OceanChemGroup

# Evaluation of the Scientific and Technical Support for the Ocean Dumping and Marine Program, Environment Canada

## Final Report

OceanChemGroup

Rawson Academy of Aquatic Science

Eliasson, Apostle, Patterson and Associates Limited

OceanChemGroup

## Table of Contents

# 1 Preface

The project team for the evaluation consisted of the following persons:

1. Scott MacKnight, Ocean**Chem**Group; technical review.
2. James Apostle, Eliasson, Apostle, Patterson and Associates; project leader.
3. The Rawson Academy of Aquatic Science; input from the staff and fellows of the Academy.

The project was undertaken for the Evaluation Branch, Environment Canada; Mr. Patrick Gore was the project officer. Contract number was KA-171-8-1854/A1.

## 2 Executive Summary

The purpose of this study was to evaluate the adequacy of the scientific and monitoring support for the Ocean Dumping and Marine Program (ODMP), and where shortcomings exist, to make recommendations for improvement. The findings of the evaluation are in line with the observation in the Marine Multi-Year Science Plan that, in current marine regulatory programs, "the number of controls is minimal, existing controls are sometimes inconsistent, and they are not always implemented on a uniform and effective basis."

Ocean dumping is a relatively small part of a much larger marine pollution problem. However, regulation of ocean dumping is entirely within the jurisdiction of the federal government, and the ODMP is potentially a good model for application to other land-based sources of marine pollution. Now that the Ocean Dumping Control Act has been integrated into the CEPA, Environment Canada has the opportunity to affirm its commitment to the principles underlying the Act through a positive response to the improvements that can be made to the ODMP.

**Findings**

The summary of findings is as follows:

1. The ODMP is concerned largely with the regulation of dredged materials. Canada is not involved in the large scale dumping of industrial waste and sewage sludge that the London Dumping Convention was intended to control.

2. Very little monitoring of Canadian disposal sites has been done, and as a consequence, there is no way of knowing whether or not an adverse impact has occurred. International experience shows that open water disposal of contaminated substances can have an adverse effect on the marine environment.

3. The substances which should be of most concern to the regulators of ocean dumping are the synthetic organic compounds, such as PCB, PAHs, and dioxins, and to a lesser extent the heavy metals, such as cadmium and mercury.

4. The program has permitted dumping in excess of scheduled limits on a regular basis, under the "rapidly rendered harmless" provisions of the Act. There has been no scientific substantiation for this practice in the Canadian context.

5. The implementation of the schedule of substances does not take into account increased awareness of the potential hazard of the synthetic organic compounds, such as dioxin and PAHs. Moreover, variability exists between regional "working lists" and the Act and regulations, with respect to substances for which tests are conducted, and the limits which are applied. The variability is not substantiated from a scientific point of view, and is also a regulatory issue.

6. Unless the program is able to establish a more sound scientific basis for the substances and limits, it will remain open to the criticism that, from a regulatory reform perspective, it is imposing an unnecessary burden on the proponent.

7. The protocols and test methods that the program is employing for the characterization of materials do not make use of the latest technological developments. The information on dumped substances, therefore, is not as accurate as it could be.

8. Inconsistencies in the permit application information requirements follow from the need to update the guidelines and protocols.

9. The value of the research program and the size of the individual projects funded under it have diminished to the point where serious questions have been raised about its effectiveness.

10. The compliance surveillance activity is limited, and there is virtually no monitoring of disposal sites for short or long-term effects.

11. The mandate for national program management is not adequate to the task of the development and implementation of a fair and consistent program across the country.

12. There is inadequate scientific capacity to provide the support necessary for the program.

**The Action Plan.**

Following are the components of an action plan to correct the shortcomings in the ODMP which were identified by the evaluation:

* focus attention on the substances of concern, i.e., the synthetic organic compounds, such as PCB, PAHs, and dioxins.
* move immediately to establish a list of substances and limits which will be applied on a national basis (proposed list in Section 3.4).
* conduct an in-depth review of the scheduled substances and limits in order to confirm or to revise them, taking a biological effects approach.
* adhere to the regulatory limits for the substances of concern, which will mean more costly disposal or restrictions for some dredging.
* institute at least a minimum monitoring program for sites at which substances of concern have been dumped.
* improve protocols and test methods for material and disposal site characterization.
* concentrate the ODCA research fund resources first on the development of policies and guidelines.
* establish a critical mass of scientific expertise on the fates and effects of marine environmental pollution.
* adopt a marine environmental control approach to ocean dumping as science, technology and resources make it possible to do so.
* establish a national committee of experts to provide scientific advice to the program.

**Cost Implications**

It is not the role of an evaluation to advocate an increase in expenditures. Nonetheless, one of the reasons that the ODMP has not fulfilled its objectives is a lack of resources. Whether or not additional funds are provided to the ODMP will be a matter of the priority that is assigned to the many competing demands for resources in the environmental control programs.

The major cost implication of these recommendations is for the proponents, both government and private sector, in the form of increased costs for material characterization and alternate forms of dumping. It has not been possible for the evaluators to calculate this cost with any precision. An immediate priority for the program should be to determine the operational and financial implications of adhering to the regulated limits for ocean disposal.

A rough estimate of the additional costs associated with the recommendations is contained in Table 1:

**Table 1, Cost of the Action Plan**

**($000 1989)**

| | **DOE** | | **Proponent** | |
|---|---|---|---|---|
| | **Annual** | **One-time** | **Annual** | |
| Review substances | -- | $500.0* | -- | |
| Adhere to limits for organics | -- | -- | $3,900.0 | |
| Minimum monitoring program | $750.0 | $300.0* | -- | |
| Improve sampling | -- | $200.0* | $ 240.0 | |
| Improve analysis $2,500.0 | -- | $200.0* | $ 500.0 | |
| Restore research | $600.0 | -- | -- | fund |
| Develop research capacity | $250.0 | -- | -- | |

*** from research fund over several years.**

Even without additional resources, program management can take steps to increase the effectiveness of the program. However, many of these improvements could be expected to result in additional cost to the proponent.

## 3 Recommendations

The following is a list of the recommendations, in the order which they appear in the text:

**RECOMMENDATION 1:**

It is recommended that exclusive, permanent disposal sites be designated for the purpose of ocean dumping.

**RECOMMENDATION 2:**

It is recommended that chemical tests and bioassay be instituted for fish waste disposal.

**RECOMMENDATION 3:**

It is recommended that an in-depth review be conducted of the ODMP substances and limits with a view to confirmation or revision, using a biological effects approach.

**RECOMMENDATION 4:**

It is recommended that the program move immediately to establish a list of substances and limits which will be applied consistently on a national basis.

**RECOMMENDATION 5:**

It is recommended that the ODMP adhere strictly to the limits which are set for the synthetic organic compounds.

**RECOMMENDATION 6:**

It is recommended that the ODMP undertake an immediate study of the practical implications of enforcement of the CEPA ocean disposal limits.

RECOMMENDATION 7:

It is recommended that the ODMP adopt a marine environmental quality objectives approach to control substances and limits.

RECOMMENDATION 8:

It is recommended that the ODMP develop and implement a sampling protocol for dredged sediments.

RECOMMENDATION 9:

It is recommended that a standard protocol for chemical testing be established, including detailed quality assurance procedures, for use by all laboratories undertaking analysis in support of the ODMP.

RECOMMENDATION 10:

It is recommended that, in conjunction with further development of program guidelines and protocols, the ODMP review and revise the permit application forms.

RECOMMENDATION 11:

It is recommended that the ODMP devote the resources in the Research Fund to the development of regulations, policies and guidelines for the program.

RECOMMENDATION 12:

It is recommended that ODMP develop a policy, guidelines and procedures for monitoring ocean disposal.

RECOMMENDATION 13:

It is recommended that the ODMP institute a minimum level of monitoring for those disposal sites at which dumping of substances of concern has occurred.

**RECOMMENDATION 14:**

**It is recommended that Environment Canada establish a national committee of expertsto provide scientific advice to the ODMP.**

## 4 Introduction

The project team for the evaluation consisted of the following persons:

1. Scott MacKnight, Ocean**Chem**Group; technical review.
2. James Apostle, Eliasson, Apostle, Patterson and Associates; project leader.
3. The Rawson Academy of Aquatic Science; input from the staff and fellows of the Academy.

The project team wishes to express its appreciation to the staff of Environment Canada, the Department of Fisheries and Oceans, Public Works Canada, contractors and international agencies for their co-operation in this study.

## 4.1 Terms of Reference

The terms of reference of the evaluation were to determine the adequacy of the scientific and monitoring activities currently undertaken in support of the Ocean Dumping and Marine Program The specific evaluation questions to be answered were as follows:

1. Is there any evidence that dumping activities carried out in accordance with a legal permit have led to any significant immediate or long-term effects on the marine biota or have led to conflicts with other legitimate uses of the sea?

2. Is the scientific information on scheduled substances adequate to support the existing control limits, and/or should additions or amendments be made? In what areas are Canadian controls less stringent than those imposed by other nations?

3. Are the test methods and protocols now used to assess the environmental impact of ocean dumping technologically current, reliable, and cost-effective in preventing marine pollution?

4. Are the information and monitoring requirements imposed on applicants for permits applied in a fair, consistent and adequate fashion?

5. To what extent does the information from present monitoring and surveillance activities adequately demonstrate any adverse effects from ocean disposal?

6. Is operational monitoring capable of measuring environmental impacts in "real time"?

The scope of the evaluation included the responsibilities of both Environment Canada and the Department of Fisheries and Oceans with respect to ocean dumping. As well, it involved an examination of the headquarters activities, and the way in which the program has been implemented in each of the four regions of DOE.

This study builds upon the evaluation assessment prepared by the Environment Canada (Environment Canada, Program Evaluation Branch, 1988), which identified the issues to be pursued in the formal evaluation. A description of the ODMP is contained in the evaluation assessment.

### 4.2 Logical Framework

The logical framework shows the causal relationships between the program's activities, outputs and impacts, as illustrated in Figure I. An understanding of these linkages is useful in the identification of issues for evaluation and the development of indicators against which the issues can be judged.

The ODMP employs a system of permits and inspection to control the dumping of contaminants at sea. The permits are issued in accordance with the schedules of substances, limits, and factors specified in the CEPA, which contains virtually all the provisions of the earlier ODCA. The permits govern the timing, handling, storing, loading, and placement of dumped substances. Inspection (here called compliance surveillance) by both program staff and the proponent is carried out to ensure compliance with the terms of the permit. The intent is that these activities should result in the control of dumping of contaminants in all Canadian marine waters.

# Program Framework

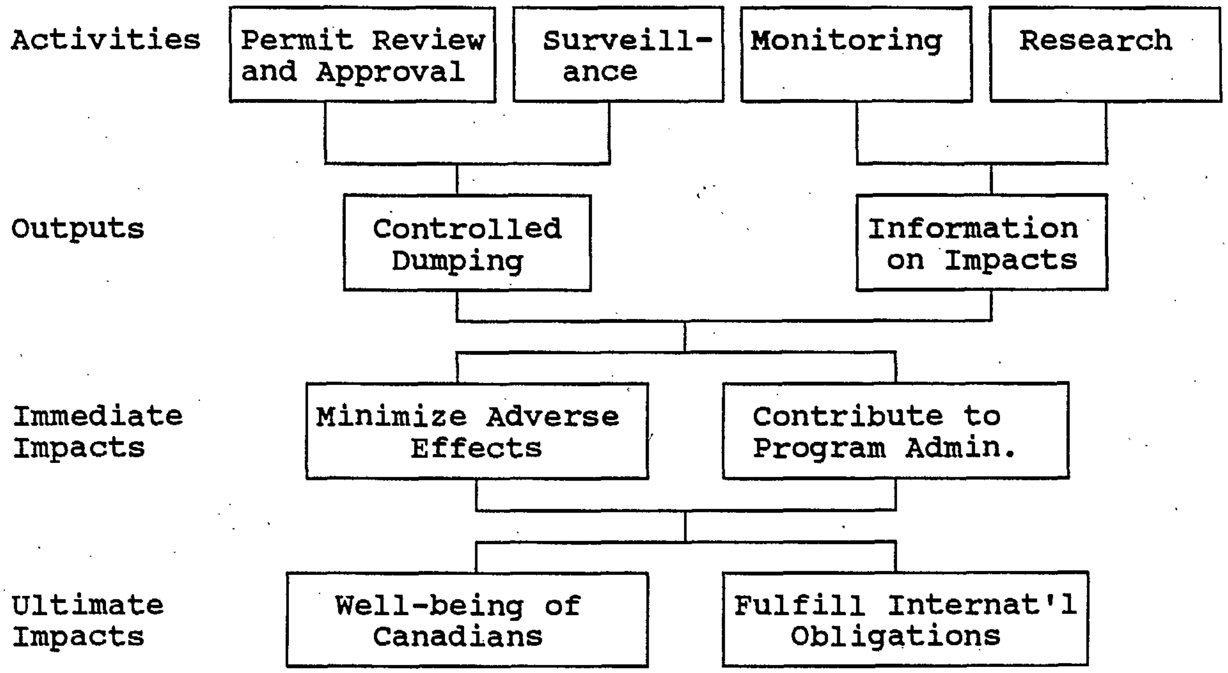


Figure 1

The program also performs the ongoing monitoring of dump-sites, and through the Ocean Dumping Control Act Research Fund (ODCARF), research activities related to ocean dumping. The monitoring and research provide information about the impact of pollutants on the marine environment, which in turn contributes to the administration of the Act.

The immediate impact of the controls is to reduce the adverse effects of ocean dumping. The purpose of the ODCA is expressed in terms of substance control, where the objective is to reduce the level of contaminants entering the marine environment. Accordingly, the level of discharge will be the principal criteria used in the evaluation in assessing adverse effects under the CEPA.

The CEPA introduces the concept of environmental quality objectives, the intent of which is to control the level of the contaminant in the environment. The UNEP Montreal guidelines define marine environmental quality objectives as the quality of water, biota or sediment that must be maintained for a desired level of quality and intended use (UNEP, 1985). The new approach taken by the CEPA potentially has profound implications for the administration of the ODMP. Environment Canada's Marine Environmental Quality management framework is in the early stages of development, and does not yet provide specific quality objectives that could be used in the evaluation of the ODMP. Nonetheless, the evaluation does attempt to examine the way in which various aspects of the scientific support for the program can be expected to operate under the MEQ regime expressed in the CEPA.

The preamble of the CEPA also acknowledges Canada's international obligations in respect of the environment, an objective entirely consistent with the ODCA, which was intended to meet Canada's commitments under the London Dumping Convention.

### 4.3 Scientific Support Activities

Scientific support is essential to all activities in the ODMP. The generic scientific activity which is central to all others is sampling and testing to characterize materials and disposal sites, and to monitor the effects of dumping. In support of the sampling and testing are guidelines and protocols to ensure reliability and validity of data. At the base of the program is research into operational issues, policies and guidelines, e.g., scheduled substances and limits, and fates and effects of dumped materials in the marine environment.

### 4.4 Methodology

The evaluation questions were framed in the context of the Office of the Comptroller General's generic issues for the evaluation of regulatory programs. One question is directed toward the effect of ocean dumping on marine biota, while the others are focused on the adequacy of program design and the cost-effectiveness of program delivery. In the absence of data about the impact of dumping under the ODMP, the program effects question was addressed by drawing on the experience of other jurisdictions. For the questions which relate to program design and delivery, the approach has been one of "best practices", with comparisons to international activity and state of the art scientific activity.

Quantitative data available for purposes of the evaluation was limited. The principal sources of information were interviews with program staff, proponents, and international experts, as well as program documents and the scientific literature. Appendix I contains a list of persons interviewed, and references are found in Appendix II. Descriptive statistics have been provided, where available, in support of the findings. Given the lack of hard data, the analysis has had to rely heavily throughout on the application of professional judgement.

In the course of the interviews it became apparent that the extent of variability between regions in the implementation of the program would require separate treatment of the practices in each region. The findings focus on the two regions, Atlantic and Pacific, which between them account for the majority of activity under the program.

Also, the nature of the issues which emerged during the evaluation required that the investigation go beyond specifically scientific activities. In order to be able to explain fully the findings with respect to the science, it was necessary to examine related organizational, regulatory and resource matters.

## 5 Program Effects and Conflicts

### 5.1 Definition of Adverse Effects

There is no widely accepted definition of "adverse effects" as it relates to ocean disposal. This is due to the complexity of the issue and the wide variation in the nature of the materials in question. Adverse effects can be defined in terms of the impact on the biological community (Sly, 1984): reduced community size or diversity, reduced growth or reproductive capability, species avoidance, and increased health-related deformities. Adverse effects can also be expressed in terms of resource-use denial: decreased marketability of fisheries products, increased costs for water treatment, and siltation of fish habitat, navigation channels and fishing equipment.

Any discussion of adverse effects requires the quantification of such impacts by relating them to some form of pre-impact conditions ("background or control") and/or to independent criteria. Adverse effects may be direct or indirect and of short or long term duration. The extent to which an adverse effect has taken place is verifiable (though not always) by statistical means. Short-term bioassay tests may be used to demonstrate "adverse effects" at the base of the food-chain. Because of the need to integrate long-term relationships between dose and exposure, risk assessment must be applied to estimate potential effects at higher levels in the food-web, including consumption by humans.

Causative factors (e.g., Hirsch, et al., 1978) include physical turbidity, smothering, and changes in substrate texture; biological introduction of exotics including macro-benthos, parasites and bacteria; and the biological availability of nutrient contaminants, and both lethal and sub-lethal toxic contaminants. Complexities in predicting the extent of adverse effects of dumping increase where the physical, chemical and biological conditions at the sediment/water interface differ significantly between the dredging and disposal sites. The effects are also difficult to predict and assess where materials are dispersed or the disposal site is affected by physical processes.

### 5.2 Volume and Type of Dumping

The volume and type of dumping is one measure of the impact of ocean dumping. The ODMP is concerned largely with dredged materials, which in 1986/87 accounted for 75.6% of the 168 permits issued. The majority of dredging projects are small in size. In 1986/87, 93% of dredging permits were for quantities under 100,000 $m^3$, totalling 40% of the quantity dumped that year. As shown in Table 2, most dumping of dredged materials under the ODMP, occurs on the Atlantic and Pacific coasts, with each accounting for roughly 40% of the volume. Much of the dumping that occurs in the province of Quebec occurs in waters within provincial jurisdiction. The activity in the North has diminished significantly in the past several years.

