed up by relevant chemical analyses and toxicology, is required for post-impact studies where sources and degree of damage are unknown. Monitoring can be based on very simple toxicological tests of effluents where relevant, but periodic assessment of the real environment will ensure not only compliance with but effectiveness of permits based on simple criteria. It was suggested also that increased levels of Ocean Dumping research funds be directed towards ecological research, such as multi-disciplinary field work on current and former dumpsites.

Four conclusions reached in a roll-up of 1975-1982 research reported by the ODCA research fund are: concerns exist regarding the possible uptake by marine biota of toxic material from contaminated sediments and the potential threat to marine life and human health; the remobilization and bioavailability of toxic material from dredged sediments are only partially understood; data on bioavailability suggest that uptake is mainly from the aqueous phase; and ODCA controls are effective in limiting ocean dumping operations to locations where adverse environmental effects are minimized. ODCA long-term and short-term research goals are, respectively, to understand cause-effect relationships associated with ocean disposal of dredged material and to clarify and update ODCA information requirements and standards by tackling specified research priorities. A five-step approach is used to update existing information standards and requirements.

Regulatory procedures used for permitting disposal sites and individual dredging and disposal activities in Puget Sound were reviewed. In response to new information regarding elevated concentrations of heavy metals and organic priority pollutants at the Four-Mile Rock open-water disposal site, coupled with strong citizen concern and need to continue on-going maintenance dredging activities, an interagency task force was established to review the Four-Mile Rock site. Although further dumping was permitted under more stringent regulations on an interim basis, it was decided that a comprehensive dredged-material disposal plan should be prepared. The Puget Sound Dredged Disposal Analysis is expected to yield designations of appropriate dumpsite locations for unconfined open-water disposal of dredged material, sediment criteria to be met for disposal at those sites, technological controls and management practices to be implemented with the alternative disposal options for materials which are too contaminated for uncontained in-water disposal, and a users' manual outlining procedures to be followed to secure appropriate permits for disposal of dredged material.

The workshop ended with a discussion of the following suggested research topics for 1986-87 Pacific RODAC funding:

- Protocol development for sediment-sample handling and preparation prior to chemical analysis.

- Laboratory evaluation of ecotoxicological tests for dredge-spoil.

- Effects of ocean dumping on the egg deposition of commercially-important fish species.

- Alteration to benthic communities resulting from wood-waste dumping activities (e.g. Port Mellon and Woodfibre areas).

- Evaluation of bioavailability of sediment-associated contaminants to benthic organisms by determining the physical and chemical characteristics of particulate matter selected by the organisms.

- Determination of transport paths for ocean-dumped material by study of trends in sediment particle size.

- Mass balance study of cadmium in B.C. coastal marine sediments (e.g. Alber i Inlet, Ucluelet Inlet and Powell River area).

- Composition of hydrocar.ons, including PAHs, in sediment, under different inputs and weathering regimes, and similar studies on other selected organics (e.g. organotins).

- Development of a simplified field-testing method for estimating metal release from sediments.

Extended abstracts of the RODAC studies contracted in 1984-85 are contained in this report. Inquiries regarding the information presented and further publications should be directed to the appropriate scientific authorities at their associated institutes. Appendix I lists the abbreviations and addresses of these institutes.

A list of those who attended the workshop is contained in Appendix II. Appendix III outlines contracts for 1984-1985 while studies contracted for 1985-1986 are listed in Appendix IV.

Copies of this Canadian Report of Hydrography and Ocean Sciences are available from the Institute of Ocean Sciences, Sidney, B.C.

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2. PARTITIONING OF CADMIUM AND LEAD FROM FALSE CREEK SEDIMENTS

V. Stukas

Contractor: Seakem Oceanography Ltd.
Prepared for: C.S. Wong, DFO/IOS

Introduction

With the high levels of cadmium (Cd) (1.5 - 40 $\mu g.g^{-1}$) and lead (Pb) (200 - 800 $\mu g.g^{-1}$) found in False Creek sediments (H. Nelson, pers. comm.), the nature and extent of their release into sea water, during either dredging operations or tidal flushing, have not been resolved. Small-scale experiments using 20 L carboys of sea water with 1 to 100 ppm levels of suspended particulate matter (3 $\mu g.g^{-1}$ Cd, 460 $\mu g.g^{-1}$ Pb) have shown that virtually all of the Cd and varying amounts of Pb (0.5% for the 100 ppm case to 19% for the 1 ppm case) would have to be released from the suspended sediment to account for the maximum concentration levels of Cd and Pb in sea water (Stukas, 1983). Maximum values of about 500 $ng.kg^{-1}$ Cd and 280 $ng.kg^{-1}$ Pb were noted in this "worst case" situation (i.e. closed system, constant mixing). Oceanographic studies in False Creek, on the other hand, indicated that concentrations of soluble Cd and Pb in surface waters were approximately 100 $ng.kg^{-1}$ and 50-80 $ng.kg^{-1}$, respectively (Stukas and Erickson, 1983). These values were much lower than expected from the laboratory release study. The primary objective of this study was to measure the flux of Cd and Pb from False Creek sediments in order to resolve the above differences. Two experiments of a scale much larger than that used earlier were conducted to determine the partitioning of Cd and Pb from False Creek sediments and to investigate the problems of scaling in extrapolating release data.

The first experiment, termed "Mini-CEPEX", using about 1500 L of sea water and 80-120 L of sediment, was conducted in a conventional polyethylene (CPE)-lined fibreglass tank. This approach allowed a greater number of variables to be tested than would a full-scale CEPEX experiment. False Creek sediments, False Creek sediments capped with alluvial material, and alluvial sediments were tested. The capping experiment was designed to determine whether a cleaner sediment cap could inhibit the flux of Cd and Pb from the metal- and organic-rich False Creek sediments. Profiles of Cd and Pb in sea water were determined weekly over an eight-week period. Four additional sets were obtained during the first week.

A meso-scale experiment was conducted using two CEPEX bags (2.5 m diameter, 13-15 m deep) containing approximately 70,000 L of sea water. A novel sediment pan was designed to carry 500-700 L (10-15 cm depth) of sediment. Sampling for soluble Cd and Pb in sea water, as well as for POC/PON, was conducted with the same frequency as the Mini-CEPEX study. Mechanical problems terminated this experiment at four weeks. In addition, a biological exposure component was added in order to assess the uptake of Cd and Pb by *Mytilus edulis*. Sixty mussels were initially suspended in a CPE cage at 1.5 m in the CEPEX bags. Due to predation by sea birds, an eight-week exposure experiment was conducted in a separate set of Mini-CEPEX experiments.

Sea Water Collection And Sampling

Clean sea water required for the 1500 L Mini-CEPEX experiments was peristaltically pumped from a depth of 10 m in Saanich Inlet near the CEPEX site. Previous work had indicated that low-Pb sea water could be collected in a relatively uncontaminated fashion using peristaltic pumps (Stukas and Wong, 1981; Stukas, 1983). Two pumping systems (Lil Giant, Sap-Sucker) were used in order to minimize the exposure of the collected water to atmospheric Pb contamination, and to obtain, as closely as practical, a simultaneous start for the release studies. Sea water collected by the Sap-Sucker was also used for 15-20 m of makeup water for the CEPEX bags. The initial capture of sea water as the divers raised the CEPEX bags from a depth of 15 m produced a 70% fill.

For analytical purposes, seawater samples were collected by a modified VIPS sampler, a system capable of ultra-low Pb work (Stukas and Wong, submitted for publication). Sampled sea water was aspirated directly into an evacuated, plexiglass sampling chamber housed in a portable Class 100 clean hood. Acid-cleaned CPE bottles were used to collect the sea water. Seawater samples were triple-bagged in CPE under Class 100 conditions and then transferred to a $4^{\circ}C$ cooler before extraction and analysis.

Sediment Collection And Sampling

Sediments required for the Mini-CEPEX and the CEPEX experiments were collected from aliquots taken from a 3 m^3 dredge during normal dredging operations in False Creek and in Richmond Marina. Surface sediments from the head of False Creek were collected in 10 x 200 L drums lined with CPE bags. Relatively clean alluvial sediment was collected in 2 x 200 L CPE-lined drums from a 3-m-deep hole dug below datum by a 3 m^3 dredge in Richmond Marina.

Sediments were shovelled into the Mini-CEPEX tanks and into the CEPEX pan and then were subsampled for chemical analysis. CPE-bagged samples were stored frozen until analysed.

Analytical Methods

The Pb and Cd in seawater samples were extracted using 0.001% dithizone in chloroform and analysed using the 'double spike' version IDMS (for details, see Stukas and Wong, 1983). CEPEX samples were filtered using acid-cleaned, 0.4µ Nuclepore filters. Previous work on Cd and Pb replication using IDMS (Stukas and Wong, 1983) showed that at the levels expected in the control sea water (about 65 $ng.kg^{-1}$ Cd and 15 $ng.kg^{-1}$ Pb), an analytical precision of about ± 1 $ng.kg^{-1}$ Cd and about ± 0.5 $ng.kg^{-1}$ Pb could be expected. In this study, both sampling duplicates and analytical duplicates generally fell within these bounds, indicating that both sampling procedures and the analytical process were in control. Blanks of 0.005 ± .003 ng Cd and 0.23 ± 0.04 ng Pb usually comprised a negligible portion of the Cd and Pb in the sample. Detection limits (3 S_B, IUPAC definition) were about 0.02 $ng.kg^{-1}$ Cd and 0.2 $ng.kg^{-1}$ Pb.

The isotopic composition of Pb in sea water was determined on unspiked 200 - 500 g subsamples extracted by the method described above. Natural Pb ratios were determined for at least three temperature steps to assess the extent of the prevalent isobaric interferences common to these samples. Pb ratios were normalized to the common Pb isotopic standard NBS 981.

Sediment and mussel digestion and analysis by IDMS has not yet commenced.

Observations and Discussions of Seawater Data

Mini-CEPEX

The IDMS results for Cd and Pb in sea water collected during weeks one to five are presented in Figures 2.1 and 2.2. Analysis of data from the first week and from weeks six to eight is not yet complete. These data showed that little if any concentration gradient with depth was present. Hence, only the mid-depth concentrations were plotted versus time. This tendency toward homogeneity within a particular tank suggested that mixing must have occurred.

Plots of mid-depth concentrations of soluble Cd results for weeks one to five (Figure 2.1) showed monotonically increasing levels with time. Surprisingly, the largest increase and the highest levels of Cd, 240 $ng.kg^{-1}$, were found in the tank containing both False Creek sediments and the alluvial capping material. While capping with a relatively clean sediment (less than 0.3 μg.g^{-1} Cd; D. Brothers, pers. comm.) was originally expected to inhibit the flux of Cd from the underlying False Creek sediments, the release patterns obtained appeared to be an additive result of the two constituents. The capping sediment on its own produced Cd concentrations in the water column equal to or greater than those observed for the metal-rich False Creek sediments. If all of the Cd from the alluvial material were released into the overlying water, then the maximum expected concentration of Cd would be 30,000 ng.kg^{-1}. Thus, even a release of 0.8% of the total alluvial-bound Cd could account for the 130-240 ng.kg^{-1} soluble Cd levels observed. Using a similar argument to account for the 120 ng.kg^{-1} Cd levels found in the water column of the two False Creek tanks, only 0.06% of the total Cd bound in the sediments would be required.

Algal growth in the Mini-CEPEX tanks and subsequent settling during weeks three to four did not appear to have a significant effect on Cd values in the water column. Any scavenging would have been more evident in the high algal-growth tanks containing the evidently nutrient-rich alluvial sediment. Cd levels in the control sea water were constant (65 ±5 ng.kg^{-1}) and typical of subsurface water in Saanich Inlet (Stukas, 1983). This indicated that negligible amounts of contamination were incurred during collection of the original sea water.

The behaviour of Pb release (Figure 2.2) from the sediments was markedly different. A sharp decrease in seawater Pb concentrations in tanks containing False Creek sediments was noted from week one to week two, followed by a secondary release until three-four weeks, then followed by another decrease, such that at five weeks,Pb concentrations in the water column approached background levels of about 15 ng.kg^{-1}. The tank containing False Creek sediment plus the alluvial sediment showed the closest approach to background levels. This was diametrically opposite to the behaviour of the Cd data. Moreover, the alluvial material by itself did not perturb the Pb concentrations in the water column above those observed in the control seawater tank. In fact, Pb concentrations plummetted from 15 ng.kg^{-1} to ultra-low values of <1 ng.kg^{-1} by the fifth week, in conjunction with the observed settling of the algal growth. This feature was even more remarkable upon consideration of the amount of Pb locked up in the sediment. With Pb concentrations of 10-15 μg.g^{-1} for the alluvial sediment (D. Brothers, pers. comm.) and 200-800 μg.g^{-1} observed in False Creek, a complete release of the Pb would require seawater values to be 1,000 - 1,500 μg.kg^{-1} and 20,000 - 80,000 μg.kg^{-1} , respectively. For the control sea water, Pb concentrations of 11-18 ng.kg^{-1} were representative of relatively clean water in Saanich Inlet (Stukas and Wong, 1981) implying little, if any, contamination during the tank filling and sampling.

CEPEX

The available IDMS and isotopic composition data for the CEPEX portion of this study are plotted in Figures 2.3 to 2.5. The early termination of the CEPEX experiment by the fourth week stemmed from the rapid loss of water through a small rent in the CEPEX bag containing the False Creek sediment.

Soluble Cd concentrations in the water column increased with depth from about 30 $ng.kg^{-1}$ near the surface to almost 600 $ng.kg^{-1}$ at 13 m, and then abruptly decreased to less than 300 $ng.kg^{-1}$ near the bottom (15 m). It was noteworthy that while the surface Cd concentrations were about half that of the control sea water (67 $ng.kg^{-1}$), the maximum of 600 $ng.kg^{-1}$ encountered was comparable to that (ca. 500 $ng.kg^{-1}$) found in earlier leaching studies (Stukas, 1983). Moreover, unlike the Mini-CEPEX experiment, the CEPEX results displayed a concentration gradient with depth and likely with time; hence, a diffusion rate or flux can be calculated once the concentration profile data are complete.

The soluble Pb concentration data were very similar to the Cd profile, in marked contrast to the Mini-CEPEX portion of this work. Soluble Pb concentrations rose from about 100 $ng.kg^{-1}$ at the surface to a maximum of 600 $ng.kg^{-1}$ at 13 m. This was followed by an abrupt drop to 400 $ng.kg^{-1}$ near the bottom (15 m). However, unlike Cd, the entire water column was elevated in Pb concentration with respect to a typical background Pb value of 13 $ng.kg^{-1}$ observed in the control seawater bag. Moreover, maximum Pb values were much greater than observed (240 $ng.kg^{-1}$) in the earlier, small-scale study (Stukas, 1983). While the rapid increase in concentration with depth and, apparently, with time may be modelled by simple diffusion, the abrupt transition to lower concentrations in the bottom 2 m was likely due to a different mechanism. Readsorption by the high loading of suspended matter is suspected.

The natural Pb isotope data presented a relatively simple situation (Figure 2.5). Apparently, the isotopic nature of the sea water in the False Creek bag became more homogeneous with time and with depth. The ratio 206Pb/207Pb, often used as an indicator (Stukas and Wong, 1981), approached the value of 1.133. Control sea water, displayed 206Pb/207Pb $\sim$ 1.148, a value identical to previous work on Canadian gasoline (Stukas and Wong, 1981, in prep.), reinforcing the hypothesis that most coastal sea water contains Pb of a predominantly gasoline origin.