The 1986/87 ODMP Annual Report states that "approximately 90% of the dredged material dumped at sea is considered relatively innocuous". (Information on the volume and type of substances dumped is not readily accessible in the ODMP data base, and it was not possible for the evaluation team to undertake analysis of specific substances which would confirm this figure. The need for data of this type is discussed further in Section 6.2.5.)

Table 2, Summary of Regional Dredged Quantities

| | Atlantic | | Pacific | | Quebec | | W & N | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $10^6 m^3$ | % | $10^6 m^3$ | % | $10^6 m^3$ | % | $10^6 m^3$ | % | |
| 1981 | 7.5 | 54 | 3.1 | 22 | 2.4 | 17 | 1.0 | 7 | 14.0 |
| 1982 | 7.8 | 67 | 3.5 | 30 | 0.2 | 2 | 0.1 | 1 | 11.6 |
| 1983 | 2.8 | 43 | 3.6 | 55 | 0.1 | 1.5 | 0 | 0 | 6.5 |
| 1984 | 3.0 | 44 | 3.2 | 46 | 0.1 | 1 | 0.6 | 9 | 6.9 |
| 1985 | 2.2 | 36 | 2.3 | 38 | 0.1 | 2 | 1.5 | 25 | 6.1 |
| 1986 | 2.3 | 36 | 2.6 | 41 | 0.1 | 2 | 1.3 | 21 | 6.3 |
| **Average 1976-86** | **4.4** | **44** | **2.8** | **35** | **0.6** | **5** | **2.3** | **16** | **10.1** |

**Source: ODUMP Annual Report, 1986/87**

The primary purpose of regulation with respect to the vast majority of dumped substances is to limit the physical impact of the material on the fishery, fishing and the fish habitat in general. However, dredged material taken from industrialized areas is contaminated with heavy metals, synthetic organics and oil and grease. The regulatory effort here is directed at the biological effects resulting from chemical contamination.

Wastes from fish and shellfish processing constitute another major category of dumped material (permit quantity - 10,650 tonnes, 1986; 200,000 tonnes, 1988). ODMP procedures do not require the chemical testing or bioassay of fish offal; the concern about effects is limited to physical impacts. Studies of the original fish stock suggest that fish wastes may be contaminated with organohalogen compounds (Patin, 1982). The consequence of dumping could be the re-introduction of these chemicals into the marine environment.

The Multi-Year Marine Science Plan observes that, by world standards, most of the Canadian marine environment is relatively uncontaminated (Fisheries and Oceans, 1988). Ocean dumping constitutes a minor source of marine pollution relative to land-based discharges, airborne pollutants and river inputs (Karau, 1987). The original intent of the London Dumping Convention (LDC) was to control the dumping of chemical and biological armaments, industrial wastes and sewage sludge. Dredged materials were also included in recognition of the degree of contamination in some harbours due to land-based discharges. For the most part, the materials dumped in Canadian waters are less contaminated than in other jurisdictions. Table 3 shows that other signatories are involved in dumping large quantities of industrial wastes and sewage sludge in a way that Canada is not.

**Table 3, International Comparison of Types of Dumping**

| | General Permit (metric tonnes) | | | | |
|---|---|---|---|---|---|
| | Canada | France | Japan | United Kingdom | United States |
| **Industrial Waste** | | | | | |
| | 106.1 | 985.5 | 4305.5 | 3148.3 | 140.0 |
| **Dredging** | | | | | |
| | 6930.0 | 15,408.5 | 14,098.7 | 36,175.1 | 0 |
| **Sewage Sludge** | | | | | |
| | 0 | 0 | 4183.5 | 9250.4 | 6685.7 |

Source: LDC, 1988. Note that other countries do not report dumping in internal waters as does Canada.

A difference of view exists amongst the signatories to the London Dumping Convention as to whether or not the long-term objective is to eliminate ocean dumping altogether. Environment Canada's policy is to permit ocean dumping if disposal at sea poses less or no greater risks to human health and the environment than practicable land-based alternatives (ODMP Annual Report, 1986/87). The total volume of dumping has diminished over the past several years, but as a result of reduced dredging activity, rather than a regulatory decision. Table 2, shows that the total quantity of dredged materials for the years 1983 to 1986 was in the order of 6.0 X 106 $m^3$, compared to an average for the years 1976 to 1986 of 10.1 x 106 $m^3$. By contrast, the number of permits for non-dredged materials has increased from 10% of the total in 1984, to 25% in 1986. The higher number is accounted for largely by the increased dumping of fish offal on the Atlantic coast (ODMP Annual Report, 1986/87).

### 5.3 Scientific Evidence of Adverse Effects

Very little monitoring of open-water disposal, during or after the event, has been undertaken in Canada. It is therefore difficult to ascertain whether or not an adverse effect has occurred, beyond the short-term physical impact.

The major issue in the ODMP, where most of the activity relates to dredged materials, is the incremental impact of dumping a contaminated sediment. The scientific literature is not conclusive on this subject. However, there are at least two circumstances under which an adverse impact can occur - when contaminated sediments are deposited at a less contaminated site, and when the substance is made more available to the marine environment through physical or chemical processes, i.e. dispersal by currents, or change in solubility.

Research by other signatories to the London Dumping Convention does show an apparent association between the ocean disposal of contaminated sewage sludges and industrial wastes and impacts upon marine biota (Norton et al., 1984; Duedall et al., 1986). As well, research into sediment quality shows that concentrations of certain substances in sediments appear to be associated with adverse impacts on marine biota (TetraTech, 1986a). By extension, the impacts of the contaminated sediments can be attributed to dumping which increases the load of contaminated materials. In turn, regulatory agencies have imposed limits upon the consumption of contaminated biota because of their potential risk to human health (Table I, Lee and Peddicord, 1988).

Indeed, there is very little information in the international scientific literature which would establish a definitive cause and effect relationship between contaminants in the marine environment and biological effects (TetraTech, 1986a). The regulatory problem is to know what controls to introduce on the basis of incomplete information - and out of concern for the future.

Important research has been undertaken recently on contaminated sediments in Puget Sound. There, measures of depression of benthic communities and sediment toxicity have been related to concentrations of various chemical contaminants in the sediments to derive "apparent effects threshold" (AET) values (TetraTech, 1986a). The Washington State Department of Ecology (PTI, 1988b) then used these values to establish screening levels. These are values for a contaminant above which it is recommended that bioassay testing occur to determine whether or not an adverse effect will result. The screening levels have been set at 10% of the maximum AET, or the minimum AET, whichever is lower. Table 4 shows the Puget Sound AETs and the State of Washington screening levels for the substances in Part I of CEPA:

**Table 4, Puget Sound AET's and Screening Levels**

| Substance | Apparent Effects Threshold | Screening Level |
|---|---|---|
| Organoghalogens | | |
| - Total PCB | 130 to 2500 ppb | 130 ppb |
| - DDT | 14.9 to 69 ppb | 6.9 ppb |
| Cadmium | 5.8 to 9.6 ppm | 0.96 ppm |
| Mercury | 0.41 to 2.1 ppm | 0.21 ppm |
| Oil & Grease | | |
| - PAH | 12 to 18 ppm | 1.8 ppm |

Additional research (PTI, 1988a) is attempting to link the Puget Sound screening values to acceptable limits of contaminated substances for human health. Lacking firm evidence, there is a conservative approach to risk (integration of dose and exposure).

The implication of this work is that dumping of sediments containing substances in excess of these limits will possibly result in adverse effects on both marine biota and humans. In order to make a more definitive statement, it would be necessary to verify the Puget Sound experiments in Canadian waters. As discussed in Section 6.4, this type of scientific activity in support of the CEPA limits is highly recommended.

The Puget Sound research and other scientific evidence (Malins et al., 1982, 1984; Adam et al., 1987) suggest that the substances of particular concern are the synthetic organic compounds, such as PCB, PAH, and pesticides. These are substances for which the "background" value theoretically should be zero.

The concern arises from the fact that they are persistent, bio-accumulative, and can lead to a variety of sub-lethal effects, such as carcinogenicity.

The synthetic organic compounds are the substances on which the ODMP should focus its attention in its regulatory efforts, and they are the ones on which this report concentrates in its recommendations for improvements to the program.

**5.4 Dumping in Excess of Limits**

Dumping in excess of limits can be used as a proxy indicator for adverse impacts. If the limits are sound in the first place, then dumping in excess of the limits would constitute prima facie evidence of adverse effects, in the absence of mitigating circumstances.

In the Atlantic Region, there has been regular over-limit dumping of cadmium (Eaton and Bradshaw, 1984). Environment Canada has justified the over-limit dumping of cadmium contaminated sediment on the grounds that much of it is either associated with geochemical phases with low bioavailability, or that a relatively small fraction of the cadmium can be readily leached into seawater.

As well, the Atlantic Region has approved the disposal of oil and grease contaminated sediments in excess of the limit in the belief that most of the compounds measured as "oil and grease" were of relatively low toxicity, low persistence, the test methods were inaccurate, or that the limit for hexane extractable materials is too restrictive (Eaton and Bradshaw, 1984). Only since 1982 has there been testing for PAHs, and then only on a limited basis. It is not known what the PAH content of most of the over-limit dumping of oil and grease contaminated sediments has been.

Anecdotal information is available about over-limit dumping of PCB contaminated sediments, e.g. Halifax Fairview Cove Terminal I, 230-850 ppb, 1977; Halifax Fairview Cove, Terminal II, 230- 1570 ppb, 1984; Halterm Container Terminal, 100-150 ppb, 1987; Halifax Pier B, 41-787 ppb, 1988; St. John's, <1-2680 ppb, 1989 (permit issued). Incidents of over-limit dumping of mercury contaminated sediments include Halifax Fairview Cove Terminal II, 0.2-4.2 ppm, 1984; Halifax Pier B, 0.5-2.39, 1988; and St. John's, 0.89-9.9 ppm, 1989. In such cases, Environment Canada has used the justification which it calls "like unto like", whereby the material is dumped onto nearby sediments that are "equally" contaminated.

In the Pacific region, there is documented evidence of systematic dumping of PCB in excess of the regional limit. A review of 93 permits which involved dumping of PCB in a seven year period from 1982/83 to 1988/89, showed that in 12% of the cases, the PCB level exceeded the Pacific region limit of 1000 ppb, with the highest value being over 2000 ppb. (Environment Canada, internal memorandum, 1988). If the Atlantic Region limit of 100 ppb had been applied, the figure would be 39%. In the case of PCB, the rationale has been that of "like unto like" or "rapidly rendered harmless". The application in the Pacific Region has been to deposit the PCB contaminated sediments at deep-water disposal sites where the contaminant is "rapidly rendered harmless" by virtue of dispersal. As well, there has been anecdotal information about the over-limit dumping of sediments containing heavy metals, justified largely on the basis that the materials are rapidly rendered harmless through geo-chemical processes.

The concept of "rapidly rendered harmless" is integral to the London Dumping Convention, and is a reasonable exemption to apply under certain circumstances. It is meant to apply to the disposal of materials which would readily undergo physical or chemical alteration in seawater. Such alterations would greatly decrease their actual or potential impact on the bioresources.

An example would be the disposal of lime sludge and acid iron wastes generated at the Halifax International Airport. Surface run-off from exposed pyritic rocks was directed into a treatment system which added lime to increase the pH and promote iron and trace metal precipitation. The sludge was then dumped at sea because the infinite buffering capacity of seawater will maintain the trace metals in an iron flocculant with very low bioavailability. By disposing of the material over a very large area, there is likely no adverse impact.

However, the legitimacy of the use of the concept of "rapidly rendered harmless" for contaminated dredge materials has not been established. Dredged sediments are more solidified and do not undergo the same degree of chemical alteration as a liquid sludge. Numerous studies by the U.S. Army Corps of Engineers (summarized in Gambrell et al., 1978) have shown that dredged sediments undergo very little chemical alteration during the descent through the water column.

In the case of PCB, and many other synthetic organic compounds, the concept of rapidly rendered harmless does not apply. Unlike the metals, PCB is relatively hydrophobic, does not undergo a chemical change in seawater, and is preferentially associated with sedimentary particles or with the lipid fraction of marine biota (Hutzinger et al., 1974). While deep-water disposal may reduce the concentration of the contaminant, and thereby its toxicity, dilution does not lessen bio-accumulation or persistence.

The LDC appendices provide a protocol to determine whether or not a given substance is rapidly rendered harmless. The protocol requires extensive testing for persistence, toxicity, and bio- accumulation. This protocol was included in the draft operational guidelines for the ODMP (1987). However, in few if any cases, has the necessary characterization and monitoring occurred in conformity with the protocol. As a consequence, the program is unable to verify whether or not the assumption that a contaminant would be rapidly rendered harmless was in fact justified.

The concept of "like onto like" is based on matching the physical and chemical regime of the dredge and disposal sites, so that there is no change in the availability of the associated contaminants. It derives from the LDC, where the approach is meant to provide a criterion under which dredged materials, in the absence of appreciable pollution sources, may be excluded from chemical and biological testing. In the ODMP, the approach is used as a means of justifying over-limit dumping in harbours with a major input of pollutants.

While "like onto like" dumping may be theoretically sound, in practice, the match is very difficult to achieve, particularly where physical processes are likely to redistribute the sediments. In the ODMP, where there is little characterization of disposal sites, and virtually no monitoring, the approach is particularly questionable. The concept appears to have been adopted as a practical way of dealing with sediments in which the contaminants exceed the scheduled limits. The practice does not meet the criteria of rapidly rendered harmless under the LDC. Nor does it satisfy those who would want Environment Canada to take advantage of opportunities to improve the quality of the marine environment when they arise.

Underlying the attitude to over-limit dumping is the belief by many Environment Canada staff that the existing substances and limits are inappropriate, and do not take into account natural background levels of contamination which may be higher than the limit, or the bioavailability of the substance. As will be discussed below, little direction has been provided to regional staff on the application of the guidelines. In the absence of adequate scientific substantiation, when faced with the practical demands of the dredging program, the regional staff would not in any case be in a good position to refuse applications for over limit dumping.

**5.5 Off-Site and Illegal Dumping**

Off-site or illegal dumping could also lead to adverse impacts. Information is scanty about the failure of proponents to comply with the terms of a permit, which usually takes the form of dumping away from the designated site. However, there does not appear to be a major problem in this area. While virtually no information exists about dumping without a permit, illegal dumping is thought not to be widespread.

Failure to comply with a permit can arise from a variety of causes, including:

1. an honest mistake by the operator in locating the position,

2. poor weather conditions or sea-state during transit to the disposal site, leading the operator to invoke the emergency rule, and dump short of the disposal site,

3. ignorance on the part of the operator as to the regulations regarding ocean disposal, and

4. a deliberate act on the part of the operator to dump short of the site, and thereby save on transit time and costs.

Due primarily to resource limitations, Environment Canada undertakes minimal compliance monitoring. Further, proponents do not always submit the report on dumping activity at the end of each project, as they are required to do by the terms of the permit. Breaches which come to the attention of the regulator do so more by accident, or as a result of a complaint from fishermen affected by the dumping. In the cases which were reported, complaints were registered and proponents cautioned or fined. However, no monitoring was undertaken to determine what, if any, adverse impacts resulted from the off-site disposal activity.

It should be pointed out that the main proponent, PWC, often places an inspector on board the haulage vessel to ensure that all terms of the dredging contract are met. This measure has done much to reduce the likelihood of off-site dumping.

None of the respondents to the evaluation survey was aware of any instances of dumping without a permit. Few believed, however, that a significant volume of illegal dumping could occur without being noticed and reported. In any case, it was felt that the scale of illegal dumping would be small in comparison to what industry and municipalities are allowed by law to discharge directly into the marine environment.

### 5.6 Conflicts

The types of conflict which can arise from ocean dumping include:

1. disruption of fishing activities,
2. physical impact on marine resources,
3. chemical impact on marine resources, and
4. interference with other legitimate users of a disposal site.

Systematic documentation of conflicts does not exist within the program, and the observations here are based on anecdotal information. The conflict which does occur is mostly physical interference with the fishery. There was no report of conflicts arising from chemical contamination.

The conflicts that arise with the fishery are disruption of habitat, siltation or destruction of fishing gear, interference with fish migration, and interference with the fishing activity. The frequency of occurrence of these conflicts is difficult to estimate without data, but is perceived to be a continuing problem by both the proponent and the fishing industry.

Conflict with the aquaculture industry could become a problem in the future. At present, the conflict arises at the dredging stage, and is a problem for regulation under the Fisheries Act. As aquaculture expands, it can be expected to restrict the selection of disposal sites as well.

From the point of view of the proponent, who is responsible for compensation in cases of damage, the problem is to determine the legitimacy of the claims. Compensation is required to be paid under the provisions of the Fisheries Act. In some projects (e.g., Miramichi River, Scarrett, 1987), committees consisting of all stakeholders have been established to review claims and award compensation. Payment was based on a physical impact on the fishery, e.g., siltation of fishing equipment or destruction of gear by dredging equipment.

Exclusive zones for dumping have not been established, except for areas where there would be no fishing in any case. As a result, a situation exists which has the possibility for continuing conflict. In the initial designation of dumping sites, preference is most often given to the fishing activity, whether or not the selection results in increased transportation costs to the proponent. Once the site has been selected, the proponent is not guaranteed exclusive use of the site, that is, fishing activity may continue. As well, the disposal site for a given harbour is not fixed, and may change from one permit to the next.

Designation of exclusive sites would limit the conflict with the fishery, and would ease the burden on the proponent. Moreover, the establishment of permanent sites would facilitate monitoring for adverse effects, and in the event that contamination of the marine resource did occur, it would be easier to limit harvesting.

**Recommendation 1:**

**It is recommended that exclusive, permanent disposal sites be designated for the purpose of ocean dumping.**

# 6 Scheduled Substances and Limits

## 6.1 Approaches to Limits

The central feature of marine pollution control programs, such as the ODMP, is a schedule of substances and limits which provides the criteria for regulating the introduction of substances into the marine environment. The limits are set on the basis of the presumed or proven hazard of a substance to marine biota and humans.