Conclusions

The release of Cd and Pb from False Creek sediments appears to be dependent upon the nature and extent of mixing of the overlying water mass as well as on the concentration of suspended particulate matter. Varying the size of release studies from the 20 L carboys used for earlier studies (Stukas, 1983) to the 1500 L Mini-CEPEX tanks and to the 70,000 L CEPEX bags in this study has shown that the maximum concentrations observed in the water column are not linearly related to the amount of sediment used. This scaling also suggests that the trace-metal release curves from the Mini-CEPEX experiment cannot be linearly extrapolated up to the CEPEX scale. CEPEX experiments allowed concentration gradients to be established over the 15 m depth, ranging from about 30 $ng.kg^{-1}$ Cd and 100 $ng.kg^{-1}$ Pb in surface waters to the very high levels of about 600 $ng.kg^{-1}$ Cd and 600 $ng.kg^{-1}$ Pb in a maxima at 13 m. The decrease in the Cd and Pb concentrations in the bottom 2 m suggested the dominance of readsorption effects, most likely on humic materials for Cd and on FeO/MnO surfaces for Pb (Lion <u>et al.</u>, 1982). The natural abundance of Pb data had shown an increasing trend towards homogeneity in isotopic composition with time and with decreasing depth as the trace-metal source (i.e. False Creek sediments) overwhelmed the background signature of predominantly gasoline Pb. Once data for the CEPEX portion of the experiment are complete, a diffusion constant or flux for False Creek sediments will be calculated from the concentration gradients and time series.

Mini-CEPEX tanks were more amenable to exploring different variables such as the effects of a capping material than to allowing concentration gradients to be established. The exposed head of sea water within the tank may have been responsible for thermally-induced mixing, leading to a general homogenization of concentration values within a given tank. Surprisingly large amounts of soluble Cd were released from an alluvial material containing approximately 0.3 $\mu g.g^{-1}$ Cd. The release equalled or exceeded that of the trace-metal-rich False Creek sediments. In contrast, the relatively small amount of Pb released appeared to be scavenged by the large algal growth prompted by the nutrient-rich alluvial sediment. The relatively large amount of Pb within this sediment did not appear to be released. For False Creek sediments, relatively high concentrations of Cd (120 $ng.kg^{-1}$ by the fifth week) and Pb (300-400 $ng.kg^{-1}$ after seven days) were observed in the water column. These maxima in concentration could be explained by leaching of less than 0.2% of the Cd and 0.001% of the Pb bound in the sediment.

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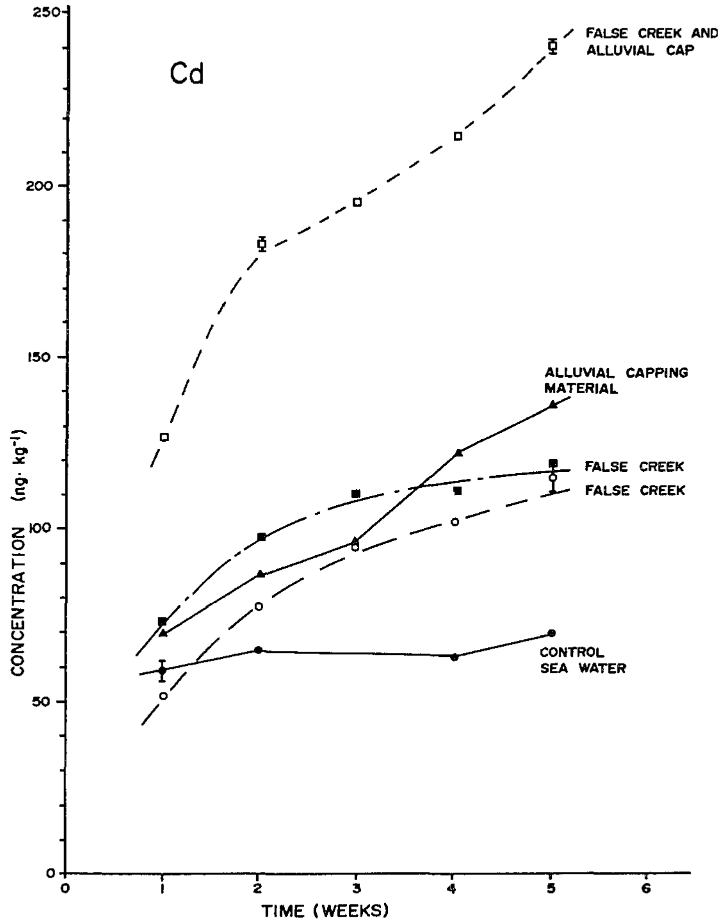

Figure 2.1 Release of Cd with time from sediments in the Mini-CEPEX experiment. Mid-depth values only from each tank plotted as the water column tends to be homogeneous in metal levels. Cd levels in alluvial cap were 0.3 ppm; in False Creek 1.5 - 40 ppm (estimate).

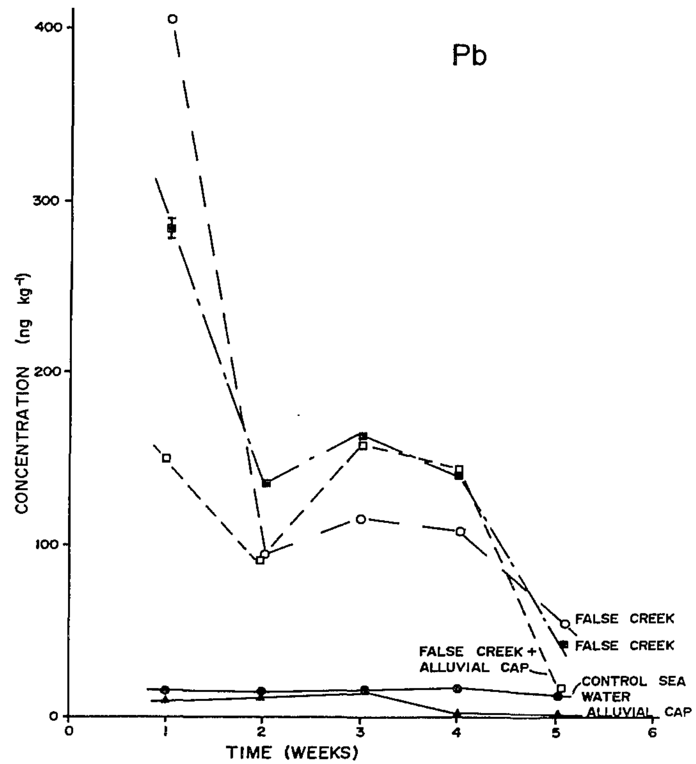

Figure 2.2 Release of Pb with time from sediments in the Mini-CEPEX experiment. Pb levels in alluvial cap were 10-15 ppm; in False Creek, 200-800 ppm (estimate). Algal growth precipitates out during three to four weeks.

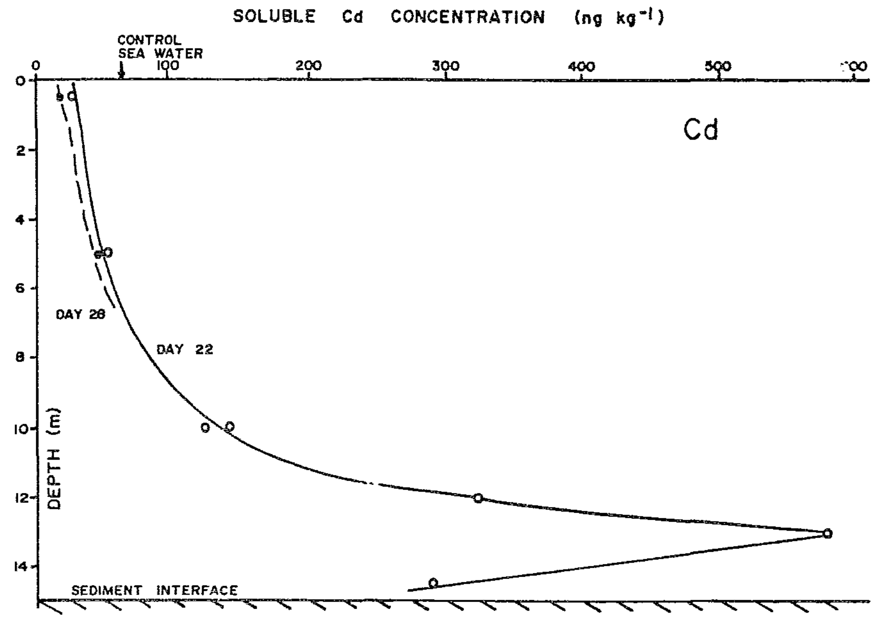

Figure 2.3 Release of Cd from False Creek sediment in CEPEX enclosure. Lowered Cd value near bottom may have been due to readsorption on humic surfaces provided by elevated levels of SPM. Note that Cd levels in upper 7 m are less than background values.

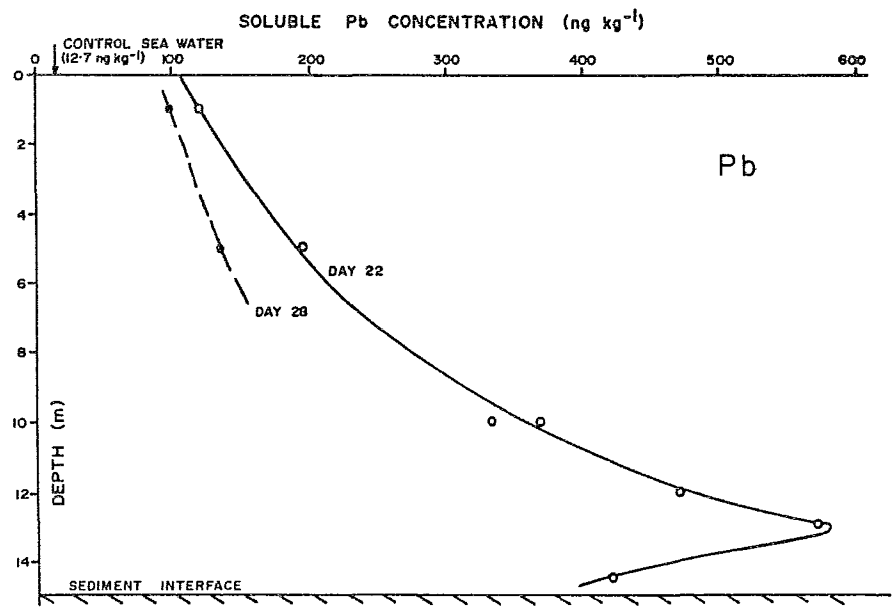

Figure 2.4 Release of Pb from False Creek sediment in CEPEX enclosure. Lowered Pb value near bottom may be due to readsorption on Fe/Mn oxide surfaces provided by elevated levels of SPM.

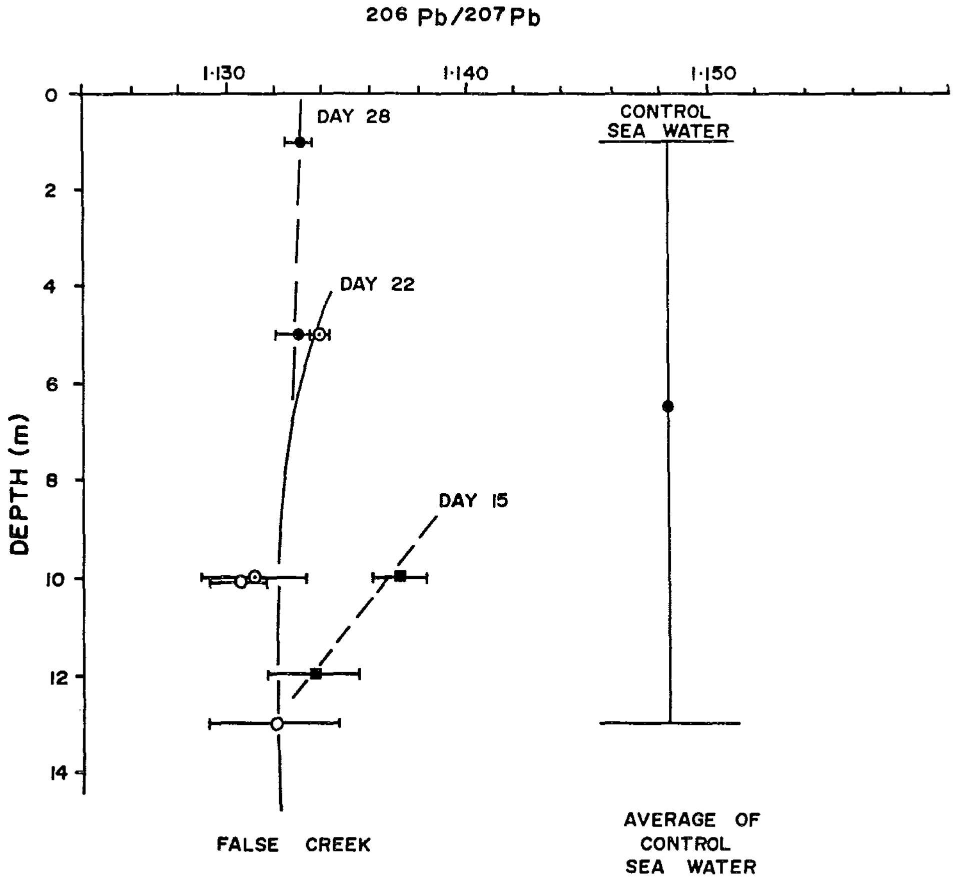

Figure 2.5 Stable Pb isotopic composition of sea water in CEPEX enclosures. Note increasing homogenization at 206 Pb/207 Pb = 1.133 with time and depth. Gasoline Pb has 206 Pb/207 Pb = 1.147.

3. EFFECTS OF WOOD WASTE FOR OCEAN DISPOSAL ON THE RECRUITMENT OF MARINE MACROBENTHIC COMMUNITIES

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Prepared for: M. Waldichuk, DFO/WVL

The effects of different thicknesses (1, 5 and 15 cm) of a fine wood waste material on the recruitment of marine macrobenthic communities were experimentally assessed using in situ settlement trays. A clean marine sediment was used in the experiment as a reference substrate.

Differences in species composition and abundance of macrobenthos settling on the reference and 1-cm wood waste substrates compared to the 5- and 15-cm wood substrates were found. Species richness showed a consistent decrease with increasing thicknesses of wood waste. Total mean abundance of macrofauna was highest in the substrate containing an intermediate thickness (5 cm) of wood. Species associated with the greater thicknesses of wood waste included common indicators of marine, organic pollution such as polychaete worms (Prionospio cirrifera, Armandia brevis, Capitella capitata) and amphipods (Ampelisca pugettica, Aoroides sp., Melita sp., Monoculodes zernori). However, only the number of amphipod taxa and amphipod abundance were found to be significantly different ($p<0.05$) when the reference sediment and substrates covered by wood waste were compared statistically.

Cluster analysis by sample differentiated three groups: one containing all reference and 1-cm wood waste samples; and two groups containing samples from the 5- and 15-cm test substrates. Cluster analysis by species differentiated four groups based on differences in recruitment density in the reference and wood substrates.

The increased amount of wood waste was also reflected in a progressive increase in percent total organic carbon which ranged from 0.2% in the reference sediment to 35.9% in the 15-cm wood substrate. Sediment redox potential was shown to be a reliable quantitative indicator of the thickness of wood waste present. Anoxia within the substrate was considered to be a major factor affecting the recruitment of macrobenthic species. Future research needs on effects of wood waste for ocean disposal were presented.

A more explicit account of this study can be found in the following technical report:

McGreer, E.R., D.R. Munday and M. Waldichuk. 1985. Effects of wood waste for ocean disposal on the recruitment of marine macrobenthic communities. Can. Tech. Rep. Fish. Aquat. Sci. 1398:29 p.

4. EVALUATION OF MICRO-ORGANISMS FOR ASSESSING THE TOXICITY AND BIOAVAILABILITY OF CONTAMINANTS FROM DREDGE-SPOILS: ALGAL AND CILIATE GROWTH, MUTAGENICITY SCREENING

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Contractor: Seakem Oceanography Limited
Prepared for: N. Antia, DFO/WVL

The growth of the algae Dunaliella tertiolecta and Amphidinium carterii and of the ciliate Blepharisma sp. were used to evaluate the utility of these types of micro-organisms as indicators of sediment toxicity rather than the use of more traditional invertebrate and fish species. Biological responses were compared with bulk chemical data. Filtered seawater extracts of contaminated sediments were prepared (1:4 sediment/water) and tested full strength. Marine sediments from two major sites of marine contamination in Canada were used in the evaluation (False Creek, B.C. and Sydney Harbour, N.S.).

Algal growth over four days was reduced by up to 70% of controls, but responses were not consistent and sites with high levels of chemical contamination did not always produce the most severe reduction in growth. Growth stimulation was often seen. Chronic (30-day) exposures of D. tertiolecta to sediment extracts in flow-through turbidostat did not inhibit algal growth or overall culture viability.