Lyman et al. (1987) summarize the various approaches that have been taken to establishing sediment quality criteria. The sediment quality criteria, in turn, can be used to establish limits for open water disposal. Earlier attempts, including the ODMP, set limits based on background levels in the marine environment. More recent efforts attempt to establish maximum levels that do not cause unacceptable biological effects. These approaches include the following:

1. use of background concentrations from a "pristine" area, i.e., an area of little or no anthropogenic input, on the assumption that concentrations in excess of such a limit would cause an adverse effect;
2. comparison of contaminant concentrations in the interstitial water in dumped materials to water quality standards;
3. use of one of various biological criteria:
   **a)** bioassessment where the limit is derived from laboratory testing of exposure of a sediment to test animals. The limit can be derived from either bioaccumulation, toxicity or defined sublethal effect;

b) apparent effects threshold (AET), where the limit is derived from a concentration which is determined by field observations to cause some effect;

c) screening level concentration (SCL) where the limit is determined as that value that can be tolerated by 95% of the benthic organisms. The concept has only been applied to organic contaminants and is normally reported as a value normalized to the organic carbon content.

d) sediment triad value (STV), where the limit is derived from a combination of sediment concentrations, results of laboratory bioassays using the sediment in question and in situ observations of the benthic community such as benthic community structure or bioaccumulation.

4. Use of the sediment-water partitioning equilibrium in which the chemical partitioning coefficients are used in conjunction with acceptable water quality criteria concentrations to calculate acceptable sediment concentrations.

5. Use of the sediment-biota partitioning equilibrium in which chemical partitioning coefficients are used in conjunction with acceptable body burdens for chemicals in biota to calculate acceptable sediment concentrations. The acceptable body burdens can be set as either those values below which there are no effects on the biota or those values which could cause a human health effect if the biota were consumed in specific quantities.

As Lyman et al. (1987) point out, there are advantages and disadvantages to each of the approaches. The background level approach is most common because such data are readily available.

This approach, which uses bulk analysis as the indication of pollution, does not adequately predict biological effects of the contaminant. The biological effects approach, in theory, could provide very accurate sediment quality criteria, but requires extensive testing, and is fraught with methodological difficulties. The problem from a regulatory point of view is that the sediment quality criteria developed by the different methods may vary by orders of magnitude for a given pollutant (Lyman et al., 1987, p. 10). Nonetheless, the biological effects approach is showing promising results, and as will be discussed in Section 6.2, has potential application within the ODMP, either to confirm or revise the existing limits.

## 6.2 Description of Substances and Limits in the ODMP

### 6.2.1 LDC and the CEPA

The London Dumping Convention classifies substances, according to their hazard, as those that are prohibited and those that are to be strictly limited. As well, it specifies factors that are to be considered in the assessment of harmful effects. The LDC does make provision for the likelihood that prohibited substances will be contained in "trace" amounts in other materials. Each signatory to the LDC is given the latitude to define its own limits for acceptable concentrations of "trace contaminants". The ocean dumping provisions of CEPA closely parallel the LDC. As shown in Table 5, Part I lists prohibited substances, Part II lists restricted substances, and Part III identifies the factors that are to be taken into account in granting permits. The original ODCA limits were derived from US Environmental Protection Agency water quality criteria, and have been incorporated into the CEPA without change.

**Table 5 ODMP Substances and Limits**

| LDC | CEPS | ATLANTIC | PACIFIC | QUEBEC | NORTHERN |
|---|---|---|---|---|---|
| **Part I: Prohibited Substances** | | | | | |
| Organohalogens | 0.1 toxicity | PCB, 1000 PPB[1] | PCB,1000 ppb[1] | PCB, 100 ppb | not applic. |
| Mercury | 0.75 ppm | 0.75 ppm | 0.75 ppm | 0.75 ppm | 0.75 ppm |
| Cadmium | 0.6 | 0.6 ppm | 0.6 ppm | 0.6 ppm | 0.6 ppm |
| Plastics | < 4% volume | not applic. | not applic. | not applic. | not applic. |
| Hydrocarbons | 10 ppm | 1500 | 1500 ppm | 10 ppm | not applic. |
| Radioactives (high level) | -- | not applic. | not applic. | not applic. | not applic. |
| Bio. & Chem. Warfare | banned | not applic. | not applic. | not applic. | not applic. |
| **Part II: Restricted Substances[2]** | | | | | |
| Arsenic | no limit specified | no tested | no limit specified | no limit specified | no limit specified |
| Lead | no limit | 45 ppm | no limit | no limit | no limit |
| Copper | no limit | 45 ppm | no limit | no limit | no limit |
| Zinc | no limit | 169 ppm | no limit | no limit | no limit |
| Organosilicons | no limit | no test | no test | no test | no test |
| Cyanides | no limit | not tested | not tested | no limit | not tested |
| Fluroides | no limit | not tested | not tested | not tested | not tested |
| Pesticides not in Part I | no limit | DDT only, no limit | not tested | no limit | not tested |

Table 5 Cont'd

| LDC | CEPS | ATLANTIC | PACIFIC | QUEBEC | NORTHERN |
|---|---|---|---|---|---|
| Beryllium | no limit | not tested | excavation | no limit | not tested |
| Chromium | no limit | not tested | excavation | no limit | not tested |
| Nickel | no limit | not tested | excavation | no limit | not tested |
| Vanadium | no limit | not tested | excavation | no limit | not tested |
| Scrap metal | regulated | regulated | regulated | regulated | regulated |
| Radioactives (low level) | -- | not applic. | not applic. | not applic. | not applic. |
| Bulk Substances | included | regulated | regulated | regulated | regulated |
| Large quantities | included | regulated | regulated | regulated | regulated |
| **Part III: List of Factors** | | | | | |
| Substances, sites, factors | included | considered | considered | considered | considered |

1. **Tests for chlorophenols in vicinity of wood preserving plants; limit 1000 ppb.**
2. **LCDC recommends 1000 ppm for Part II metals.**

### 6.2.2 Regional Application of the CEPA Schedules

The evaluation of the adequacy of the scientific basis for the current CEPA limits required that the analysis go beyond the Act and regulations, inasmuch as these are applied differently in each region. The interviews revealed that regions employ "working lists" which introduce variability in the substances tested and in the limits applied, as shown in Table 4. The variability has implications for the enforcement of the regulations under the Act, for the proponent who must comply with the regulations and, potentially, for the quality of the marine environment.

**Part I: Prohibited Substances**

**Atlantic Region**

The Atlantic Region requires that materials be tested for all Part I substances. The analysis for organohalogens is limited to PCB and DDT's even when there may be reason to believe that other pesticides or trace organic compounds, e.g., dioxins, are present. In Sydney harbour, the oil and grease characterization has been extended to include polyaromatic hydrocarbons (PAHs).

As noted in Eaton and Bradshaw (1984), there have been numerous instances on which permits have been granted for materials in which the oil and grease limit of 10 mg/kg was exceeded. The decisions were made in the belief that the analytical method was inadequate to detect PAHs, the most toxic fraction of oil and grease. Even though the test has proven to be unsatisfactory, it continues to be used (OceanChem, 1989). Moreover, specific tests for PAHs are not being conducted in harbours where there is evidence of significant concentrations of such compounds.

Over-limit dumping of cadmium, to a level of 1.5 ppm (limit of 0.6) is regularly permitted (Eaton and Bradshaw, 1984), in part, on the grounds that the limit does not account for a high natural level of cadmium.

The Atlantic region has set a guideline limit for PCB of 100 ppb. As noted in Section 5.4, exceptions to this guideline have been permitted in recent years. Moreover, fish wastes, which are believed to contain unacceptable levels of organohalogens, are not required to be tested before disposal. Numerous studies (e.g., Addison et al., 1972; Patin, 1982; Duinker et al., 1979) have shown that fish, in particular lipid-rich species such as herring, can significantly bioaccumulate and biomagnify organohalogen compounds. As well, there is evidence (Martec, 1988) that the fish wastes are rapidly scavenged by predator species, and re-cycled through the biological system. There has been a significant increase in the requests for fish waste disposal permits. Present controls are limited to site and quantity and do not include analyses. While DFO staff feel that testing fish wasters would impose an unnecessary bureaucratic burden it is recommended that the controls on fish wastes be re-evaluated.

**Recommendation 2:**

**It is recommended that chemical tests and bioassay be instituted for fish waste disposal.**

**Pacific**

The Pacific Region routinely requires testing of dredged materials for mercury and cadmium. PCB and PAHs testing is required where there is a strong likelihood of occurrence. When dredging takes place near a wood treatment facility, a test for chlorophenols, in particular, pentachlorophenol, is also requested. In the case of excavated soils, the analysis covers all metals, and where suspected, PCB and PAHs. Testing for oil and grease has not been done on a regular basis.

Disposal of materials with high concentrations of heavy metals (e.g. lead over 6000 ppm in excavated soils from a Vancouver battery site) was reported to have taken place, on the grounds that the substances were rapidly rendered harmless at deep water sites. As well, dredged sediments contaminated with various metals or organic substances have been dumped near the dredge site under the "like onto like" concept.

The Pacific Region has adopted a PCB limit of 1000 ppb on the basis that it is a reasonable value for the sediments in the region. The principal harbours which have high levels of PCB contamination are Vancouver, Victoria and Esquimalt. The difference in values between the Pacific and Atlantic Regions has come about because the program has not provided an interpretation of the CEPA limit for PCB of 0.1 of a toxic level. As noted in Section 5.4, the Pacific Region exceeded its own limit of 1000 ppb in 10% of permits for contaminated sediments containing PCB, over a seven year period. Had the Atlantic Region standard of 100 ppb been used, the figure would be 39%.

The chlorinated phenols associated with wood treatment processes have been a matter of some concern since the inception of the program. Pentachlorophenol has been a required test since 1976, with a limit of 1000 ppb. Recently, analysis for dioxins and dibenzofurans in water and sediments in areas affected by pulp mill effluents has led to the closure of three areas to fish and shellfish harvesting. There has as yet been no requirement to extend the test for these substances to other areas where there is reason to believe that they exist at significant levels.

Constraining factors are the cost of the tests ($1500-2000 per sample) and the limited laboratory capability in Canada to undertake the analysis.

**Quebec Region**

The dumping activity in Quebec Region which falls under the jurisdiction of the CEPA is by and large limited to dredging in a number of small craft harbours on the Baie des Chaleurs coast of Quebec, ports in the Magdalen Islands, and ports of the North Shore of the St. Lawrence River. The Quebec Region requires extensive testing for Part I substances, including mercury, cadmium, total petroleum hydrocarbons, PCB and pesticides. The limits in Quebec Region are the same as those in the Atlantic.

**Western and Northern Region**

The Western and Northern Region varies the requirements according to the activity in question. Thus, dredging in a harbour such as Churchill, which has the potential for significant anthropogenic input, requires tests for more parameters than areas such as McKinley Bay. The requirements typically include all the metals, PCB, and detailed petroleum hydrocarbons (i.e., aliphatics, PAH, and aromatics).

**Part II: Restricted Substances**

The Atlantic region routinely requires a proponent to determine the concentrations of lead, zinc, copper, total organic and inorganic carbon, and particle size distribution of the sediments.

The CEPA does not set limits for Part II substances, and each region has adopted its own approach. For lead, zinc and copper, the Atlantic Region uses as a guide the "average" background values for the three metals developed in Swiss et al. (1980); i.e., 45 mg/kg for copper and lead; 69 mg/kg for zinc. In most cases, however, it is the presence of a Part I substance in excess of the limits, e.g., cadmium, that results in a restriction on dumping.

From 1976 to 1979, the permit applicants were required to report on the concentrations of vanadium, chromium, beryllium, nickel, and arsenic. The demand was dropped after several years of experience suggested that there was little variation between industrialized harbours and background levels in remote harbours. The requirements for cyanide, fluoride and the radioactive substances was also discontinued by 1979. Analysis is not undertaken for Part II pesticides, even where there is reason to believe they may exist, e.g., fenitrothion where spraying for spruce budworms occurs.

Of the Part II substances, the Pacific Region tests regularly only for lead in dredged substances, even where there is reason to believe that other contaminants may be present. All metals are covered in the characterization of excavated soils, as well as other substances that are believed to be present. As part of its evaluation, the region applies the LDC suggested guidleline of 1000 ppm for Part II metals. The difference in guideline values between the Atlantic and Pacific regions reflects the lack of agreement on the toxicity of the Part II metals. The high LDC value is based on the much higher levels of contaminants found in European sediments.

The Quebec Region requires tests for all Part II metals and cyanide. The Region does not have a fixed limit for Part II substances; rather, it compares the concentrations in the dredged sediment to background values.

In the Western and Northern region, in addition to dredging, there are two other major disposal activities - abandonment of artificial islands created by dredging for the purposes of oil and gas exploration, and dumping of scrap metal and construction debris. As the latter type of material is considered "inert", no chemical analyses is required. DOE has established fixed open- water disposal sites for these materials. The policy for assessment of abandoned islands is under discussion between DIAND and DOE, and no policy has yet been decided. The Canadian Standards Association has recently established an industry guideline for the abandonment of off-shore oil and gas structures and artificial islands (CSA 472).

**Part III: List of Factors**

Both the Quebec and Atlantic Regions undertake analysis of particle size distribution and total carbon content of materials. As discussed in more detail in Section 8, there is a good deal of variability in the way in which the Part III factors are addressed in the various regions.

**6.2.3 Impact on the Proponent**

The variability in the application of the substances and limits has been a source of frustration to the major proponent, Public Works Canada. It should be noted here that PWC acts on behalf of other federal government departments, including Transport Canada and Fisheries and Oceans, who are the true proponents. Other proponents do not deal with the program frequently enough to become aware of the differences. In the interviews, PWC questioned the use of more stringent controls in one region than in another, resulting in greater cost to the proponent. Within a region, the variability makes it difficult to additional testing may be required to justify over-limit dumping. The fact that Environment Canada does permit over-limit dumping only creates the incentive for the proponent to push to take advantage of the practice.

The fact that some staff do not have faith in the control limits leaves the department open to criticism that it is imposing an undue regulatory burden. If the limits do not have a solid scientific basis, a legitimate question can be asked about the necessity of the characterization of materials, and the legitimacy of the constraints that are placed on proponents on the basis of the limits. Without the limits, a much reduced control program could be operated which was aimed solely at preventing adverse physical impact on the fishery and other resource users.

A broader issue for the proponent is the appearance of a double standard in pollution control programs. Contaminants are discharged relatively freely into a number of harbours (e.g., introduction of PCB via fish waste effluents in Petit-de-Grat, N.S., Ernst et al., 1982). However, once they are there, the proponent is subject to strict regulatory control just to be able to move them from one location in the harbour to another. The relationship between ocean dumping and other land-based sources of marine pollution is discussed in Section 6.5, with respect to the Montreal Guidelines and the marine environmental quality approach to pollution control.

### 6.2.4 Scientific Substantiation

The application of the ODMP list of substances is not sufficiently discrete to provide adequate consideration of synthetic organic compounds. For example, the broad category of oil and grease does not specifically identify the PAHs, which more recent research has shown to be a group of substances of concern (Malins et al., 1984). The use of "total PCB" does not take into account the effects due to the individual PCB congeners (Boon, 1985; Boon et al., 1985) nor does it adequately represent other organohalogens suich as dioxins or pesticides, which are potentially toxic at concentrations lower than the guideline concentration for total PCB (Fanelli et al., 1980; Helder, 1980; Schwetz et al, 1973).

The available evidence tends to confirm the appropriateness of a number of the ODMP limits. A review of the Part I limits by Swiss et al. (1980), using a background level approach, provided corroboration for the limits imposed by the Act. As well, it served as a basis for the Atlantic Region guideline values for copper, lead and zinc. For example, the study found that virtually all the harbours in the region had sediments containing less than 20 ppb PCB. The team attributed concentrations of less than 50 ppb to atmospheric input, and concentrations over 100 ppb to major anthropogenic inputs. By setting a limit of 100 ppb, Swiss et al. allowed a reasonable safety factor to ensure that only "clean" sediments would be dumped. A shortcoming of the study is that it does not fully address the question of biological impacts.

The more recent work of the Puget Sound Water Quality Authority (Tetra Tech, 1986a), using a biological effects approach, has produced values similar to those in Swiss et al., as shown in Table 6. The values for Part 1 substances, including PCB, mercury and cadmium, are similar in the two studies. The congruence gives more weight to the ODMP level for cadmium and mercury, and the Atlantic Region figure for PCB.

**Table 6 Comparison of Screening Levels**

| | Atlantic Average[1] | Swiss[2] | CEPA[3] | Puget[4] |
|---|---|---|---|---|
| PCB (ppb | 143 (+/- 108) | <100 | -- | 130 |
| Cadmium (ppm) | 0.8 (+/- 0.1) | <0.6 | <0.6 | 0.91 |
| Copper (ppm) | 45 (+/- 6) | -- | -- | 80 |
| Zinc (ppm) | 169 (+/- 27) | -- | -- | 160 |
| Lead (ppm) | 45 (+/-7) | -- | -- | 70 |
| Mercury (ppm) | 0.2 (+/- 0.1) | 0.75 | 0.75 | 0.21 |

1. **Averages for Atlantic Region harbours for 1976-78 taken from ODCA Permits, as reported in Swiss et al., (1980).**
2. **Swiss et al., 1980**
3. **Canadian Environmental Protection Act, 1988.**
4. **State of Washington, Department of Ecology, (PTI, 1988b)**

Also, the Puget sound values are close to the Atlantic Region averages for Part II substances, including copper, lead and zinc, thereby giving some greater credence to the use of these levels as guideline values by the Atlantic Region.

The current scepticism about the appropriateness of the ODMP substances and limits should then be addressed by an in-depth review of the current regulations, with a view to confirming or revising them. As discussed in earlier sections, this review should take advantage of the work that has been done elsewhere to establish control limits based on biological effects.

**Recommendation 3:**

**It is recommended that an in-depth review be conducted of the ODMP substances and limits with a view to confirmation or revision, using a biological effects approach.**

On the basis of available evidence, the regional "working lists" are not substantiated. The working lists exclude from consideration in the characterization of materials some of the substances which are contained in the CEPA regulations. As well, the lists vary from region to region in the way in which they do so. Moreover, the exclusions have been extended to harbours in which there is reason to believe that potentially harmful substances do exist. A rationale can certainly be made on behalf of the proponent that a complete battery of tests is not necessary in harbours where it has been proven that there is low anthropogenic input. However, the data base which now exists is not adequate to justify some of the exclusions which have been made, e.g. PAHs.