Ciliates were useful indicators of sediment toxicity. Development of test procedures included reduction of experimental variability through: use of single-strain cultures; choice of most appropriate test-container size; provision of suitable food source; and use of six animals per replicate and 15 replicates per treatment. Variability in mean densities of individuals between control replicates was reduced to a standard error of the mean in the 8-15% range.

As a companion measure to growth, mutagenicity of neutral, basic and acid fractions of methanol-dichloromethane extracts of the test sediments was assessed with the Ames strains of bacteria. Both activated and unactivated tests were run. Sediments from all five Sydney sites evaluated were mutagenic and the levels of mutagenicity were related to contaminant concentrations.

Total PAH levels in Sydney Harbour ranged from 5-911 $\mu g.g^{-1}$. High PCB concentrations (maximum of 52.2 $\mu g.g^{-1}$ dry wt.) also existed. False Creek was a less-contaminated site.

Algae were deemed generally not to be the most useful indicators of sediment toxicity in short-term growth tests. In chronic tests, they are suitable as indicators of potential bioavailability of at least some metals. Ciliates are a more useful test organism and not subject to the nutrient-stimulation problems that complicate algal tests. Mutagenicity of chemicals in sediments to bacteria is not uniformly expressed as growth-pattern alteration in algal and ciliate test cultures. More than one species is needed for toxicity assessments with contaminated sediments. Nutrient enrichment effects can mask contaminant effects with algae.

5. NATIONAL QUALITY ASSURANCE PROGRAMME

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Presently, the programme is stalled in Phase 1, the preliminary evaluation of laboratory procedures and methods of calibrating. This is due in part to time constraints on the organizers and in part to the large volume of information we have received from the labs. In spite of lengthy reports from some labs, inadequacies and inconsistencies have been found in all lab responses and we have been forced to go back to each lab with a questionnaire and telephone calls. In some cases this iterative step has been repeated several times.

It is clear for some and perhaps the majority of labs that quality objectives have not been formulated, and there is not a plan to control and measure quality to show that it satisfies the objectives. Written quality protocols have not been received; rather what we have received tends to fall under the classification of "motherhood statements".

Since we have been unable to extract sufficient detail on "current" digestion procedures and on preparation and running of calibrants, we have not been in a position to prepare the check calibrants. We are hoping to start this process early in 1986, however.

A valid point raised at the workshop was that "tailor-made" check calibrants would be different for each lab and therefore not strictly intercomparable. That this is true must be admitted; however our objectives for this phase of the programme were to evaluate the calibration step within each lab and collect information on the source of error from this term. This kind of information was generally lacking in the reports supplied as part of Phase 1. Further, we wanted to estimate range and detection limit for each lab so that we could predict performance on the solid samples. Therefore, we assigned greater importance on matching individual laboratory calibrants than to providing identical material to each lab. The sediments, which are the central element of the study, will in no way suffer from this problem and we believe the combination of Phase 2 and Phase 3 will allow us to achieve all of our objectives.

6. THE THREEFOLD PATH*

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While this paper is aimed at a wider consideration of environmental management research in Canada than that pursued under ocean-dumping regulations, several of the points might be considered relevant and appl cable to work in that area.

In summary, this paper attempts to define and evaluate approaches to the problem of preventing and ameliorating damage to the environment due to human activity in physical construction (e.g. dams, drainage diversions), waste disposal of all kinds and even product use and abuse (e.g. pesticide and fertilizer application in agriculture). These lead to a need for information on the source, degree of damage and causative agent where these are unknown or unpredicted, a scientifically-based body of control legislation and methods of determining both compliance to and effectiveness of controls in order to retain ecological integrity.

The scientific responses have been: A - The massive descriptive overkill of impact assessment before the fact, with a lack of focused prediction of real potential hazards, and very little post-impact check on predictions (see Rosenberg et al., 1981; Hecky et al., 1984); B - Detection of ecological integrity by field scientists using pre-post impact or upstream-downstream comparisons; and, C - Estimate of toxicity of water in laboratory bioassays.

The pros and cons of B and C were debated in view of a perceived overemphasis on C because of the engineering rather than ecological approach to the issue common to many jurisdictions. While toxicity tests can yield quantitative results under controlled conditions, especially when rigourously pursued under ideal conditions (including genetically-controlled test organisms), field ecological studies are site-specific and address the issue of environmental assessment head-on. Modern statistical procedures can remove much of the old elitist approach based on a professional evaluation of complex taxonomic data sets interpretable only by the biologist operating much as a

*Original version published in: P.J. Wells and R.F. Addison (eds.). 1985. Proceedings of the 10th Annual Aquatic Toxicity Workshop, Halifax, November 7-10, 1983. Can. Tech. Rep. Fish. Aquat. Sci. 1368:3-9.

diagnostic medical practitioner. Other aspects of the two approaches were reviewed, and evidence was presented from extensive single factor and multifactorial lethal and sublethal toxicological studies of sludge worms (tubificids) to show both the strengths and weaknesses of toxicology (Chapman and Brinkhurst, 1984). Field data from Alberni Inlet ocean-dumping work of the late 1970's (Levings et al., 1985; Iseki et al., 1984) can be cited, along with the investigations of mine-tailing disposal in Alice Arm (Kathman et al., 1983, 1984) to support the contention that field studies can provide direct and accurate, repeatable benthic surveys of impacted ecosystems, thus facilitating the decision-making process in ecosystem management.

Conclusions

We might conclude that field work can be used in pre-development impact assessment to identify the major pool sizes (what's there) and flux rates (who's important), and that toxicology using both standard reference organisms and significant endemic species can be combined with the field studies to make hard-nosed risk-assessments and predictions. Post-impact studies where sources and degree of damage are unknown are clearly the province of the field surveyor, backed up by chemical analyses and toxicology where relevant (not a scatter-gun attack on lists of contaminants). Multivariate analyses (clusters, ordination) are powerful tools where real impacts exist (and sometimes impacts are insignificant). Monitoring can be based on very simple toxicological tests of effluents where relevant, but periodic assessment of the real environment will ensure not only compliance with but effectiveness of permits based on simple criteria.

It might be pertinent to consider increased ecological thinking in the use of ocean-dumping research funds, because toxicological research is being supported by almost every conceivable agency already. The risk to the human food chain from bioaccumulation might best be assessed in the product inspection procedure as it is the unanticipated among a myriad of potential risks that strikes at us. We are well prepared with defence mechanisms to combat human health problems as they are identified. The sediment-water interface, so significant in both dredging and dumping research, is a dynamic area in which geology, chemistry, microbiology and benthic animal communities are tied together so intimately as to render work on one or the other aspect in isolation difficult to evaluate in relation to the real environment. Multidisciplinary field work on current and former dumpsites may reinforce the general perception that the Act is working (basically because of what no longer gets dumped), and will give us predictive capability on the recovery time of dumpsites rich in materials, such as the wide variety of wood wastes that still constitutes a potential ecological problem due more to smothering and anoxia than to toxic hazards.

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7. NATIONAL OCEAN DUMPING RESEARCH STRATEGY

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Background

The ODCA (Ocean Dumping Control Act) research fund was established to provide scientific information related to:

- specific ocean-dumping problems with regard to permit issuance;
- the development, modification or appraisal of regional, national or international policies; and
- the possible long-range effects of pollution.

The majority of current ocean dumping and ocean dumping research in Canada centres on marine disposal of dredged material. Approximately 20,000,000 metric tons of dredged material are dumped at sea annually.

Research Roll-Up

A roll-up of research results generated between 1975 and 1982 lead to the following conclusions:

1) Concerns exist, on a site-specific basis, that toxic material contained in contaminated sediments may be taken up by biota and potentially endanger marine life or human health.

2) The remobilization and bioavailability of toxic material from dredged sediments are only partially understood. The main concern lies with contaminants remobilized in overlying and interstitial water. However, the toxicological consequences of the release are not well documented.

3) The data on bioavailability suggest that uptake is mainly from the aqueous phase. Sediments appear to bind substances to particulates or produce insoluble compounds which serve to reduce the availability of contaminants. No conclusive research results are available on acute or chronic toxic effects of contaminated sediments.