Nor is there a scientific substantiation for the use of different control values for the same substance in different regions. PCB can be expected to have adverse impacts at the same level on the Pacific Coast as on the Atlantic. The same can be said for most other substances. The program should move immediately to establish a list of substances and limits that will be applied on a national basis. Section 6.4, contains specific recommendations in this regard.

**Recommendation 4:**

**It is recommended that the program move immediately to establish a list of substances and limits which will be applied consistently on a national basis.**

The current practice, which permits over limit dumping on the basis of the concepts of "rapidly rendered harmless" and "like onto like", has not been supported by monitoring to demonstrate that no adverse impact is occurring (see Section 5.4). One of the few studies undertaken in Canada indicates that over-limit dumping of cadmium at Dalhousie, N. B. open-water site has led to bioaccumulation, that there was a very slow recovery of the benthic community, and that a significant sediment toxicity still existed 12 years after the last disposal operation (OceanChem, 1988; Lee, 1988). Tetra Tech (1986a) suggest an association between sediment contaminant concentrations at levels similar to or lower than CEPA limits and adverse biological effects. As discussed earlier in Section 5.3, the substances of concern are the synthetic organic compounds, such as PCB, PAHs and dioxins. Because of their chemical properties, the concept of rapidly rendered harmless does not apply. For these substances at the very least, the program should set uniform limits and adhere strictly to them.

**Recommendation 5:**

**It is recommended that the ODMP adhere strictly to the limits which are set for the synthetic organic compounds.**

The variability of the substances and lists raises a series of related issues, including enforcement of the regulations, the authority which program managers have to vary the regulations set under the Act, and the scientific expertise they possess to exercise the discretion which they now do. These topics are discussed under other observations in Section 13.

**6.2.5 Implications of Adhering to Scheduled Limits**

For the ODMP to enforce the existing limits in whole or in part would mean a curtailment of dredging activity, or increased cost to the proponent for alternative forms of disposal. Summary data is not available that would allow a ready quantification of the consequences of adhering to the existing limits. It will be necessary for program staff to examine individual permits to identify the nature and level of substances which were contained in materials dumped in the past, to be able to predict what the impact might be. It is important for senior management in Conservation and Protection to have this information in order to know the practical consequences of any decisions about enforcement of the limits.

**Recommendation 6:**

**It is recommended that the ODMP undertake an immediate study of the practical implications of enforcement of the CEPA ocean disposal limits.**

**6.3 Practices in Other LDC Countries**

In comparison to other signatories to the LDC, Canada relies on specific numerical criteria and is more restrictive in their application. The United States has shifted to the use of elaborate bioassay testing, but questions have been raised as to the effectiveness of this testing versus the cost. With the development of the AET values for Puget Sound, a shift back to numerical criteria has begun, but with values derived from scientific evidence of biological effects. The European countries concentrate their regulatory control on the ocean disposal of industrial wastes and sewage sludges, rather than dredged sediments. The criteria values used tend to be higher, especially for the trace metals. For example, it was the European countries that suggested that the LDC adopt a limit for Part II metals of 1000 ppm.

The salient points which emerged from the evaluation team's discussions with scientists in these countries are summarized below.

**United States**

Like Canada, the United States initially used bulk assessment limits based on background levels of contamination (the Jensen criteria). Finding these too restrictive, the US Army Corps of Engineers and the U. S. Environmental Protection Agency developed a complex set of bioassessment procedures for the evaluation of dredged materials. These tests address short-term effects only, and there has been some concern that, as a consequence, dumping has been permitted of substances which could have adverse effects in the long term. Moreover, depending on the type and volume of dumping, the bioassessment can be extremely expensive.

The most recent developments attempt to combine the advantages of both bulk analysis and bioassay, as in the Puget Sound research (Tetra Tech, 1986a). Studies are now being undertaken (C.R. Lee, personal communication) to extend the AET values to other areas and other biota. Ultimately, a range of values applicable to both freshwater and marine sediments within the over-all concept of sediment quality criteria will be developed (C. Zarba, personal communication).

**Europe**

Although most European countries belong to regional conventions to control pollution of the seas (London Dumping Convention, Oslo Convention, Paris Convention), they have only recently begun to plan to move toward a common set of criteria (J. Karau, personal communication). The comparison is made more difficult by the fact that these countries also apply exemptions to their scheduled substances and limits. There is no readily available documented source of information on the European scheduled limits and their application to dredged sediments.

In general, it can be said that the Europeans are primarily concerned about industrial wastes and sewage sludge. With the exception of sediments in heavily contaminated estuaries, e.g. the Rhine River, the European countries do not consider dredged sediments to be a major source of marine pollution.

**6.4 Potential Changes**

This section proposes a number of interim changes which could be made in the short term to ensure national uniformity in the application of the regulations. The section also suggests items for consideration in the recommended in-depth review of the current substances and limits.

**6.4.1 Immediate Changes to Ensure National Consistency**

tThe following changes are proposed as the basis for establishing a list of substances and limits that can be applied immediately in all regions:

1. characterization for organohalogens be expanded from PCB and DDT's to include additional organochlorine

pesticides or compounds in harbours or channels where there is reason to believe that they exist. The list of pesticides could be that used in the Quebec region.

2. the "oil and grease" category be defined as PAHs.

3. the Part I limits now used in the Atlantic region should be used for all regions until a detailed sediment quality criteria program is developed.

4. Part II should be split into two groupings, Group A to include lead, zinc, copper, chromium and possibly arsenic, Group B to include fluoride, cyanide, specific pesticides, vanadium, beryllium, and nickel; the organosilicone compounds should be deleted.

Group A should become a fixed part of the requirements of all Permit applications and the guideline values should, in the interim, approximate the State of Washington screening values. Tests for Group B should only be required where past data or industrial effluents would give "reason to believe" that there could be a contamination problem.

A revised list of Part I and Part II substances, following this general approach would be as shown in Table 7. The list is based on best available information, and clearly cannot be definitive. The list should be submitted to the proposed national committee of experts (see Section 13.1) for consideration, and should be modified as new scientific evidence becomes available.

The value for PCB is the present Atlantic regional guideline, as substantiated by Swiss et al. (1980). It should be reported as congeners, with a total of no more than 100 ppb, rather than in Aroclor equivalents. Reflecting their higher toxicity, the limits for organochlorine pesticides should be set

**at 10 ppb for any one pesticide, using the Quebec list of substances as a guide. The other chloro-compounds, such as dioxins or dibenzofurans, should also have a limit of 10 ppb.**

**Table 7, Proposed Schedule of Limits and Substances for National Application**

| | **Existing** | **Proposed** |
|---|---|---|
| Total PCB (ppb) | 100/1000 | 100 |
| Pesticides (ppb) | -- | <50 for any one |
| Other chlorocompounds * (ppb) | -- | <10 for any one |
| PAH (ppb) | -- | 1000** |
| Mercury (ppm) | 0.75 | 0.75 |
| Cadmium (ppm) | 0.6 | 0.6 |
| Copper (ppm) | -- | 60-100 |
| Lead (ppm) | -- | 50-75 |
| Zinc (ppm) | -- | 150-200 |
| Chromium (ppm) | -- | 60-100 |
| Arsenic (ppm) | -- | 5.25 |

* For example, dioxins, dibenzofurans, chlorophenols

** Sum of 18 priority pollutant PAH; concentrations for the individual 18 should be set following further scientific investigation

These limits are similar to the screening levels set by the State of Washington, Department of Ecology. In the case of the other chloro-compounds, the proposed limit may still be too high, and further research should be undertaken.

The suggested limits for mercury and cadmium are the current ODMP values. An argument can be made for decreasing the level for mercury to 0.3 - 0.5 ppm, based on the Puget Sound findings. The range of values proposed for Part II (Group A) metals reflect average values observed in Atlantic region harbour sediments, and the Puget Sound screening levels. These values are proposed as interim limits only, and should be confirmed by further study.

The categories, parameters and processes in Part III should be amplified to serve as the base for a guidance document for undertaking an environmental assessment and review process. The present listing is essentially an outline, and the lack of expertise on the part of proponents suggests the more direction is required.

**6.4.2 In-Depth Review**

London Dumping Convention Deliberations

Three formal proposals for change to the schedules of substances and limits have been proposed over the past several years:

1. introduction of a more rigorous definition of "oil and grease" to cover petrogenic hydrocarbons. This proposal was accepted by the LDC, and has been incorporated into the CEPA.

2. move lead from Annex II to Annex I, with a limit in the range of 10-50 ppm. This motion, put forward by Canada, has not been approved, and Canada has not yet made the change itself.

3. delete organosilicons from the list of substances. This possibility is now under serious consideration. Canada has made no move to delete the substance from its schedule, but has never made it a requirement for analysis, and therefore has not data to support deletion or retention.

Historically, the LDC deliberations on changes to the schedules of substances have been protracted. If Canada is to amend its lists, it will have to do so on its own initiative.

**The CEPA "List of 50"**

One element of the in-depth review of the substances and limits should be a consideration of the application of the CEPA list of 50 substances to ocean dumping. A number of the priority compounds are already contained in the ocean dumping regulations, and a point that requires clarification is whether or not the other substances also apply to ocean disposal. In any case, a thorough review of the CEPA "50" should take place. As a first step, the program could undertake a limited scope survey to test for the presence of these substances in samples of sediment destined for ocean disposal. If they are present in concentrations that cause concern, further review should be undertaken with a view to establishing regulatory limits.

**A Biological Effects Approach**

In summary, the in-depth review of substances and limits should attempt to establish values based on a biological effects approach. The outcome can be expected to resemble, in type, if not in actual numbers, the apparent effects thresholds and screening levels of the Washington State Department of Ecology. There, research into biological impacts has been used to establish bulk analysis values which, if they are exceeded by a sample of material to be dumped, trigger further bioassay to determine if an adverse effect is likely to result from the dumping. The development of a new set of substances and guidelines for the ODMP will take several years, and should be dealt with on a priority basis, and related to environmental risk (exposure, toxicity and sub-acute lethal effects).

### 6.5 Substances and Limits Under an MEQ Regime

In 1987, Environment Canada adopted a Marine Environmental Quality (MEQ) Management Framework, which is intended to guide the use of Conservation and Protection resources in addressing the marine environment (Environment Canada, 1987). Marine environmental quality is defined as "the condition of a marine environment measured relative to each intended use of that environment." (Wells and Cote, 1988). It is usually expressed in quantitative terms and is measured relative to objectives which take into account social, economic and other factors. The MEQ approach differs from the current practice in that control standards would be derived from sediment quality objectives rather than background levels. A pollution control strategy for marine pollution from land-based sources taking environmental quality objectives as a starting point is outlined in the UNEP Montreal Guidelines. The CEPA provides the authority for Environment Canada to establish environmental quality objectives. Even before the proclamation of the Act, the Department had established a Marine Environmental Quality Advisory Group within Conservation and Protection. Recently, a sub-committee of the Inter-Departmental Committee on Oceans has been established to develop a national framework and action plan for the conservation and protection of marine environmental quality in Canada. The MEQ program is in the early stages of development, and it is too early yet to know the precise implications for the ODMP. In concept, it can be expected that a MEQ approach would broaden the requirement for scientific support for the program. There would be increased scientific activity, in the physical, chemical, microbiological and biological disciplines. It is not possible at this time to estimate the resource requirement to develop and implement a MEQ approach for the ODMP, but it is expected to be more costly than the existing emissions control approach.

The research in Puget Sound provides an example of how scientific research can assist to develop ocean disposal limits within an MEQ framework. The Puget Sound Dredged Disposal Analysis (PSDDA) takes as its starting point a determination of the level of a given substance in the marine environment which will have an adverse impact (Tetra Tech, 1986). Called an apparent effects threshold, the level is expressed as a range of values, because the impact will vary depending on the nature of the sediment and the biota. For example, the Puget Sound values for PCB range from 130 to 2500 ppb.

A step further would be to establish a sediment quality objective which defines a maximum acceptable level of contamination, based on the apparent effects threshold, and in relation to the intended use of the marine environment in question. If the objective were to keep PCB levels below a value that would have an apparent effect on marine biota, the minimum AET would become the sediment quality objective. Given that dumped materials contribute directly to the level of contamination in a sediment, the sediment quality objective might also be adopted as the limit for the dumped substance.

In this example, given the bioavailability and the persistence of PCB, the lowest apparent effects threshold level of 130 ppb, would be a likely limit for open water dumping of dredged materials. In fact, the State of Washington Department of Ecology has taken these values to establish a screening level at 10% of the highest apparent effects threshold (but not greater than the lowest effects threshold), as a basis for identifying concentrations of substances which are a potential concern. If a contaminant exceeds the screening values, bio-assay and other tests are performed to determine whether or not an adverse impact from the substance will occur in a given physical and chemical regime. If the contaminant exceeds the maximum AET, dumping is prohibited.

The MEQ approach is seen by Environment Canada as a framework for identifying legislative and administrative initiatives which will help Canada to honour its commitments to international conventions and agreements on the marine environment such as the LDC, UNCLOS III, and the UNEP Montreal Guidelines. There are certainly some important links that can be established between the Montreal Guidelines and the ODMP, which is derived from the London Dumping Convention. The Montreal Guidelines establish principles for the protection of the marine environment against pollution from all land-based sources, and outlines a pollution control strategy based on marine quality standards. The LDC contains a regulatory mechanism which would serve as a good model for the implementation of the Montreal Guidelines. Seen from this perspective, developments within the ODMP toward a MEQ regime could assist the federal government in its initiative to control pollution from other land-based sources. If the ODMP were to serve as a model pollution control program, the need to maintain a sound scientific basis for the regulatory process would become even greater.

The ODMP can make some limited progress toward an MEQ approach to substances and limits with its own resources. The program should also ensure that sediment quality objectives are a priority item for consideration under the MEQ framework and action plan.

**Recommendation 7:**

**It is recommended that the ODMP adopt a marine environmental quality objectives approach to control substances and limits.**

It should be noted that a substantial source of information and expertise also exists within the Great Lakes research community. Source documents in journals, DOE publications and reports of the International Joint Commission have much potential for application to the ODMP activities and concerns. Great Lakes information should be used in addition to marine information sources outside Canada.

# 7 Protocols and Test Methods for Material Characterization

## 7.1 Introduction

A proponent is presently required to furnish a characterization of the material as a means of determining whether or not the material, once disposed, will be harmful to the marine environment. To provide such a characterization, the proponent undertakes to collect and analyze the material, with the results of the analyses forming part of the permit application. The collection, analyses and data reporting are undertaken using a series of test methods and protocols. Protocols are defined in this study as broad guidelines for the conduct of data collection and analysis. Test methods are defined as specific techniques that yield a quantitative value for a parameter or a process.

The purpose of using established protocols and methods is to ensure that:

1. the information supplied is accurate and reliable;
2. the information requested and the techniques to collect it are consistent amongst all applications;
3. the information provides a complete characterization of the material to be disposed;
4. all actions undertaken by Environment Canada are consistent and substantiated.

These purposes serve for both the characterization of the material to be dumped and the disposal site.

## 7.2 Current Protocols and Test Methods

### 7.2.1 Sampling

The characterization of the material begins with the collection of an adequate number and type of samples to ensure that the material is totally characterized. Walton (1978), which is the standard ODMP guide, provides a reasonable description of methods of collection, but does not provide direction on the number of samples or how to locate them. As a consequence, the practice varies within and between regions, and there can be no certainty that the samples which are taken provide an accurate characterization of the materials.

The Atlantic region requires the proponent to undertake the program design and sample collection. The Region most often will request that the proponent first meet with staff to review the plans and specifications. There has been a considerable variance in the number of samples collected for projects of similar size within the region. Given that most dredging is undertaken by PWC, the variance is due in part to the fact that there are four PWC district offices and a regional office on the Atlantic coast. This results in at least five different approaches to the design of a program and the number of samples per program. Typically the samples are collected either as grab samples by PWC staff (about half the time) or as core samples by consultants following a PWC design.

The Quebec and Western and Northern Regions are similar to the Atlantic region in that the proponents are responsible in most cases for collection of their own samples.

By contrast, in the Pacific Region, most of the programs are designed by Environment Canada staff, which will at times also undertake the collection of the samples, with no compensation from the proponents. This is advantageous in that staff have a clear understanding of the site and the material. The drawback is the drain on resources, the need for specialized equipment, and the potential conflict which results from involvement in the sample program design and collection.

Many proponents, in particular PWC in the Atlantic region, have voiced the complaint that the sampling requirements are too arbitrary. In response to these complaints, Environment Canada developed an interim sediment sampling scheme (OceanChem, 1985). The guidelines were intended to provide direction for the sampling of contaminated sediments, and therefore required a larger number of samples than had been the case. For a variety of reasons, the guidelines remain as a draft internal document. The requirements have been reduced to a table of numbers, without explanatory notes, which specify the number of samples to be taken for a given unit of material. Quebec Region is attempting to implement the full guideline, while Pacific Region does not use it at all. Proponents have reacted negatively to the requirement for additional samples.

**Recommendation 8:**

**It is recommended that the ODMP develop and implement a sampling protocol for dredged sediments.**

### 7.2.2 Test Methods

Environment Canada presently requires proponents and their contractors to use Walton (1978) as the guide for test methods. This document was developed in 1976/77, and while it represented the state-of-the-art at that time, it has been overtaken by scientific and technological developments in the past decade. The contractors who perform the analysis on behalf of the proponents by and large ensure that the procedures for the tests that are performed are up to date. The issue is that other, better tests have been developed that could be used to yield a more accurate characterization of materials.

Experience has been gained in sediment analysis in other jurisdictions that could be applied in the ODMP. Some references are:

1. Procedures for Handling and Chemical Analysis of Sediment and Water Samples. (Plumb, 1981).
2. Sampling and Analysis in the Arctic Marine Benthic Environment. (Arctic Laboratories Ltd., 1985).
3. Puget Sound Testing Protocols. (Tetra Tech Inc., 1986b)

There are also methods which have been developed by the Marine Analytical Chemistry and Standards Program, National Research Council of Canada (MACSP) which are published in the primary literature, but not gathered into one reference manual.