4) Based on a limited number of monitoring studies, the ODCA controls are effective in limiting dumping operations to locations where adverse effects to marine environmental quality are minimized.

Research Goals and Strategies

Our long-term research goal is to understand cause-effect relationships associated with ocean disposal of dredged material. In the short-term, we hope to clarify and update ODCA information requirements and standards by tackling the following research priorities:

- Sediment Toxicity Tests (Feasibility Assessment)
- Physical Impacts (Dumpsite selection criteria, sediment transport modelling)
- Quality Assurance Programme (Sampling guidelines, QA/QC requirements for sampling work-up and analysis)
- Dumpsite Assessment (Effects at dumpsites, field verification).

The update of existing information requirements and standards is conducted in a five-step approach:

1) Feasibility Assessment
2) Pilot Scale Tests
3) Interpretation Guidelines
4) Workshops/Consultations
5) Implementation

8. DREDGED-MATERIAL DISPOSAL IN PUGET SOUND (FOUR-MILE ROCK DISPOSAL SITE AND THE PUGET SOUND DREDGED-DISPOSAL ANALYSIS)

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Puget Sound commercial fishermen in the early 1970's complained that dredged-material debris was fouling their nets. In response, the Washington tate Department of Natural Resources (WDNR), in conjunction with an interagency team, designated the currently utilized open-wate disposal sites in Puget Sound.

These sites (Figure 8.1) are for disposal of dredged material. Disposal of upland excavation materials, construction debris, wood waste, etc., is not allowed in Puget Sound waters.

The regulatory procedures used for permitting the disposal sites and individual dredging and disposal activities are discussed below.

Site Designation Permitting Process

Pursuant to the State of Washington Shorelines Management Act (SMA) which is consistent with the U.S. Government Coastal Zone Management Act, the appropriate city or county jurisdiction after public notice issues a substantial development permit to the WDNR for use of the open-water site under question. WDNR applies for the permit because it owns the aquatic lands on which the disposal site is located. Once issued by the city or county, the shorelines permit is reviewed by the State of Washington Department of Ecology (Ecology) for consistency with the SMA. Upon receipt of Ecology approval, a valid permit exists for use of the site in question.

Individual Dredging Project Permitting Process

A dredging proponent must secure both an SMA permit and a Corps of Engineers permit.

The SMA permitting procedure is similar to that used to designate a disposal site. The applicant applies to the appropriate city or county government for a substantial development permit. After the local authority has completed public notice procedures and the permit is issued, Ecology reviews the permit to assure consistency with the SMA.

The Corps permit process occurs pursuant to Section 10 of the 1899 Rivers & Harbors Act (which regulates structures and dredging in navigable waters) and Section 404 of the Clean Water Act (which regulates the disposal of dredged and fill material in waters of the United States). Upon receipt of the application, the Corps issues a public notice which is widely circulated and includes all appropriate local, state and federal resource agencies. Each agency provides comments based on its area of expertise. The U.S. Environmental Protection Agency (EPA) and Ecology have direct authority regarding suitability of dredged material for open-water disposal.

Ecology coordinates comments from various state agencies including Departments of Game and Fisheries. Ecology also has the State of Washington Coastal Zone Management (CZM) and Section 401 Water Quality certification authority over the Corps permit, without which the Corps permit normally will not be issued. (Note: Ecology will not provide certification until SMA procedures have been fully satisfied.)

A diagram of the combined SMA and Corps permitting process is contained in Figure 8.2.

Upon receipt of state certification and agency review comments, the Corps undertakes its own public interest review and either issues or denies the permit. Once the Corps permit has been issued, the applicant must secure a disposal lease agreement with WDNR to dump material on state lands.

Determinations regarding material suitability for in-water disposal were historically based on testing of sediments for conventional pollutants such as total volatile solids, oil and grease, sulphides and total organic carbon. Additionally, total PCB's and elutriate testing for heavy metals were required.

Elutriate values, however, were found to be low and always close to control levels. As such, water column effects were not predicted. Recent information has confirmed that greatest environmental concern is with contaminated bottom sediments, not the water column.

Elutriate testing is now only required when adverse water column effects can be anticipated, such as might occur when dredging is in an area with little mixing activity. Standard testing today generally involves the following:

1. Grain Size Analysis
2. Conventional Pollutants

3. Metals (Total Bulk Test)
4. Priority Pollutants (Total Bulk Test for the Base Neutral and Pesticide Extractable Fractions)
5. Amphipod Bioassay (Rhepoxynius abronius)

Four-Mile Rock Disposal Site Permit

In the time period of 1981 to 1984, results from a variety of new research studies caused pollution in Puget Sound to become a major issue. Liver lesions and tumours were found in bottomfish. Elevated levels of heavy metals and organic pollutants were found in various embayments. Shellfish beds were being decertified.

During this same time period a number of municipal wastewater treatment facilities had applied for waivers from secondary treatment because of the anticipated large waste-assimilative capacity of large bodies of salt water such as Puget Sound or the Pacific Ocean. Included in this group seeking waivers was the Municipality of Metropolitan Seattle (Metro).

Metro instituted a series of studies in Elliott Bay to develop baseline information on which to assess the effect of its sewage discharges. A surprising study result was the discovery of elevated concentrations of heavy metals and organic priority pollutants at the Four-Mile Rock open-water disposal site in Elliott Bay, as well as in many other areas of Elliott Bay. Concentrations at the site ranged up to five times greater than the approximated 1890 background Puget Sound concentrations for those same pollutants.

In August 1984, the SMA permit for the Four-Mile Rock site located in Elliott Bay expired. The new information discovered by Metro, coupled with strong citizen concern and need to continue on-going maintenance dredging activities, resulted in the establishment of an interagency task force to review the Four-Mile Rock site.

This task force, chaired by the City of Seattle, recommended: (1) issuance of an SMA permit to expire two years after issuance, (2) preparation of an environmental impact statement (EIS) prior to issuance of the next SMA permit, and (3) preparation of interim disposal criteria for inclusion in the SMA permit.

The interim disposal criteria, developed by EPA, are based on the concept of no further degradation at the site. Criteria background sediment datum are the Metro sediment testing data collected at and near the Four-Mile Rock site. The permissible individual pollutant chemical concentrations allowed at the site are based on 125% of the geometric mean of that pollutant at the disposal site. As a result of using the geometric mean rather than arithmetic mean, as basis for developing sediment criteria, the quality of material suitable for discharge is expected to be somewhat better than currently exists at the site. Some capping effect is expected.

Additionally the proposed dredged material is tested with an amphipod bioassay. If toxic effects greater than at the disposal site are exhibited, the material is not suitable for disposal at the Four-Mile Rock site.

The SMA permit, issued in August of 1984, was appealed by concerned citizens but eventually upheld by the SMA Hearings Board and State of Washington Superior Court. The site is now officially open. First disposal under the interim disposal criteria occurred in August 1985.

Puget Sound Dredged Disposal Analysis (PSDDA)

The difficulties with permitting the Four-Mile Rock site caused regulatory agencies to re-examine ongoing management practices for the other Puget Sound disposal sites. Several issues were of concern in late 1984 and early 1985:

1. The Port Gardner site near Everett was issued an SMA permit shortly after issuance of the Four-Mile Rock site permit. Permit conditions required development of interim disposal criteria before any disposal could occur. These interim criteria, also based on non-degradation, will contain more stringent chemical criteria than the Four-Mile Rock site. The difference in chemical criteria between the two disposal sites is a strong cause for citizen concern, especially those living near the Four-Mile Rock disposal site.

2. Criteria for the remainder of the Puget Sound sites did not exist. Judgement regarding material suitability at those sites was made on a case-by-case basis. Decision-making consistency between sites was difficult. (Note: Ecology has recently identified interim criteria to be used until completion of PSDDA.)

3. Individual sites were subject to a wide variety of local conditions which often conflicted with the overall management of dredged material in Puget Sound.

4. Clean-up of Puget Sound was a major campaign issue in the 1984 Washington State Governor's race.

5. Citizen environmental groups undertook an intensive campaign lobbying on behalf of a comprehensive study

addressing dredged-material disposal throughout all of Puget Sound.