The fact that the guidelines are out of date has led the consulting laboratories to adopt their own methodologies. The consequence has been an improvement in the sensitivity of the tests, but also a greater inconsistency between and within regions.

There are two ways of addressing the problem - either to enforce a fixed protocol to which all laboratories must adhere, or to set guidelines for acceptable test results, which laboratories may then implement in different ways. The fixed protocol has a number of benefits, which include:

1. the methodologies are consistent throughout the data set,

2. staff reviewing data can have greater confidence in the test, and focus on the results rather than the methodologies, and

3. the proponents have a clear set of requirements to meet.

The disadvantage of this approach is the need to have a group of experts prepare the set of methodologies and ensure that they are kept up to date.

The guideline approach would see a group of experts establish criteria for data review covering such factors as quality assurance, quality control and the minimum detection limits acceptable for the particular determination. It has the drawback of requiring more detailed quality assurance reporting and a strong dependence on the use of standard reference materials. Such materials are available for the trace metals, total PCB and 18 PAH's, but the extensive effort in preparing and certifying such materials makes it difficult to keep up with developments in the field.

A review of the protocols and test methods established for the Puget Sound (Tetra Tech, 1986b), which provide a fixed protocol for testing, could form the basis for the development of similar protocols for the ODMP.

**Recommendation 9:**

**It is recommended that a standard protocol for chemical testing be established, including detailed quality assurance procedures, for use by all laboratories undertaking analysis in support of the ODMP.**

### 7.2.3 Disposal Site Selection

The principal criteria for the selection of disposal sites, at present, is to minimize the impact on fishing activities or other uses of an area. In general, there is also an attempt to select a site which is hydraulically quiescent and within a reasonable transit distance of the source of material. There are no fixed or defined protocols for disposal site selection except those developed and implemented for the identification of disposal of "inert" wastes in the Western and Northern Region.

A further problem with disposal site selection is the frequent need to re-establish a site for each dumping permit. In practice, the Pacific Region has established a limited number of deep water sites, thereby attempting to reduce the likelihood of re- suspension due to physical processes. In the Atlantic region, many of the disposal sites are re-used with a fair degree of frequency and have become de facto fixed sites. In the period 1982-85, there was a policy to establish a set of common-user disposal sites. The philosophy was to limit the impact to one site, and facilitate pre-use and post-use monitoring efforts. This was successful for Strait of Canso, Sydney, and the Acadian Peninsula. It is recommended that fixed disposal sites be established for all dredging projects.

In order to properly establish such sites, studies should be undertaken to establish baseline conditions. Such characterization would provide a benchmark against which subsequent monitoring could be performed. Protocols have been developed in the U.S. (Pequegnat et al., 1981; USACE, 1984; SAIC, 1986) for establishing and monitoring disposal sites. It is recommended that Environment Canada prepare similar protocols for site selection in the ODMP.

### 7.2.4 Standards for Analytical Reliability

A recurrent problem for regulatory agencies is to ensure the quality and accuracy of the results of chemical analysis. In the ODMP, the issue arises most frequently with respect to minimum detection limits and replication of testing.

The Pacific region requires that all permit applications include results for five replicate sub-samples on 10% of the samples for trace metals, with a minimum of one replicate. The Region also requests the concurrent analysis of two standard reference materials. The Atlantic region requires that all permit applications include results for replicate samples of 10% of the samples analyzed, and concurrent analyses of standard reference materials. In practice, proponents often do not follow these specifications except for large projects, or where the data has been criticized or rejected. In many cases, the samples are submitted to the laboratories in small quantities (typically 3-5 samples), and costs for replicate analyses or inclusion of reference materials would be significant.

It is recommended that a standard policy for the number of replicates and use of standard reference materials be established and enforced. The National Research Council of Canada has a large selection of reference materials now available for metals, PCB and PAHs. The advisory committee to the Marine Analytical Chemistry and Standards Program has strongly encouraged the development of more materials and the testing of new methodologies. However, there are no staff from the ODMP on that advisory committee. It is recommended that one staff member from the national office be appointed to the advisory committee to make NRC aware of the program needs.

## 7.3 Recent Technological Developments

Considerable development has taken place in three areas since the inception of the ODMP in 1976:

1. methods of determination of the parameters of interest,
2. ability to determine, on a routine basis, additional parameters, and
3. use of biotesting.

By and large these developments have not been incorporated into the ODMP procedures.

The present method of analysis for the metals is total dissolution of the sample using hydrofluoric and perchloric acids, with determination by atomic absorption spectroscopy. Using this method, all the metal in the sample is determined and the results can be confirmed by other "total" methods of analysis (e.g., spark source mass spectrometry). This approach provides a straight-forward and readily reproducible analysis, but assumes that all the metal is equally bioavailable. Studies have shown (e.g., Neff et al., 1978) that there is no relationship between the concentration of contaminants in biota and the "total" metal concentration in the sediment. To achieve a better definition of bioavailable metal, a variety of methods have been suggested (see discussion in Bourg, 1988). However, the ability to model the mechanisms by which sediment geochemistry affects and controls metal bioavailability is still poorly developed (Luoma, 1988). Until this problem can be resolved, it is recommended that the "total" method of analysis be used to ensure reproducibility and comparability of data.

Major technological changes have occurred in the determination of trace synthetic organic substances in the last ten years. The improvements have not been reflected in the program or in the requirements for material characterization by the proponents. The program has continued to require that proponents use the methods outlined in Walton (1978). One result has been the determination of PCB as total Aroclor rather than as individual congener. The latter method permits a better definition of the concentration of a particular PCB in terms of its known toxicity. The ability to identify and determine the concentration of synthetic organic compounds to extremely low concentrations (less than 1 ppb) is now possible on a routine basis. The improved tests have been used on the Great Lakes to monitor a wide variety of synthetic organic compounds in lake sediments (International Joint Commission, 1986).

One of the arguments put forward in the ODMP against the introduction of new techniques is that they are not "routine", and, as well, require extremely sophisticated instrumentation and highly trained staff, available only in select research facilities or universities. Yet, as has occurred throughout the development of environmental regulation, there is a logical progression of such capability from the research setting to the routine laboratory. The advances have been driven by the need for proponents to respond within limited time frames to meet regulatory criteria. However, because the ODMP has not imposed such demands, there has been no response by proponents to do other than meet the program's requirements.

The ability to define or characterize a material in terms of its chemical composition is feasible. The issue to be resolved is how do such concentrations relate to an adverse biological impact. The question has led to the development of various bioassay techniques, ranging from laboratory tests (96hr LC50 for absolute toxicity and longer term bioaccumulation testing) to a variety of laboratory/field tests, e.g., in situ bioaccumulation tests or analysis of field collected biota (e.g., Alf and Munawar, 1988). The use of bioassessment has the obvious advantage that it measures the impact on the biota, but also has several drawbacks. These include:

1. comparability of field and laboratory conditions,
2. representativeness of the test species of the impact which may occur at higher levels in the food chain,
3. the time delays that are required for the effect to occur, and
4. the variability of response of the test species. Program staff have expressed the concern that the use of bioassessment would simply replace chemical data, which says little about biological impact, with bioassay data which are variable and imprecise. As noted by Ahlf and Munawar (1988), more detailed testing and test development is required. The work undertaken in Puget Sound (e.g., PTI, 1988a) attempts to link biomonitoring and chemical analysis to derive sediment quality criteria. With these criteria in place, characterization by chemical means can be used to assess the adverse effects of sediments proposed for disposal, thus combining the stronger features of both approaches.

# 8 Information Requirements for Application and Compliance

## 8.1 Introduction

In order to evaluate the adequacy and appropriateness of the information requirements imposed upon the proponents in the ODMP, a comparison was made between the information needs for decision making under the CEPA, the application form contained in the CEPA regulations and the actual practice in the field, as shown in Table 8. The analysis examines the extent to which the application form satisfies the formal requirements of the Act, and the way in which the application form is completed as part of the permit application process. It also identifies gaps in the information requirement in the Act, the applications forms, and in practice. Finally, the analysis considers the consistency and fairness of the way in which the information requirement is imposed upon proponents.

## 8.2 The Act and the Regulations

The CEPA sets out conditions under which a permit for ocean dumping may be granted, the factors which must be taken into account in making a decision to grant a permit, and the terms and conditions which may be included in a permit. The information requirements are contained in application forms specified in the regulations to the Act, as follows:

Form 1: Substances for Dumping

Form 2: Dredged Materials

Form 3: Incineration or Thermal Degradation

Form 4: Ship, Aircraft or Other Man Made Structure

Form 5: Disposal on Ice.

**Table 8 ODMP Information Requirement**

| CEPA | Application Form | Practice |
|---|---|---|
| **71 (3) Conditions for Granting Permits** | | |
| substance rapidly rendered harmless | Item 28 | see factors below |
| does not exceed regualtions | Item 28 | varies between regions |
| does not render marine organisms inedible or unpalatable | Item 29 (c) | see factors below |
| does not endanger human health | 30 | not routinely compled |
| **72(1) Factors in Part III**<br>**1. Characteristics of Substances** | | |
| total amount and average composition of substances | Item 9, 10 | varies beween regions |
| form, e.g., solid, sludge, liquid | Item 11 | yes |
| properties: physical, chemical, biochemical, and biological | Item 28, scheduled substanced only | varies between regions |
| toxicity | Item 29 (d) | not routinely completed |
| persistance | Item 28 (b) | not routinely completed |
| accumulation and biotransformation | Item 29 (a), (b) | not routinely completed |
| changes and interaction in the aquatic environment | Item 28 (c) | not routinely completed |
| tainting and other changes in marketable resources | Item 29 (c) | not routinely completed |

**Table 8 Cont'd**

| CEPA | Application Form | Practice |
|---|---|---|
| **Characteristics of Dumpsite and Method of Deposit** | | |
| location | Item 24 | Yes |
| rate of disposal | Item 24 | Yes |
| method of containment | Item 23 | Yes |
| initial dilution | NIL | varies between regions |
| dispersal characteristics | NIL | varies between regions |
| water characteristics | Item 25, depth only | varies between regions |
| bottom characteristics | NIL | varies between regions |
| effect of other dumping | NIL | varies between regions |
| existence of adequate scientific basis for assessing impact | NIL | varies between regions |
| **3. General Considerations** | | |
| possible effects on amenities, e.g., turbidity, odour, discolouration | see above | see above |
| possible effects on marine life | see above | see above |
| possible efffects on other uses in the sea | NIL | varies between regions |
| practical availability of alternative methods of disposal or treatment | NIL | not routinely completed |

**Table 8 Cont'd**

| CEPA | Application Form | Practice |
| --- | --- | --- |
| **72(2) Terms of Permit** | | |
| nature and quantity of substance<br>method, frequency, date of disposal<br>manner of unloading and stowing<br>site of dumping<br>route to be followed by ship | Items 1-26 | Yes |
| **Compliance Reporting** | | |
| not specific reference | location and quantity dumped | Yes |

The application forms in the CEPA regulations are identical to those found in the original ODCA, that is, they have not been amended since 1976. The information demanded by each form is similar in nature, and for purposes of this analysis, the dredged material form was used, because of the predominance of the dredging activity in the ODMP.

Items 1 to 26 in the application form provide the information necessary to specify the conditions of the permit, while the remaining items, 27 to 30 address the conditions and factors. In general terms, the application form is intended for the dumping of liquids, and is not well suited to the characterization of solids. The form does not make specific provision for the consideration of alternative methods of disposal, and the information related to characterization of the disposal site is limited. From the proponents' point of view, there should be provision in the form for the financial and economic considerations related to the dumping application.

Compliance reporting is not directly mentioned in the Act. The requirement to report the volume and location of dumping upon completion is normally imposed as part of the conditions of a permit.

**8.3 Application of Information Requirements**

In practice, certain items of information are not routinely required to be completed, and there is variability in the way in which the requirement is applied in the regions. This situation is a direct consequence of the variable application of substances and limits in the absence of guidelines and protocols, as discussed in earlier in the report. The section of the form which is least well applied is that having to do with the characterization of the material.

Items 28(b) and (c), and all of item 29, which relate to chemical stability, biochemical behaviour, and bioaccumulation are not routinely answered. Proponents normally append chemical reports in response to item 28(a) dealing with characterization of materials. The information contained in the chemical reports is determined by the requirement for characterization in each region. In the Pacific Region, these requirements are transmitted to the proponent in a form letter, and in the Atlantic Region, a standard requirement has been drafted for Public Works Canada. Proponents do not have a documented source which explains the nature of the information requirements. The problems for the proponent and Environment Canada which result from this situation have been discussed above.

As noted, protocols for dump-site selection and characterization do not exist, and there is a gap in the treatment of this subject in the application form. The result is variability in the requirement from permit to permit, and for the most part, sketchy information about disposal sites. Moreover, consideration of alternative disposal methods where substances are over limit, does not routinely take place, as required under Schedule III, Part III.

The interviews did not reveal a great deal of difference in the application of information requirements between classes of proponents within a region, although as noted earlier, fish wastes do not require testing. A proponent such as PWC is, however, aware of the different approaches on the east and west coasts, and has begun to question the justification for the difference. Concerns are being raised about the new guidelines for the number of samples that must be taken to characterize dredged material, even though it is acknowledged that the previous methodology was unreliable. The greatest source of frustration for the proponent is the additional information requests which may follow the original application to dump. These arise when the proponent attempts to justify over-limit dumping. In such cases the proponent is asked to undertake additional characterization of materials and the disposal site, to satisfy questions 28(b) and (c), and 29.

Proponents have also questioned the technical qualifications of RODAC staff to evaluate the information which is required in the application form, from a scientific, dredging technology and socio-economic point of view. This issue is discussed further in Section 13, Other Observations.

In summary, while there are shortcomings in the application forms, the more serious issue is the type of information which regions routinely require to be provided with the application. The gaps and the inconsistencies are largely a result of the absence of up-to-date guidelines and protocols, and it is in this area where developments must take place before there will be much benefit from a revision to the application forms.

**Recommendation 10:**

**It is recommended that, in conjunction with further development of program guidelines and protocols, the ODMP review and revise the permit application forms.**

# 9 Research

## 9.1 Authority and Management

The Ocean Dumping Control Act Research Fund operates under the authority of the Fisheries Act. The current budget of $140,000 is contained in the Department of Fisheries and Oceans A-base. Decisions about the allocation of resources are made at the annual the ODMP National Managers meeting. An annual call letter is issued to interested parties, stating the national and regional priorities for the coming year. Concept proposals are reviewed in the autumn of each year, first by the regional RODACs, and then at the National Managers meeting. Normally the number of proposals is far in excess of the funds available. The sponsors of the concept proposals which have been approved in principle are asked to submit detailed proposals in early winter, and a final decision is made at the National Manager's meeting in March. The concern was expressed by a number of respondents to the evaluation that this amount of administrative process is excessive for so small an amount of research funds.

## 9.2 Number and Value of Projects

The size of the research fund has diminished from an initial amount of $300,000 in the mid-1970's to $140,000 in 1988/89. With the effect of inflation taken into account, the resources available for ocean dumping research are roughly one quarter of the original value. In the early years of the program, blocks of money were dedicated to each of the regions for allocation by the RODACs. Although there has been a national review of proposals since 1980/81, funds tend still to be allocated to the regions on a pro rata basis.

The number and value of projects, by region for the years 1976/77 to 1988/89 are shown in Table 9. A total of 172 projects were funded during this period, with an average value of $12,340.

**Table 9, ODCARF Expenditures by Year by Region**

| Year | Atlantic | | Pacific | | Quebec | | W & N | | NCC | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $ | # | $ | # | $ | # | $ | # | $ | # | $ | # |
| 1976/77 | 95.1 | 9 | 116.8 | 15 | | | | | | | 211.9 | 24 |
| 1977/78 | 58.0 | 6 | 82.4 | 6 | | | | | | | 140.4 | 12 |
| 1978/79 | 87.3 | 7 | 82.0 | 9 | | | | | | | 169.3 | 16 |
| 1979/80 | 78.0 | 5 | 76.1 | 5 | 14.0 | 1 | | | | | 168.1 | 11 |
| 1980/81 | 83.0 | 9 | 87.5 | 6 | 26.0 | 2 | 15.0 | 1 | | | 211.5 | 18 |
| 1981/82 | 74.0 | 6 | 64.0 | 5 | 25.0 | 2 | | | | | 163.0 | 13 |
| 1982/83 | 64.0 | 4 | 61.0 | 4 | 25.0 | 2 | 30.0 | 1 | | | 180.0 | 11 |
| 1983/84 | 62.0 | 6 | 49.0 | 4 | 20.0 | 2 | 37.0 | 2 | | | 168.0 | 14 |
| 1984/85 | 50.0 | 4 | 53.5 | 3 | 36.5 | 5 | 30.0 | 2 | 10.0 | 1 | 180.0 | 15 |
| 1985/86 | 61.2 | 5 | 62.0 | 5 | 4.3 | 1 | 24.0 | 1 | 0.0 | 2 | 151.5 | 14 |
| 1986/87 | 55.7 | 5 | 41.0 | 3 | 15.0 | 1 | | | 15.0 | 1 | 126.7 | 10 |
| 1987/88 | 73.0 | 4 | 70.0 | 3 | | | | | 7.0 | 1 | 150.0 | 8 |
| 1988/89 | 66.0 | 4 | | | | | 10.0 | | 58.0 | 6 | 102.0 | 6 |
| **Total** | **907.3** | **74** | **845.3** | **68** | **165.8** | **16** | **146.0** | **8** | | | **2122.4** | **172** |

The distribution of projects by size is shown in Table 10.

**Table 10, Distribution of ODCARF Projects by Size**

| Value ($000) | Number | % |
|---|---|---|
| 30 - 40,000 | 6 | 3.0 |
| 20 - 30,000 | 21 | 12.0 |
| 10 - 20,000 | 57 | 33.0 |
| 0 - 10,000 | 89 | 52.0 |
| **Total** | **172** | **100.0** |

A small number of projects were carried over from one year to the next, and the number of large projects is slightly higher than is shown above. A repeated criticism of the research fund is that, because of the way in which funds are parcelled out in small amounts through the regions, it has become difficult to achieve significant results from any one project. DFO has in the recent past suggested that what remains of the program be absorbed within the Universities Subvention Fund. DOE has opposed this approach on the grounds that the resulting research would not be sufficiently targeted to meet the requirements of ocean dumping. The different perceptions about the use that should be made of the research fund stem in part from the fact that the resources available are clearly not adequate to meet the objectives of the fund.

### 9.3 Objectives and Priorities

The stated purpose of the research program is to provide scientific information related to:

1. specific ocean dumping problems associated with permit issuance,

2. development, modification or appraisal of dumping policies, regulations and guidelines, and

3. possible long-term effects of ocean dumping.

The national priorities expressed for the program in the 1988/89 call letter are as follows:

1. biotesting,
2. physical impact,
3. disposal site assessment,
4. QA/QC follow-up,
5. sampling guidelines, and
6. sample processing.

Each of the RODACs has been free to set priorities for its own region within the national framework.

The priorities of the research program, as expressed by the allocation of funds to each of the objectives since 1976/77 are shown in Table 11.

**Table 11, Allocation of ODCARF Resources, by ojective ($000)**

| | # | % | $ | % |
|---|---|---|---|---|
| I - Operations | 67 | 39.0 | 739.0 | 35.0 |
| II - Policy and guidelines | 26 | 15.0 | 251.4 | 12.0 |
| III- Effects | 64 | 37.0 | 1026.0 | 48.0 |
| IV - Administration | 10 | 6.0 | 60.2 | 3.0 |
| V - Other | 5 | 3.0 | 45.9 | 2.0 |
| **Total** | **172** | **100.0** | **2122.5** | **100.0** |

The number of projects in the operational and effects categories has been almost identical, although the amount of money spent on effects research has been greater. During the past five years the importance of operational research has increased, moving to a share of 43% of projects and 44% of expenditures in the past five years compared to 36% of projects and 30% of expenditures over the previous eight years. The shift has been the consequence of a conscious policy on the part of program managers, and results at least in part from the inadequacy of operating funds to meet the surveillance and monitoring requirements of the program (See Section 10.0 on surveillance and monitoring.) The priority assigned to operational research is expressed in the 1987/88 call letter which proposed the following allocation of resources between the objectives:

Specific problems related to permit issuance 50%

Development of policies, regulations and guideline 35%

Basic scientific information related to the transport 15%
fate and effects of material dumped at sea

It was stated in the call letter that much of the basic scientific information needed in support of ocean dumping is marine science information, and that the small size of the research fund precluded the funding of large basic research projects. A number of the scientific authorities associated with the program reiterated the point that, for the most part because of the small size of the projects, it has not been possible to relate the findings from much of the effects research that has been funded to the practical problems of ocean dumping.

The policy and procedures category is the objective which has received the least attention over the thirteen years of the research fund, accounting for only 15% of projects and 25% of expenditures. As discussed in the previous sections, all aspects of policies and procedures require additional work. It is the view of the evaluation team that, given the limited resources available, the program should devote the research fund to the development of policies, regulations and guidelines. Now that the ocean dumping activity has been included in the Canadian Environmental Protection Act, it is even more important that there be a sound scientific basis for the regulations.

**Recommendation 11:**

**It is recommended that the ODMP devote the resources in the Research Fund to the development of regulations, policies and guidelines for the program.**

The type of initiatives and the rough costs associated with this recommendation are shown in Table 12. The tasks are identified as having a first or second order priority.

**Table 12, Priorities and Costs for Ocean Dumping Research**

| | | ($000) |
|---|---|---|
| #1 | - national limits for regulated substances | $500.0 |
| #1 | - guidelines and protocols for sampling and handling of samples for charactgerization of materials and disposal sites | 200.0 |
| #1 | - adequate data base for the program | 100.0 |
| #1 | - guidelines and protocols for monitoring | 100.0 |
| #2 | - guidelines and protocols for testing | 200.0 |
| #2 | - guidelines and protocols for surveillance | 100.0 |
| | **Total** | **$1200.0** |

The size of the undertaking will make it necessary to phase the implementation over a period of years.

Actions which should be taken to direct resources in a way which will yield a greater benefit include:

1. identify a small number of key priorities, on the advice of a national committee of experts (see Section 10.1),
2. develop a multi-year plan for the fund,
3. allocate funds on a national basis, with a regional focus as necessary to address the priorities of the fund,
4. fund a smaller number of larger projects, and
5. target the requests for proposal more directly to the priorities of the fund

This approach will enable the program to obtain a greater return on its investment, even if no additional funds are made available.

**9.4 Executing Agent**

The majority of projects, 75% of the total number and 76% of total expenditures, has been delivered by the private sector. The balance of projects is delivered by government agencies, primarily the DFO research institutes. The high percentage of private sector participation has been consistent since the inception of the program. The firms which have provided the service are relatively small in size, and have benefited from the funding. It would appear that the program has met the requirements for contracting-out in the Ministry of State for Science and Technology policy which requires that wherever feasible, federal science and technology activities should be performed in the private sector and universities. (MOSST, 1987)

**9.5 Dissemination of Research Findings**

The findings of the research funded under the ODCARF are not generally very widely disseminated. While there is a requirement for the production of a final report, few copies are printed, and circulation is limited. Up to 1979, a number of the ODCARF studies were published in a report series "Ocean Dumping Reports", and some of the later studies conducted by DFO scientists continue to be appear in DFO publications. As well, a limited number of studies have appeared in the scientific literature or have been presented at international conferences.

The main channel for communication of research findings has been workshops sponsored by Environment Canada. Until 1988, the Pacific and Northern and Western regions held yearly meetings in British Columbia. The Atlantic region has held meetings approximately every two years. Typically, abstracts or copies of the presentations have been incorporated into proceedings documents. These are then distributed within the region and through the National Managers' Meeting to staff within other regions.

Proponents are generally unaware that the ODCARF exists. Many of those interviewed who are familiar with the findings feel that the results are too "basic", with little or no practical application (this in spite of the fact that many of the studies are operational in subject matter). Because of the perceived shortcomings of ODCARF research, there was little expressed need for wider dissemination of the findings.

Following are suggestions for improved dissemination of research results:

1. all reports should include a summary of findings and conclusions,

2. the summaries should be compiled by headquarters annually (including compilation of back data and reports) and circulated widely to a mailing list of interested persons, and to libraries,

3. funds should be made available to print a larger number of study reports for distribution on request, and

4. headquarters should periodically review the results of the research and produce an overview report which relates the findings to the research objectives.

These measures would increase the usefulness of the studies, and improve the prospects for scientific review.

# 10 Surveillance and Monitoring

## 10.1 Introduction

Monitoring can be defined as the measurement of a pollutant or its effects on either man or components of the marine resources for the purposes of assessing and controlling exposure to that pollutant (UNEP, 1985). Monitoring is necessary to determine what type of control measures are necessary, and to evaluate their effectiveness.

For the purposes of this study, a distinction has been made between compliance inspection, surveillance, and monitoring. Inspection consists of those tasks undertaken to ensure that the proponent adheres to the terms of the permit, for example, disposal at the designated location. Inspection is a regulatory rather than scientific activity, and is discussed in Section 10.5, under other observations. Surveillance is intended to determine the immediate impacts created by the disposal, in order that mitigative measures can be taken before a harmful effect has occurred. Also known as real-time monitoring, surveillance is discussed further in Section 11.0.

Monitoring consists of those activities which are undertaken to prove or disprove the hypotheses and predictions which form the basis for the approval of a permit. Monitoring requires a baseline against which to measure change, and can occur at any time after disposal is complete. Long-term monitoring and research differ only in the way in the information is used, that is, monitoring would examine the impact of dumping at a particular site, while research might take the monitoring results from a number of sites to determine an appropriate control limit for a substance.

Surveillance and monitoring for fate and effects include physical, chemical and biological components. The physical component includes turbidity and suspended solids within the water column, deposition on the bottom, and stability of deposited materials; the chemical component includes changes in water column and sediment geochemistry, toxicity, bio-accumulation, tainting and introduction of various sub-lethal effects; the biological component includes loss of total biomass, loss of community diversity, replacement of commercially harvested resource with non-economic species, attraction of undesirable or non-resource species and intervention in the food chain.

Frustration with the ineffectiveness of most monitoring programs can be related to (Fredette et al., 1986):

1. poor experimental approach (statement of objectives, sampling designs).
2. inability to relate observed effects to generalizations of significance concerning ecosystem structure and/or function,
3. failure to assess the spatial scale of effects, and
4. inability to distinguish anthropogenic impact from background variation.

Various methods for developing and implementing frameworks for effective monitoring have been developed (e.g., Fredette et al., 1986; Segar et al., 1986; Krawetz et al., 1987). The major emphasis in any program is the need to develop objectives and design which will answer the questions being posed (i.e, what are the adverse effects of the disposal operation), recognizing the constraints imposed by our present knowledge of sampling and analysis.

## 10.2 Current Surveillance and Monitoring Activities

### 10.2.1 Inspection

See Section 13.5.

### 10.2.2 Surveillance

See Section 11.0.

### 10.2.3 Monitoring

Monitoring is undertaken by Environment Canada, using resources from its A-base or from the ODCARF. Monitoring of the approximately 700 disposal sites occurs at the rate of roughly two sites per coast per year. As discussed in Section 10.4, the number of sites that can be considered "hot" in the sense that they are used for the disposal of significant amounts of potentially harmful substances is approximately 50. Even in comparison to this smaller number, the current monitoring level is not adequate to determine the effects of dumping under the CEPA. The situation is exacerbated by the small amount of disposal site characterization which occurs prior to disposal. Given that over limit dumping is permitted on the grounds that the substance in question is rapidly rendered harmless, adequate monitoring to determine that this effect has been achieved is particularly important.

The primary orientation of the monitoring that has taken place has been biological, that is, recovery of the benthic community, out of a concern for the impact of dumping on the fishery. Little work has been done on chemical contamination that would be useful in evaluating the appropriateness of the regulatory limits.

There are no guidelines or protocols within the ODMP which specify the hypotheses that are to be tested by monitoring, the methodology that is to be used, or the reports that are to be produced.

**Recommendation 12:**

**It is recommended that ODMP develop a policy, guidelines and procedures for monitoring ocean disposal.**

A recommendation on a minimum monitoring program is found in Section 10.4.

### 10.3 Dissemination of Monitoring Information

Monitoring information is not widely distributed by the ODMP. Monitoring reports which are funded under the auspices of the ODCARF may or may not be circulated. Monitoring reports which are produced with operating funds may or may not appear at a later date in the Environment Canada Surveillance Series. Reports prepared in the regions are not always forwarded to headquarters. In most cases, only a small number of reports are submitted to the regulatory agency, and they have only a limited distribution. Some of the monitoring activity is reported at workshops or conferences on dredging and dredged material disposal, but there is no mechanism by which the information can be widely distributed to the government agencies and proponents which would benefit from the results.

Canada does not provide monitoring information to the LDC, as required by the Convention. While it does submit annual data on the number of permits, and the type and volume of dumping to the LDC, it does not meet the commitment to submit monitoring reports as they become available. In this respect, Canada is little different from many other signatories to the Convention.

Following are some suggestions as to how the ODMP could improve the dissemination of monitoring results:

1. Every monitoring report should include a summary, which would be distributed on a yearly basis to all interested parties within a region;

2. All monitoring reports should be submitted to headquarters,which would maintain a central library.

3. Headquarters should consolidate the reports, identify the key findings related to hypotheses on adverse effects, and issue a yearly summary document to all interested parties.

4. The summary document could also be used to meet Canada's reporting requirements under the LDC.

Systematic compilation and dissemination of monitoring results would improve the quality of subsequent monitoring activity, contribute to the development of guidelines and protocols, and add to the base of knowledge necessary to evaluate the appropriateness of regulatory controls.

**10.4 A Minimum Level of Monitoring**

As discussed in Section 6.2, a strict adherence to the scheduled limits would either curtail dredging or require more expensive alternative forms of disposal. Adequate monitoring to ensure that substances in excess of scheduled amounts are in fact rendered harmless may well be the trade-off. With this in mind, an estimate has been developed for the cost of a minimum level of monitoring for existing disposal sites. A minimum level is defined as rotational monitoring on a five year cycle of all sites at which significant levels of Part I substances have been dumped. This type of program, if properly structured in advance, could also provide valuable status and trends information for purposes of the MEQ approach to marine environmental management.

The first stage of a monitoring program is the identification and characterization of the disposal site. Characterization should include (Pequegnat et al., 1981):

1. site geochemistry (sediment and water column),
2. site benthic community,
3. site marine bio-resources,
4. body burdens of chemical substances in site biota,
5. site topography,
6. physical regime in the water column and bottom currents, and
7. site geology (modern active vs. relic materials).

Having established the characteristics of the disposal site and determined that the choice of site meets various criteria (e.g., does not impinge on fishing activity or other use of the waters), a baseline or bench mark is established against which the results of the monitoring can be measured. Without this site-specific benchmark, any effect perceived in a monitoring program can only be gauged against some type of general conditions for that particular area. Conditions defined on a generalized basis are not likely to provide the level of detail adequate for comparative analysis. As well, inappropriate choice of disposal sites, e.g., subject to strong current action, or frequent changes in site location, will make it virtually impossible to collect useful data on fates and effects. The minimum monitoring program should include the following elements:

1. changes in the site geochemistry,
2. degree of consolidation of the deposited materials,
3. restoration of the benthic community,
4. physical transport and dispersion disposed material,
5. invasion of the site by a benthic community different than the original community,
6. bioaccumulation of contaminants, and
7. reduction in harvesting of marine bioresources.

Based on an evaluation of several monitoring projects, costs have been estimated as follows:

1. **establishment of the disposal site:**

   - existing site = $30,000
   - new site = $60,000

2. **monitoring:**

   -$30,000-100,000 per occurrence, depending on the size of the site and its location relative to the coast.

Costs could be contained by the multiple use and re-use of a disposal site. The identification of a disposal site which can be used over several years and also, where possible, by several projects, lowers the per project costs of disposal site characterization, and subsequent monitoring.

There are approximately 700 sites that have been used for ocean disposal, of which possibly 50 may be considered to contain significant concentrations of Part I substances. On the basis of 10 sites per year (50 sites / 5 year cycle x $75,000) an annual budget of up to $750,000 would be required. In addition, there should be some monitoring of the balance of the sites on a longer cycle, to obtain reliable information about the physical and other possible effects of the dumping.

**Recommendation 13:**

**It is recommended that the ODMP institute a minimum level of monitoring for those disposal sites at which dumping of substances of concern has occurred.**

## 11 Real-Time Monitoring

Real-time monitoring is a form of effects surveillance which is conducted during a disposal operation in order to permit immediate intervention by the regulatory agency if an adverse impact occurs. Monitoring of this type attempts to assess changes in the characteristics of the water column at the disposal site. Real-time monitoring has been employed on occasion under the ODMP, in cases where the concern was for the impact of dumping on the fishery. The focus has been upon factors such as:

1. changes in suspended solids,
2. changes in the dissolved oxygen concentrations,
3. mortality in plankton, and
4. mortality in other marine resources (e.g., fish kill).

Technology is available to undertake the real-time monitoring, and regional staff resources have been adequate to process the information for the limited number of operations on which it has been used. However, the process is costly to the proponent, e.g. $112,000 over three months in Pictou harbour (1987). Moreover, unless the dredging contract makes specific provision for alteration to the nature of the work, the proponent can face significant penalty charges.

The lack of adequate disposal site characterization to take into account the wide degree of natural variation in factors such as plankton population or dissolved oxygen concentrations undermines the reliability of the real-time monitoring that has been done. The technique could prove useful in limited circumstances when there is a moderate to high risk of an adverse impact on a marine resource, e.g. siltation of a shellfish bed, under certain physical conditions at the disposal site.

It is recommended that the requirement for real-time monitoring be reviewed, with a view to curtailing the practice. This type of monitoring might, however, form part of a research program, to gather information about all stages of the impact of an open water disposal operation.

# 12 Program Cost

## 12.1 Cost to Government

The interviews with regional staff confirmed that the estimate of the cost of administration of the ODMP to DOE and DFO contained in the evaluation assessment (Environment Canada, Program Evaluation Branch, 1988) is correct, as shown in Table 13:

**Table 13, Cost to Government**

| | ($000's) |
|---|---|
| Salaries and benefits - 12 PY | 600.0 |
| O&M expenses | 180.0 |
| ODCARF (DFO A-base) | 140.0 |
| **Total** | **920.0** |

Inasmuch as the person year count includes an allocation of a fraction of the time of persons who have a partial involvement in the program, it is difficult to arrive at a precise figure for the program costs.

## 12.2 Existing Cost to Proponents

The cost to the proponent include the following components:

1. material characterization,
2. additional transportation,
3. alternative forms of disposal,
4. monitoring, and
5. permit fees.

The disposal site location is determined largely by impact on navigation and the fishery, which would in any case be controlled under other Acts, if not under the CEPA. As a consequence, little incremental cost for transportation can be attributed to regulation of chemical contaminants. Confined disposal has been required on only a few instances, and has not been a significant cost to the proponent over the past decade.

A minimal requirement for disposal site characterization and monitoring by the proponent has added roughly $25,000 to $100,000 per year to the cost to the projects. The major expense attributable to the CEPA is the characterization of materials and permit fees.

A rough estimate of the annual cost of characterization can be made by applying "typical" unit costs to the number of permits.

| | | |
|---|---|---|
| sampling: 5-10 samples (say 8) x $100 | = | $800 |
| analysis: 8 samples x $200 | = | $1600 |
| **Total: $2400 x 127 permits (1986/87)** | **=** | **$305,000** |

This figure would be increased by the few very large projects which occur each year. However, the total is overstated by the value of the sampling which the Pacific Region undertakes on behalf of the proponent.

Fees are charged to the proponent on a sliding scale between $50 and $1000. Public Works Canada is exempt from fees. The issue of cost-recovery was addressed in the evaluation assessment (Environment Canada, Program Evaluation Branch, 1988), and was not included in the terms of reference for this study.

### 12.3 Cost to the Proponent of Program Modifications

The various recommendations to improve the effectiveness of the ODMP have cost implications which can be quite significant for the proponent, including:

1. increased sampling,
2. increased analysis, and
3. alternate forms of disposal.

Rough estimates of the costs have been prepared based on extrapolation from individual projects. The information does not exist that would allow more exact calculations.