To address all these issues, it was decided that a comprehensive dredged-material disposal plan for Puget Sound should be prepared. In February 1985, the Corps of Engineers, EPA, WDNR, and Ecology announced the Puget Sound Dredged Disposal Analysis (PSDDA). PSDDA, which will address all phases of open-water disposal, is expected to take approximately three years to complete and will be accomplished in two phases. Phase I will cover central Puget Sound from Tacoma to Everett and Phase II will cover the remainder of Puget Sound to the Canadian border and Port Angeles (Figure 8.1). Joint EIS's, which satisfy both federal and state EIS requ rements, will be prepared for each project phase. Approximat ly $4 million has been targeted for PSDDA.

PSDDA is expected to yield the following useful products:

1) Designations of the site locations in Puget Sound for unconfined open-water disposal of dredged material.

2) Sediment criteria which must be met to allow for disposal at those sites.

3) Technological controls and management practices which must be implemented with the alternative disposal options [e.g. upland, nearshore, or open-water (confined)] for materials which are too contaminated for unconfined in-water disposal.

4) A users' manual outlining procedures to be followed to secure appropriate permits for disposal of dredged material.

Three workgroups have been formed to generate these products. The Disposal Site Workgroup (DSWG) is responsible for locating the disposal sites. The Evaluation Procedures Work-group (EPWG) will identify sediment disposal criteria and technological controls necessary for disposal of contaminated dredged material. The Management Workgroup (MWG) is charged with assuring that PSDDA products are feasible and workable; a users' manual will also be prepared.

Goal of the DSWG is to choose open-water disposal sites which are environmentally compatible and economically feasible where use conflicts are minimized. Critical site selection factors include:

1) Material must be generally confined rather than dispersed.
2) Material must not contain unacceptable levels of contaminants.
3) Conflict with biological and human resources must be minimized to the maximum extent feasible.
4) If dumping ceases, healthy biological recovery of the area is expected.

Efforts, to date, include mapping of human uses (e.g. navigation lanes, anchorage areas, utility lines, outfalls) and biological resources (e.g. salmon, crab, bottomfish and shellfish). These individual maps (milar plastic sheets) when placed on top of each other identify areas of concern and areas where disposal sites could possibly be located. Based on this approach, zones of siting feasibility (ZSF) have been identified.

Studies undertaken or proposed to precisely identify disposal site locations within the ZSF's include:

1) Side-scan sonar of bottom surface,
2) Moving-picture video of bottom surface,
3) Still photographs of bottom surface,
4) Still photographs of the vertical profile of the bottom substrate,
5) Bottom grabs with grain-size analysis of sediments,
6) Computer modelling of dredged-material passage through the water column after a dump,
7) 2-D computer modelling of currents in areas of the proposed dumpsites, and
8) Current meter installation at the proposed disposal sites.

Detailed baseline and verification monitoring of the selected disposal sites will begin in early 1986. Baseline testing will likely include physical, chemical and biological analyses. Monitoring of the site at different times of the year will be necessary to assess seasonal variations in benthic and fisheries resource use. Detailed seasonal studies of crab usage at each site will also be performed.

Identified sites will be specified in the EIS and recommended for official designation.

The stated goal of the EPWG is:

"Establish evaluation procedures for dredged-material assessment that allow open-water, unconfined disposal in an environmentally safe manner by avoiding unacceptable adverse effects to human and environmental health."

Efforts are currently underway to establish sediment disposal criteria based on using biological and/or human health effects information to interpret chemical and biological tests on the dredged material. Where data are lacking, comparison to a suitable reference area will be necessary.

Additionally, EPWG is researching alternative disposal options and appropriate controls for disposal of contaminated material. Economic comparisons of "generic" upland, nearshore, and aquatic capped sites will be made with the unconfined open-water disposal option. Specific locations for these alternative sites will not be identified.

Additional products from this group will include:

1) Protocols for laboratory sediment testing analyses,
2) Identification of contaminants of concern and required sediment-testing requirements,
3) Cost and environmental review of proposed disposal criteria,
4) Design and selection of confinement options, and
5) Review of sea-surface microlayer contamination related to dredging.

The task of the MWG is to develop a joint interagency process to follow when regulating dredging and disposal activities. Products will include:

1) An interagency process to be used when reviewingg dredging and disposal projects,
2) Development of guidelines for verifying permit compliance and necessary compliance actions, and
3) A manual to be used by the dredging community.

PSDDA Contacts

To be placed on the PSDDA mailing list, or address questions and comments evaluating the study, write to:

U.S. Army Corps of Engineers
P.O. Box C - 3755
Seattle, Washington 98124
U.S.A.
Attn: Frank J. Urabeck
Study Director, NPSEN-PL
Telephone (206) 764-3708

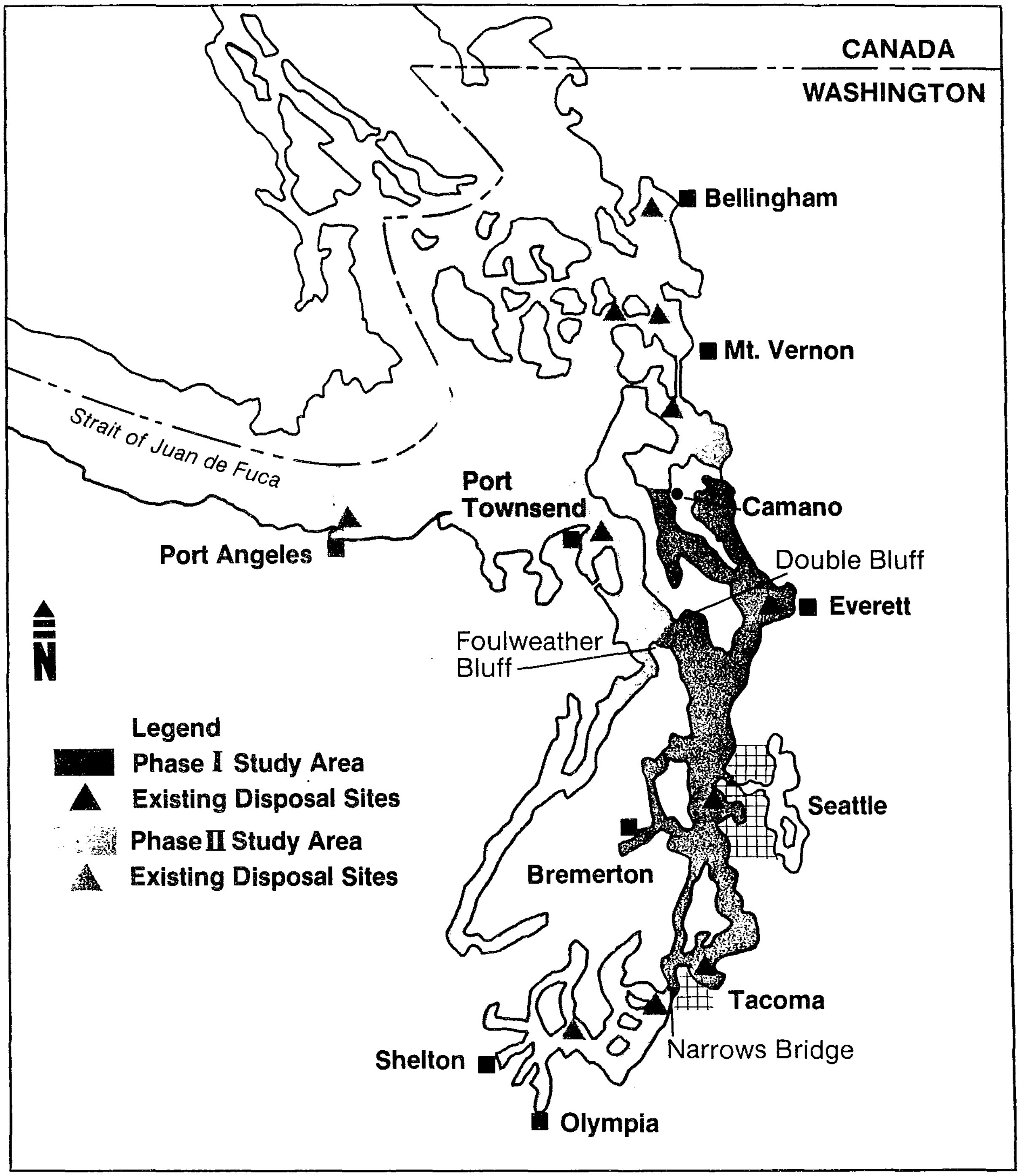

FIGURE 8.1 Puget Sound dredged-disposal analysis - Phase I and Phase II.