#### 12.3.1 Cost of Increased Sampling

The application of the interim sediment sampling guidelines would require the proponent of a dredging project to alter the technique of locating sample collection sites and increase the number of samples to be collected for a particular project.

To evaluate the cost implication of the increased sampling effort, estimates from two recent Atlantic region projects are used as examples:

**Example 1:**

Courtenay Bay, Saint John, N. B.

proposed project: 100,000 cu. m.

past history: open-water disposal at harbour entrance, contaminants near or just above contaminant limits.

existing: 20 samples uniformly placed.

estimated sampling cost: $2500

analytical costs of 20 grab samples for Atlantic working list : 20 @ $200 = $4000

Total existing: $6500

sampling guideline: 20 core samples, specially placed.

estimated costs for sampling: $2500.

analytical costs (20 cores = 40 samples): 40 @ $200 = $8000.

Total sampling guideline: $10,500.

**Example 2:**

Pictou, N. S.

proposed project: 145,000 cu. m.

past history: new project to remove silt for wharf construction and wharf access. No previous history of dredging in harbour in that area.

existing: 5 samples.

cost: $1500.

analyses: 5 @$200 = $1000

Total existing: $2500

sampling guideline: 20 core samples.

cost of collection: $2500.

analyses: 40 @$ 200 = $8000.

Total sampling guideline: $10,500. In both cases, the application of the interim protocol would require more samples to be collected and more samples to be analyzed, resulting in higher cost for material characterization. These estimates are based on current analytic practices in the Atlantic Region. The cost of additional analysis is discussed below.

The application of these individual project costs to the total number of projects and volumes in the program would yield a rough estimate of the cost increase as follows:

**30 permits with high contamination x $8000 = $240,000.**

The estimate of the number of permits which would require a full sampling protocol is likely low, as it is based on existing analytical requirements, and does not take into account testing for an increased number of substances, e.g. PAHs.

### 12.3.2 Cost of Increased Analysis

Changes in analytical requirements can be of two types:

1. improved methodology for a substance now on the list, and

2. addition of new substances to the "working lists".

Examples of improved methodologies might include modification of the oil and grease category to include analysis for PAH, or the determination of the individual congeners of PCB. Examples of the addition of new substances include dioxins, dibenzofurans or organochlorine pesticides.

The major source of changes in existing methodologies will come about in the analysis of the organic contaminants. Introduction of changes in methodology for existing substances will vary depending on the substance to be determined and on the required degree of refinement. A change from the "oil and grease" test to a test for the 18 priority pollutant PAHs would increase costs from $20 to $150-250 per sample; for PCB by congener the costs would increase from $100 to $200 per sample.

The addition of substances to the lists would appear to involve primarily the organic contaminants. The analytical techniques for many of these compounds are still in the development stage, and the adaptation of the methodologies for use in the type of sediments found in most marine harbours has not even begun. Using present estimates, the addition of organochlorine pesticides would add about $150-200 per sample; dioxins, about $1500 per sample; and dibenzofurans, about $1500-2000 per sample.

Using the present Atlantic region estimate of $200 per sample for the working list as a base figure, and taking into account the above changes, the result would be an increase in cost of $700 to $3700 per sample. Given 130 dredging permits in

1986, with an average of 5 samples per project, or 650 samples, the total analytical budget would increase by a range of $455,000 to $2,400,000.

This figure provides estimates only for dredged sediments. It should be noted that fish wastes do not require characterization, and any change would result in a cost increase.

### 12.3.3 Cost of Alternate Disposal

Schedule III Part III 3(4) of CEPA requires that the permit applicant consider:

> "The practical availability of alternative land based methods of treatment, disposal or elimination, or of treatment to render the substance less harmful for dumping at sea."

The present policy of PWC and most proponents is to favour open- water disposal because of the relatively low cost of disposal, roughly $5 - 7 cu. m. As well, approval is more easily obtained for an ocean disposal site than for a shoreline facility. At present, a confined disposal facility (CDF), either shoreline or upland is considered only when the sediments does not meet open- water disposal criteria. Confined disposal is often used in the United States, and virtually all dredged material disposal in the Great Lakes (both Canada and the U. S.) is in CDF's (IJC, Water Quality Board Dredging Sub-Committee, personal communication).

Disposal options can be divided into a number of possibilities:

1. no generation, e.g., no dredging,
2. unconfined shoreline or upland disposal,

3. placement in a confined disposal facility, either shoreline or upland,

4. use of the material for a beneficial purpose, e.g., use of dredged sediment as part of an open-pit mine rehabilitation,

5. in situ treatment, and

6. open water containment.

Most dredging projects arise from a socio-economic need and therefore the "no dredging" alternative would not likely be acceptable. Nor is unconfined shoreline or upland disposal a viable option in most cases. In areas where the dredged sediment is gravel or coarse sand, the material has been used to off-set natural shoreline erosion ("beach nourishment"). However, the number of areas where this is possible is few. Most dredged material is not suitable for such a purpose, being fine-grained and organic rich. Local concerns about the effect of salt run-off from unconfined upland disposal, combined with the short-term problem of odour from the disposed sediments, can provoke significant public reaction and has led some provinces to effectively ban this option. Similarly, the concerns for unconfined fish waste disposal on land have led to strict provincial regulations (e.g., Nova Scotia).

Although CDF's do meet the objective of removing a contaminant from the eco-system and isolating it, they do have several drawbacks:

1. difficulty in siting and construction,

2. expense of construction,

3. possible double handling to place materials inside berms,

4. dewatering of sediment with effluent having to meet water quality criteria,

5. long-term maintenance of the facility, and

6. the requirement to design a facility to meet future needs.

Based on data collected in the Canadian Great Lakes (A. Khan, PWC-Ontario, personal communication), placement of material in a CDF is about four to five times more costly per cubic meter than open-water disposal, for the disposal component of a total project cost, i.e., exclusive of dredging and haulage.

Using cost figures and project sizes from the Atlantic region (G. Weber, PWC-Atlantic, personal communication), an approximation of the impact of restricting open-water disposal can be made.

**Example 1:**

Lunenburg, N. S. (1988)

characterization: cadmium in excess of 0.6 ppm, many areas greater than 1.0 ppm, and one site contaminated with PCB.

size: 48,000 cu. m.

total project cost: $1,180,000

mobilization component: $100,000

estimate ratio of dredge to scow and tug: $0.66 for dredge; $0.33 for scow

scow/tug component of cost: $360,000 = open-water cost

allow 4 x $360,000 for CDF, new disposal cost: $1,444,000

new total cost: $2,164,000

increase: 84%

Remark: This estimate could be somewhat high as the open-water site was 13 km out into the Atlantic Ocean and with only one scow/tug, the original contractor price may be somewhat high.

**Example 2:**

Pier B, Port of Halifax

characterization: silt heavily contaminated with metals and PCB.

size: 5,400 cu. m.

total project cost: $850,000

mobilization cost: $150,000

with dredge/scow ratio of 2:1, the open-water cost: $231,000

using the 4 x CDF ratio, new disposal cost: $924,000 new total cost: $1,393,000

increase: 64%

From these two examples, it can be seen that the placement of contaminated sediments in CDF's, compared to open-water disposal, will increase disposal costs in the order of 75%. Without knowing the current volume of over-limit dumping, it is not possible to give a reliable estimate of the impact of enforcing the scheduled limits for synthetic substances on the dredging program. Assuming that 10% of the current volume of dumping involves synthetic substances in excess of the scheduled limits, the total additional annual cost of adhering to the limits would be:

> 10% x 130 permits per year x 20,000 $m^3$ average project size x $20 $m^3$ x 75% = $3.9 million.

The 10% estimate of over-limit dumping is based on PCB, and would likely be higher if other substances were taken into account.

An alternative to confined disposal is the in-situ treatment or removal and treatment combined with subsequent replacement of the "cleaned" sediment. A variety of techniques have been suggested (e.g., SAIC, 1985; NRC, 1988). Most of these have been developed from systems for hazardous wastes or contaminated soils on land. A major technical problem to be overcome with dredged sediments is the large quantity of entrained water which must first be separated. Even if that could be resolved, the total cost of dredging, treatment, open-water disposal of the cleaned sediments and specialized treatment of the removed contaminants is greater than the placement of all the material in a CDF.

The placement of contaminated substances in a trench or depression with a cap of clean material is being investigated in the United States and Japan, and the technique is still at an experimental stage. There is some concern about the physical integrity of the cap, and about long-term bioturbation.

## 13 Other Observations

This section includes observation which, although not falling within the terms of reference of the evaluation, are necessary to help understand the findings in the earlier sections. If the issues identified here are not also addressed, it will become more difficult for the ODMP to act on the recommendations of this report. The additional observations relate primarily to organizational, procedural and resource matters.

### 13.1 Scientific Support Capacity

The requirement for scientific support for the ODMP falls into four broad categories of activity:

1. information and advice on the issue of permits,
2. development of regulations and guidelines,
3. monitoring, and
4. fates and effects research.

The original division of responsibilities between the Fisheries Management Service and the Environmental Protection Service, before a separate Department of Fisheries and Oceans was established, assigned all research studies and monitoring activities to Fisheries Management (Seaborn, 1975). Under the terms of the subsequent draft interdepartmental agreement between DOE and DFO of March 8, 1979, management of the national research and development program remained a DFO responsibility, while monitoring was seen to be a co-operative effort.

Questions were raised by various respondents about the capacity of DFO to meet the scientific support requirements of the ODMP. It was reported that the thrust of DFO research is toward the harvestable resource, with a lesser priority assigned to marine pollution. Moreover, it was felt that DFO not only does not apply adequate resources to the program, but also lacks necessary expertise in the area of sediment toxicology, trace contaminants and dredging technology. Proponents felt that the staff on the RODAC's who are processing applications are not qualified in all the areas necessary to make informed judgements, for example dredging technology. For its part, DFO states that marine pollution continues to be a priority for the department, and that it has the necessary range of skills to address ocean dumping issues, but that resource cuts and competing demands have left it without the capacity to meet all the immediate needs of the ODMP.

It would appear, then, that if Environment Canada wishes to increase the level of scientific support to the ODMP, it will have to do so largely through the use of its own resources. If DOE does provide additional funds to the ODMP, it has a number of options on the source of the scientific support:

1. provide DFO both PY's and money on a contractual basis,
2. purchase service from private sector,
3. develop internal capability, comparable to the freshwater research institutes,
4. establish marine satellites to existing freshwater research institutes, or
5. use freshwater researchers on temporary assignment to marine issues.

Any attempt by DOE to establish its own marine research facility would be a costly venture. Moreover, the approach taken in the Multi-Year Marine Research Plan (ICO, 1988) and the MEQ

Management Framework (Environment Canada, 1987) is one of cooperative activity on issues that cross the boundaries of departments and scientific disciplines. A related consideration is the government policy to encourage contacting of research to the private sector and universities.

An approach that recognizes these constraints, and at the same time would provide additional scientific support to the program contains the following elements:

1. the ODMP contract to establish a core of scientific expertise, within the disciplines of sediment toxicology, sediment geochemistry and the physical processes of sediments, at a cost of $250,000 per year;

2. this unit would undertake targeted research and development in areas of interest to the ODMP, act as scientific authority for contract research, and provide operational advice to the regions and headquarters, as required;

3. DOE increase ocean dumping research funds to their original value, i.e., $600,000 per year in $1989, and use the resources as a source of funds for the immediate work that is necessary on the program policy, guidelines and protocols;

4. the bulk of the actual research would continue to be contracted to the private sector, as is now the case.

The core unit will likely have to be lodged in government in order to provide the ongoing operational advice that cannot readily be contracted, and to act as scientific authority for the work which is contracted. The resources required to achieve a critical mass of scientific capacity would be three person years and $250,000 salary and operating. The unit would be expected to respond to national research priorities for ocean dumping set by a national committee of experts, as described below.

Independent scientific advice would be useful to the program in a number of key areas, including the development of the schedules of substances and limits, and the establishment of research priorities. It is clear from the evaluation that many of the issues facing the program are national in scope, and an advisory body created at the national level would be most effective. It is suggested that a national committee of experts be created, with membership from government, the private sector and academia, and with broad regional representation. The first task of the committee would be to recommend a set of interim substances and limits for immediate national application.

**Recommendation 14:**

**It is recommended that Environment Canada establish a national committee of experts to provide scientific advice to the ODMP.**

### 13.2 Mandate and Structure

Variability in practices between regions has been raised as an issue throughout the evaluation. The differences have arisen historically as a result of the lack of a clear mandate to develop a national program. In the early days of the program, the Fisheries Management Service provided the chairperson for a standing committee which had the responsibility for policy and program development. Within Environmental Protection Service, the authority for delivery of the program rested with the regional offices. After the separation of the two departments, the responsibility for ensuring policy consistency in the interpretation of the Act passed nominally to Environment Canada headquarters. However, the headquarters office was not given a sufficiently strong mandate to exercise that responsibility. The consequence has been the evolution of regional variation in the implementation of the program in ways which are not justified by differences between the regions. In the absence of widely agreed guidelines for the program, issues have developed between headquarters and regional offices in relation to individual permits, with no objective basis for their resolution.

In order to establish a national ocean dumping program it will be necessary to provide to headquarters a mandate and senior management support for policy formulation, program development and evaluation. The headquarters interest should be focused on matters which have application across the regions, while the RODAC's and the Regional Directors should continue to be responsible for the administration of the permitting process.

### 13.3 Resources

It is not the place of an evaluation to advocate additional resources for a program. The recommendations in this report have by and large attempted to suggest what could be done with existing resources, and what would be the priority for the use of new monies, if they were available. Nonetheless, one of the reasons that a program can fail to meet its objectives is not through a fault in design or the weakness in the organization, but because of a shortage of resources. It is clear to the evaluation team that the program cannot be expected to accomplish fully the objectives that have been set out in the Act and the international obligations with the resource level now available (see the earlier discussion of surveillance, monitoring and research). However, it is a decision of C&P management whether the issues in the ODMP merit the allocation of additional funds in relation to the many other demands within the environmental conservation and protection context.

A summary of the costs associated with the recommendations made in the report is as shown in Table 14.

**Table 14, Resource Implications of Recommendations ($000, 1989)**

| | DOE | | Proponent |
|---|---|---|---|
| | Annual | One-time | Annual |
| Review substances | -- | 500.0* | -- |
| Adhere to limits for synthetics | -- | -- | 3,900.0 |
| Minimum monitoring program | 750.0 | 300.0* | -- |
| Improve sampling | -- | 200.0* | 240.0 |
| Improve analysis | -- | 200.0* | 500.0 to 2,500.0 |
| Restore research fund | 600.0 | -- | -- |
| Develop research capacity | 250.0 | -- | -- |

*** from research fund over several years.**

The dollar values shown for improvements to the policy, guidelines and protocols is the total amount required, which could be funded over a number of years from a restored research fund. The person year requirement of the ODMP associated with the monitoring program has not been identified. It should not be large, inasmuch as the actual monitoring would be performed by private contractors.

Even without additional monies, as indicated throughout the report, management can take steps to achieve improvements in the program within existing resource levels.

### 13.4 Procedural Issues

A number of procedural issues that arise out of the science activities of the program were voiced during the course of the study. These include:

1. The implication that different regional limits have for the enforcement of the regulations.
2. The authority that the regions have to vary the application procedures established in the Act and regulations.
3. The authority that the regions have to vary the substances and limits.
4. The applicability of the CEPA "List of 50" to material characterization for ocean dumping.

It was not possible during the course of the evaluation to find answers to these questions, and they are noted here for management's attention.

### 13.5 Inspection

Inspection of disposal activities has been in the past performed by Environment Canada staff, with additional assistance from Fisheries Inspection Officers. As well, Public Works Canada employs inspectors for the projects which are contracted out. Although the PWC inspectors are acting on behalf of the proponent, they do ensure that the contractor is meeting the terms of the contract, and hence the permit. Because of a shortage of manpower, and insufficient funds for travel, the program has provided only 10 to 20% inspection coverage. As well, proponents often fail to file the necessary follow-up information on the quantity and location of dumping.

The resources available for inspection were further reduced when the Ocean Dumping Control Act was integrated into the Canadian Environmental Protection Act. Fisheries inspectors, who had been registered as inspectors under the ODCA, have not been certified under the CEPA. To accomplish this would require extensive training of the fisheries officers to meet the requirements of the CEPA enforcement and compliance policy.

The absence of protocols for the inspection activity adds to the problem of ensuring complete and uniform compliance with permit conditions. Neither the inspector nor the proponent has a clear idea of the requirements, and as a consequence there is considerable variability in the inspection practice. Nonetheless, inspection is not considered to be a high priority activity, because, as discussed in Section 5.5, the inspection that has occurred indicates a reasonably high degree of compliance by the proponents.

# Appendix I: Persons Interviewed

Peter Adams, P. Eng.
Fenco-Shawinigan Engineering Ltd.
Halifax, N. S.

David Aggett
Ocean Dumping and Marine Program
Environment Canada, Atlantic Region
Dartmouth, N. S.

Don Amos, P.Eng.
Senior Production Line Manager Architectural and Engineering Services
Public Works Canada, Atlantic Region,
Halifax, N. S.

Larry Anthony
Fish Habitat Management Fisheries and Oceans, Gulf Region
Moncton, N. B.

Gowan Barford, P.Eng.
Architectural and Engineering Services Public Works Canada,
Pacific Region Vancouver, B. C.

Roland Beaulieu, P.Eng.
(consultant) Consultants BPR
Quebec City, Quebec

C.G. Benckhuysen, P.Eng.
Dredge Fleet Services Public Works Canada Ottawa

R. Boulton
Environment Canada, Headquarters Ottawa

J. Doug Bradford
Ocean Sciences Fisheries and Oceans Ottawa

Dwayne Brothers
Ocean Dumping and Marine Program
Environment Canada, Pacific Region West Vancouver, B. C.

Gilles Brunet
Quebec Ministry of Environment
Quebec City, Quebec

Don Carter, P.Eng.
Port of Halifax Corporation
Halifax, N. S.

Dr. Peter Chapman
(contract laboratory/consultant) EVS Consultants Ltd.
North Vancouver, B. C.

Michel Chevalier
Ocean Dumping Program Environment Canada, Quebec Region
Montreal, Quebec

Peter Darnell
Aquaculture Association of Nova Scotia
Indian Harbour, N. S.

Jules Demers, P.Eng.
Public Works Canada, Quebec Region
Quebec City, Quebec

Rob Deverall
(contract laboratory/consultant) ASL Ltd.
Vancouver, B.C.

Harvey Doane, P.Eng.
Waterfront Development Corporation
(formerly with N.S. Department of Industry, Trade and Technology)
Halifax, N. S.

Andre B Ducharme
Fish Habitat Management Fisheries and Oceans,
Scotia-Fundy Region
Halifax, N. S.

J.C. Dumesnil
Environment Canada, Headquarters Ottawa

Linda Duncan
Enforcement and Compliance Environment Canada, Headquarters
Ottawa

Peter Eaton
Environmental Assessment Environment Canada,
Atlantic Region
Dartmouth, N. S.

Dr. Ulrich Forstner
Technische Universitat Hamburg-Harburg Hamburg,
West Germany

Dr. Tom Fredette
U. S. Army Corps of Engineers New England District
Waltham, Mass.

Larry Giovando
Institute of Ocean Sciences Fisheries and Oceans
Sydney, B.C.

Darcy Goyette
Marine Environmental Quality Environment Canada, Pacific Region
West Vancouver, B. C.

Denis Hache P.Eng.
Fish Habitat Management Fisheries and Oceans, Gulf Region
Moncton, N. B.

Dr. Lars Hakanson
Water Quality Laboratory National Swedish Environment Protection Board
Uppsala, Sweden

Hugh Hall Director,
Ocean Dumping and Marine Program
Environment Canada, Atlantic Region
Dartmouth, N. S.

Ken Hamilton, P.Eng.
A/Director-General Environmental Protection
Environmental Canada, Atlantic Region
Dartmouth, N. S.

Lee Harding
Marine Environmental Quality Environment Canada, Pacific Region
West Vancouver, B. C.

Capt. T. Higgins
Waterways Experiment Station U.S. Army Corps of Engineers
Vicksburg, Miss.

G. L. Holland
Director General Physical and Chemical Sciences Directorate
Fisheries and Oceans Ottawa

Dr. W. D. Jamieson
Marine Analytical Chemistry and Standards Program National Research Council of Canada,
Atlantic Region
Halifax, N. S.

Brian Jollimore, P.Eng.
Fish Habitat Management Fisheries and Oceans, Scotia-Fundy Region
Halifax, N. S.

John Karau
Marine Environmental Division International Maritime Organization
London, U. K.

Colin Kingman
Environmental Co-ordinator Architectural and Engineering Services Public Works Canada, Pacific Region
Vancouver, B. C.

Dr. Paul Kluckner Laboratory Services Environment Canada, Pacific Region West Vancouver, B. C.

Charalyn Kriz
Ocean Dumping and Marine Program Environment Canada, Headquarters Ottawa

Rick Kussat
Ocean Dumping and Marine Program Environment Canada, Pacific Region West Vancouver, B. C.

Yves Lavergne
Fish Habitat Fisheries and Oceans, Quebec Region
Quebec City, Quebec

Dr. C. R. Lee
Waterways Experiment Station U.S. Army Corps of Engineers
Vicksburg, Miss.

Maurice Levesque,
Fish Habitat Management Fisheries and Oceans, Gulf Region
Moncton, N. B.

Dr. Colin Levings
Pacific Environmental Laboratory Fisheries and Oceans
West Vancouver, B. C.

Dr. S. N. Luoma
U. S. Geological Survey Menlo Park, California

Dr. Robbie MacDonald
Institute of Ocean Sciences Fisheries and Oceans
Sydney, B.C.

Camille Mageau
Ocean Sciences Fisheries and Oceans Ottawa

G. Mazetta, P.Eng.
Norsk Hydro (formerly DG Environmental Protection - Quebec Region)
Montreal, Quebec

Dr. Patrick McLaren
Geosea Ltd.
Cambridge, U. K.

Paul Mills
Plant Manger National Gypsum Corporation
Dartmouth, N. S.

Chris Moir, P.Eng.
Nova Scotia Department of Industry, Trade and Technology Halifax, N. S.

Brian Mosher
Environmental Co-ordinator Architectural and Engineering Services
Public Works Canada, Atlantic Region Halifax, N. S.

Paul Mudroch
Ocean Dumping and Marine Program Environment Canada,
Headquarters Ottawa

Raymond Murray, P.Eng.
Public Works Canada, Quebec Region
Rimouski, Quebec

Hal Nelson
Ocean Dumping and Marine Program Environment Canada,
Pacific Region
West Vancouver, B. C.

G. Packman
Fish Habitat
Fisheries and Oceans
Ottawa

Luc Palmer
(proponent) Daishowa Inc.
Montreal, Quebec

Dr. K. Pye
Department of Earth Sciences University of Cambridge
Cambridge, U. K.

Rene Rochon
Centre de St.-Laurent Environment Canada, Quebec Region
Montreal, Quebec

Tim Sakman
Ocean Dumping Program Environment Canada, Western and Northern Region Yellowknife, N.W.T.

Dr. P. G. Sly
The Rawson Academy of Aquatic Science
Ottawa, Ontario

G. Swanson
Fish Habitat Fisheries and Oceans
Ottawa

Dr. K. Tay
Ocean Dumping and Marine Program
Environment Canada, Atlantic Region
Dartmouth, N. S.

Jim Thornton
State Department of Ecology
Olympia, Washington

Dr. Mike Waldichuk
Pacific Environmental Laboratory
Fisheries and Oceans
West Vancouver, B. C.

G. Weber, P.Eng.
Architectural and Engineering Services Public Works Canada,
Atlantic Region
Halifax, N. S.

Dr. Peter Wells
Marine Environmental Quality Environment Canada,
Atlantic Region
Dartmouth, N. S.

Robert Wentzell, P.Eng.
Director-General, Architectural and Engineering Services Public
Works Canada, Atlantic Region
Halifax, N. S.

Warren Williams, P.Eng.
Architectural and Engineering Services Public Works Canada,
Pacific Region Vancouver, B. C.

# Appendix II: References

Adam, M. W. D. McKone, and H. Shear. 1987. Report from a Workshop on Chemical Hazards to Fish and Fisheries. Canadian Technical Report on Fisheries Aquatic Science. 1525.

Addison, R. F., M. E. Zinck and R. G. Ackman. 1972. Residues of Organochlorine Pesticides and Polychlorinated Biphenyls in Some Commercially Produced Canadian Marine Oils. Journal of the Fisheries Research Board of Canada. 29, 349-355.

Ahlf, W. and M. Munawar. 1988. Biological Assessment of the Environmental Impact of Dredged Material. (127-142) In, Chemistry and Biology of Solid Waste (Dredged Material and Mine Tailings) (W. Salomons and U. Forstner -eds.) Springer-Verlag Publishing Co., New York.

Arctic Laboratories Ltd. 1985. Sampling and Analysis in the Arctic Marine Benthic Environment. Vol. I: Review of Methods; Vol. II: Guide to Practice. Report to Environment Canada.

Boon, J.P. 1980. Uptake, Distribution, and Elimination of Selected PCB Components of Clophen A40 in Junvile Sole (Solea solea) and the Effects on Growth. (35-54) In, Marine Biology of Polar Regions and Effects of Stress on Marine Organisms (J. S. Gray and M. E. Christiansen, eds.)

Boon, J. P., M. B. Van Zantvoort, and M.J.M.A. Govaert. and J. C. Duinker. 1985. Organochlorines in Benthic Polychaetes (Nephtys spp.) and Sediments from Southern North Sea. Identification of Individual PCB Components. Netherlands Journal of Sea Research, 19, 93-109.

Bourg, A.C.M. 1988. Metals in Aquatic and Terrestrial Systems: Sorption, Speciation and Mobilization. (3-32) In, Chemistry and Biology of Solid Waste (Dredged Material and Mine Tailings) (W. Salomons and U. Forstner -eds.) Springer-Verlag Publishers. New York.

CEPA. 1988. Canadian Environmental Protection Act. Government of Canada

Duedall, I.W., B.H. Ketchum, P.K. Park, and D.R. Kester (eds). 1986. Wastes in the Ocean. Vol. 1-6. (Proceedings of 3rd International Ocean Disposal Symposium, Woods Hole, Mass.). John Wiley and Sons Ltd. New York

Duinker, J. C., M. Th. H. Hillerbrand, and R. F. Nolting. 1979. Organochlorines and Metals in Harbour Seals (Dutch Wadden Sea). Marine Pollution Bulletin, 10, 360-364.

Eaton, P. and V. Bradshaw. 1984. The Ocean Dumping Control Act: An Evaluation of Its Effectiveness in the Atlantic Region. Internal Report to Environmental Protection Service, Atlantic Region, Environment Canada. (101 pg).

Environment Canada. 1987. MEQ Management Framework.

Environment Canada, Program Evaluation Branch. 1986. Evaluating Regulatory Programs: Discussion Paper.

Environment Canada, Program Evaluation Branch, 1988. Evaluation Assessment of the Ocean Dumping and Marine Protection Branch.

Ernst, B., V. Hawkins, and K. L. Tay, 1982. Investigation of the Cause and Extent of PCB Contamination of Petit-de-Grat Harbour, N. S. Environment Canada Atlantic Region Report EPS-5-AR-82-2.

Fredette, T. J., G. A. Anderson, B. S. Payne, and H. D. Lunz. 1986. Biological Monitoring of Open-Water Dredged Material Disposal Sites. Proceedings of IEEE Oceans '86 Conf. (764-769).

Gambrell, R. P., R. A. Khalid, and W. H. Patrick, jr. 1978. Disposal Alternatives for Contaminated Dredged Material as a Management Tool to Minimize Adverse Environmental Effects. Technical Report DS-78-8 U. S. Army Corps of Engineers, Waterways Experiment Station.

Helder, T. 1980. Effects of 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) on Easrly Life Stages of the Pike (Esox lucius L.). The Science of the Total Environment, 14, 255-264.

Hirsch, N. D., L. H. DiSalvo, and R. Peddicord. 1978. Effects of Dredging and Disposal on Aquatic Organisms. Technical Report DS-78-5. U. S. Army Corps of Engineers, Waterways Experiment Station.

Hutzinger, O., S. Safe, and V. Zitko. 1974. The Chemistry of PCB. CRC Press Inc.

International Joint Commission. 1987. Report of the Water Quality Board, Dredging Sub-Committee.

Karau, J. 1987. Role of Ocean Disposal in Canada's Waste Management Strategy. In, Proceed. of 7th International Ocean Disposal Symposium. Wolfville, N.S. (21-25 Sept., 1987) Environment Canada.

Krawetz, N. M., W. R. MacDonald, and P. Nichols. 1987. A Framework for Effective Monitoring. Report to the Canadian Environmental Assessment Research Council. Ottawa, Ont.

Lee, C. R. and R..K. Peddicord. 1988. Decision-Making Framework for Management of Dredged Material Disposal. (324-371) In, Environmental Management of Solid Waste (Dredged Materials and Mine Tailings) (W. Salomons and U. Forstner, eds). Springer-Verlag Publishing Co., New York.

Lee, K.R. Research Ltd. 1988. Toxicity Testing of Dalhousie, N. B. Open-Water Disposal Site Sediments. Report to Environment Canada, Atlantic Region.

London Dumping Convention, Scientific Group on Dumping. 1988. Agenda Item 7.1: Monitoring and Control of Dumping Activities, Draft Report of Permits Issued in 1985. (LDC/SG 11/WP.1)

Luoma, S. 1989. Can We Determine the Biological Availability of Sediment-Bound Trace Elements?. Hydrobiologia, in press.

Lyman, W.J., A. E. Glazer, J. H. Ong., and S. F.Coons. 1987. An Overview of Sediment Quality in the United States. U. S. Environmental Protection Agency Report. 905/9-88-002

Malins, D. C., B. B. McCain, D. W. Brown, A. K. Sparks, H. O. Hodgins, and S.-L. Chan. 1982. Chemical Contaminants and Abnormalities in Fish and Invertebrates from Puget Sound. Technical Memorandum OMPA-19. U. S. National Oceanic And Atmospheric Administration.

Malins, D. C., B. B. McCain, D. W. Brown, S.-L. Chan, M. S. Myers, P. G. Prohaska, A. H. Friedman, L. D. Rhodes, D. G. Burrows, W. D. Gronlund and H. O. Hodgins. 1984. Chemical Pollutants in Sediments and Diseases of Bottom-Dwelling Fish in Puget Sound, Washington. Environmental Science and Technology, 18, 705-713.

Martec Ltd.. 1988. Monitoring of a Fish Waste Disposal off Yarmouth, N. S. Presentation to the 5th Atlantic Regional Ocean Dumping Control Act Research Fund Workshop, Halifax, N.S.

MOSST. 1987. (Ministry of State for Science and Technology). A Decision Framework for Science and Technology.

ICO. 1988. (Interdepartmental Committee on Oceans). Multi-Year Marine Science Plan. Ottawa.

NRC. 1988. (U. S. National Research Council, Marine Board Committee on Contaminated Marine Sediments. Draft Proceed. of Contaminated Marine Sediments Symposium/Workshop. (Tampa, Florida, June, 1988)

Neff, J. W., R. S. Foster, and J. F. Slowey. 1978. Availability of Sediment-Adsorbed Heavy Metals to Benthos with Particular Emphasis of Deposit-Feeding Infauna. Technical Report, D-78-42. U.S. Army Corps of Engineers Waterways Experiment Station.

Norton, M. G., S. M. Rowlatt and R. S. Nunny. 1984. Sewage Sludge Dumping and Contamination of Liverpool Bay Sediments. Estuary, Coastal and Shelf Science, 19, 69-87.

OceanChem group. 1985. Background document for the development of a sediment sampling guideline for ODCA Permits. Report to Ocean Dumping and Marine Program. Environment Canada, Ottawa.

OceanChem group. 1988. Dredged Sediment and Ocean Disposal Site Assessment Study, Dalhousie, N. B. 1988. Report to Environment Canada, Atlantic Region.

OceanChem group. 1989. Schedule Substances Review - Hydrocarbons. Investigation of the Ocean Dumping "Oil and Grease" Test Method. Report to Ocean Dumping and Marine Protection Branch, Environment Canada. Ottawa.

ODMP. 1987a. Keeping the Ocean Clean. Report to Parliament on Ocean Dumping Control Act Activities for 1986/87. Environment Canada

ODMP. 1987b. A Guide to the Canadian Ocean Dumping Control Program: Description, Interpretations Procedures, and Guidelines. Draft Report prepared by Ocean Dumping and Marine Protection Program, Environment Canada.

Patin, S. A. 1982. Pollution and Biological Resources of the Oceans. Butterworths Publ. Co. (Table 4.10)

Pequegnat, W. E., L. H. Pequegnat, B. M. James, E. A. Kennedy, R. R. Fay. and A. D. Fredericks. 1981. Procedural Guide for Designation Surveys of Ocean Dredged Material Disposal Sites. Technical Report, EL 81-1. U. S. Army Corps of Engineers, Waterways Experiment Station.

Plumb, R. H. Jr. 1981. Procedures for Handling and Chemical Analysis of Sediment And Water Samples. U. S. Environmental Protection Service/Army Corps of Engineers Report EPA/CE-81-1.

PTI Environmental Services. 1988a. Contaminated Sediments Criteria Report. Draft Report to the State of Washington Dept. of Ecology (Sediment Management Unit).

PTI Environmental Services. 1988b. The Apparent Effects Threshold Approach. Briefing Report to the EPA Science Advisory Board. (Puget Sound Estuary Program).

SAIC. 1985. (Science Applications International Corp.) Removal and Mitigation of Contaminated Sediments. Report to U. S. Environmental Protection Agency.

SAIC. 1986. (Science Applications International Corp.) Ocean Dumping Site Designation Delegation Handbook for Dredged Material. Report to U. S. Environmental Protection Agency.

Scarrett, D.J. 1987. Review of Fishermen's Compensation Claims Against the Miramichi Channel Dredging Project. Proceedings, 4th Atlantic Regional Ocean Dumping Control Act Research Fund Workshop, Halifax, N.S. Environment Canada, Atlantic Region.

Schwetz, B. A., J. M. Norris, G. L. Sparschu, V. K. Rowe, P. J. Gehring, J. L. Emerson, and C. G. Gerbis. Toxicology of Chlorinated Dibenzo-p-dioxins. Environmental Health Perspectives 5, 87-107.

Segar, D. A., E. Staman, and P. G. Davis. 1986. Development of Dumpsite Monitoring Program. In, Oceanic Processes in Marine Pollution Volume 4: Scientific Monitoring Strategies for Ocean Waste Disposal. (Hood, D.W. and Schoener, A., eds.) R. E. Krieger Publishing Co.

Sly, P. G. 1984. Biological Considerations for Open Water Disposal of Dredged Material in the Great Lakes. Inland Waters Directorate. Scientific Series, Ottawa, Number 137. 14 pages.

Swiss, J.J., R. F. Addison, D. W. McLeese, and J. F. Payne. 1980. Regulated Levels of Schedule I Substances in the Ocean Dumping Control Act - A Review. Ocean Dumping Report #3. Fisheries and Oceans.

Tetra Tech Inc. 1986a. Development of Sediment Quality Values for Puget Sound. Report to Puget Sound Dredged Disposal Analysis and Puget Sound Estuary Program.

Tetra Tech Inc. 1986b. Recommended Protocols for Analysis of Water, Sediment And Tissue Samples from Puget Sound. Report 3991-04 to the U. S. Environmental Protection Agency.

UNEP 1985. UNEP/WG 120/3(Part IV). Protection of the Marine Environment Against Pollution from Land-Based Sources, Montreal Guidelines. In, Proceedings Canadian Conference on Marine Environmental Quality. Halifax, N.S. (29 Feb. -3 Mar., 1988) Environment Canada.

U. S. ACE. 1984. General Approach to Designation Studies for Ocean Dredged Material Disposal Sites. U. S. Army Corps of Engineers Water Resources Support Centre Report

Walton, A. (ed.) 1978. Methods for Sampling and Analysis of Marine Sediments and Dredged Materials. Ocean Dumping Report #1. Fisheries and Environment Canada.

Wells, P.G. and R. P. Cote. 1988. Protecting Marine Environmental Quality from Land-Based Pollutants. Marine Policy. January, 9-21.