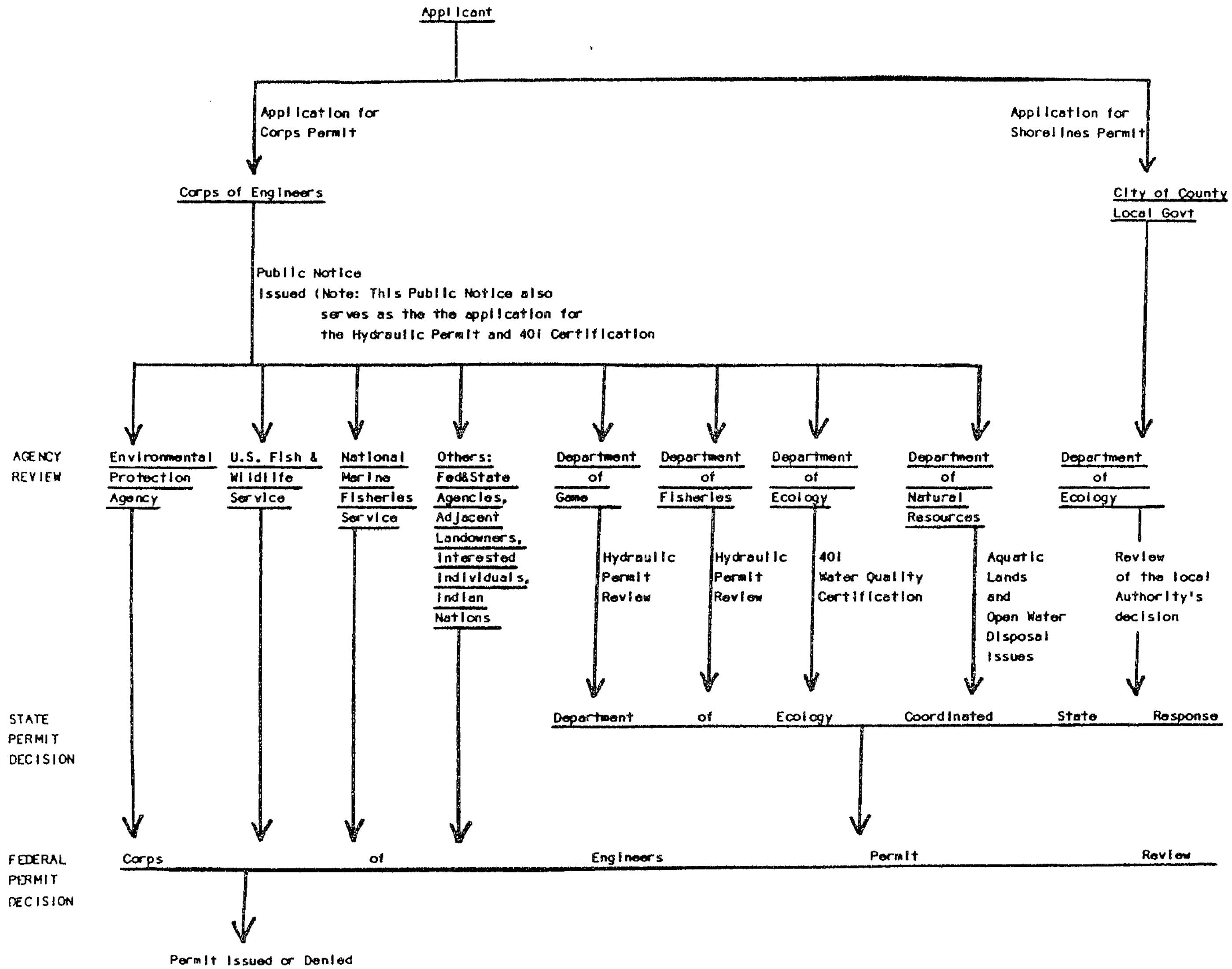

FIGURE 8.2 Combined State of Washington Shorelines Management Act and Corps of Engineers permitting process.

APPENDIX I

LOCATIONS OF PARTICIPANTS 1985

I. Government

CANADA: DFO - Department of Fisheries and Oceans:

Habitat Management Division
Water Quality Unit
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IOS - Institute of Ocean Sciences
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WVL - West Vancouver Laboratory
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and

Kapilano 100, Park Royal South
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and

9th floor, Bellanca Building
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YELLOWKNIFE, N.W.T. X1A 2N3

and

Aquatic Toxicity Laboratory
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Public Works Canada:

1166 Alberni Street
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Ministry of Environment, British Columbia:

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VICTORIA, B.C. V8V 1X5

Marine Resources Branch
Parliament Buildings
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Planning and Assessment Branch
3rd floor, 777 Broughton Street
VICTORIA, B.C. V8V 1X5

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CRD - Capital Regional District:

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U.S.A.: EPA - Environmental Protection Agency

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APPENDIX II

OCEAN DUMPING WORKSHOP ATTENDANCE LIST

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M. Yunker, Dobrocky SEATECH Ltd., Sidney, B.C. (604-656-0111)

APPENDIX III

1984-1985 CONTRACTS PACIFIC REGION

1.	Study of the effects of wood wastes for ocean disposal on the recruitment of marine benthic communities (macrobenthos). Scientific Authority: M. Waldichuk, DFO/WVL Contractor: COASTLINE Environmental Services Limited DSS File No.: 06SB. FP 941-4-0776	$ 7,500
2.	An experimental simulation of the release of cadmium and lead from contaminated dredge-spoil in sea water. Scientific Authority: C.S.Wong, DFO/IOS Contractor: Seakem Oceanography Limited DSS File No.: 06SB. FP 941-4-1832	$22,000
3.	National Quality Assurance Programme. Scientific Authority: R.W. Macdonald, DFO/IOS Contractors: numerous laboratories DSS File No.: numerous	$24,000
4.	Organization of west coast ocean dumping workshop and preparation of workshop proceedings for publication. Scientific Authority: L. Giovando, DFO/IOS Contractor: Sea-I Research Canada Limited DSS File No.: 06SB. FP 941-4-2409	$ 5,000

APPENDIX IV

1985-1986 CONTRACTS
PACIFIC REGION

1. An experimental simulation of the release of cadmium and lead from contaminated dredge-spoil in sea water. $15,000

   Scientific Authority: C.S. Wong, DFO/IOS
   Contractor: Seakem Oceanography Limited
   DSS File No.: 06SB. FP 941-4-1832

2. Feasibility assessment of sediment toxicity tests suitable for ODCA dredging application review. $14,400

   Scientific Authority: R. Kussat, EPS, West Vancouver
   Contractor: Envirochem Services Limited
   DSS File No.: 03SB. KE 603-5-0909

3. Review, analysis and application of the current knowledge of environmental effects of dredged material disposal at Point Grey. $ 9,500

   Scientific Authority: H. Nelson, EPS, West Vancouver
   Contractor: E.V.S. Consultants
   DSS File No.: 11SB. KE 603-5-0415

4. A critical state-of-the-art literature review of representative sampling and subsampling of heterogeneous substances. $ 7,500

   Scientific Authority: R. Macdonald, DFO/IOS
   Contractor: Dobrocky SEATECH Limited
   DSS File No.: 06SB. KE 603-5-0971

5. Development and testing of the benthic lander: a free-vehicle experimental platform for studying the environmental effects of ocean dumping. $12,000

   Scientific Authority: C. Levings, DFO/WVL
   Contractor: Edward Anderson Marine Sciences
   DSS File No.: 03SB. FP 941-5-2323

6. Organization of west coast ocean dumping workshop and preparation of workshop proceedings for publication. $ 4,010

   Scientific Authority: R. Wilson, DFO/IOS
   Contractor: S.M. Woods Consulting
   DSS File No.: 06SB. FP 941-5-2240