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Ocean Dumping: The Canadian Scene

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OCEAN DUMPING:
THE CANADIAN SCENE

by

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ABSTRACT*

Suitable land disposal sites are exceedingly limited on the west coast of Canada, and they are expected to become more scarce in the future. In consideration of alternative locations for disposal, increased interest is being directed towards the marine environment. On December 13, 1975, the Ocean Dumping Control Act was proclaimed. Environment Canada was designated to administer the new legislation, which includes a permit system through which the major controls are exerted.

To date, in excess of 90% of all ocean dumping applications processed have involved the disposal of dredged materials. Much of this dredgeate originates from the diversified forest products industries, some of which are located in areas already contaminated with other industrial wastes. The resultant materials are generally found to be high in organic content, and are occasionally found in association with other pollutants, such as mercuric compounds.

In the past year, Environment Canada has expended considerable effort evaluating the physical and chemical fates of dredgeates dumped into unconfined marine areas, and their subsequent effects upon the resident ecosystems. Preliminary conclusions include the following: that the environmental impact of ocean disposal upon the water column is generally short-term and minimal; that most of the pollutants contained in the dredged materials tend to remain bound in the sediments; that the greatest impact appears to be localized on the bottom in the vicinity of the dump-sites; and that the degree and duration of effects are site-specific and generally related to the prevailing oceanographic conditions.

* This paper was presented at the Pacific Northwest Pollution Control Association Conference held in Seattle, Washington in October 1976.

RÉSUMÉ

Les terrains convenant aux décharges publiques sont très peu nombreux sur la côte ouest du Canada et tout indique qu'ils se feront de plus en plus rares. La recherche de solutions de rechange a mené les intéressés à considérer le milieu marin. Le 13 décembre 1975, on adoptait la Loi sur l'immersion des déchets en mer. Environnement Canada se vit chargé de faire appliquer cette loi, qui prévoit un système de permis pour effectuer les contrôles les plus importants.

Jusqu'à présent, plus de 90 p. 100 des demandes d'immersion avaient pour objet des détritus dragués. Une grande partie de ces déchets provient de l'industrie des produits forestiers dont certaines installations se situent dans des régions déjà contaminées par d'autres rebuts industriels. Ces détritus contiennent généralement un taux élevé de matière organique et sont parfois mêlés à d'autres substances polluantes telles que les composés mercuriels.

Au cours de l'année écoulée, Environnement Canada a fait des efforts considérables pour estimer les transformations physiques et chimiques que subissent les détritus déversés dans des zones marines imprécises et leurs incidences sur les écosystèmes du milieu. Voici les premières constatations: les répercussions écologiques de l'immersion des déchets dans l'océan sur la masse d'eau verticale sont généralement peu importantes et de courte durée; la plupart des substances polluantes qui se trouvent dans les détritus dragués tendent à rester emprisonnées dans les sédiments; les répercussions les plus importantes semblent se manifester sur le fond marin, à proximité des lieux de décharge et, finalement, l'importance et la durée des effets varient selon les emplacements et sont généralement liés aux conditions océanographiques.

1 INTRODUCTION

On December 13, 1975, the Ocean Dumping Control Act was proclaimed by Canada. This legislation regulates the ocean disposal of most types of materials from ships, aircraft, and platforms operating in Canadian territorial or internal waters, and all Canadian vessels anywhere in the world. The only exceptions are disposal that is incidental to, or derived from, the normal operations of a ship or an aircraft, and, discharges that are incidental to, or derived from, the exploration for, exploitation of, and associated off-shore processing of sea-bed mineral resources.

Environment Canada was designated the lead agency to administer the provisions of the Act, including the establishment and operation of a permit system to regulate the loading (for the purposes of dumping) and the disposal of wastes at sea. Permit applications respecting the Act are processed through Regional offices of the Environmental Protection Service located in Vancouver, British Columbia; Edmonton, Alberta; Montreal, Quebec; and Halifax, Nova Scotia (Figure 1.) During the initial 10 months of its administration, a total of 167 permit applications have been received and processed. Many more are in preparation and several have been screened out prior to the application stage. Table 1 summarizes the distribution of applications by Region and type of material considered for disposal.

Table 1 SUMMARY OF OCEAN DUMPING CONTROL ACT PERMIT APPLICATIONS PROCESSED BY REGIONAL OFFICES

	Atlantic	Pacific	Quebec	Northwest
Dredged material	88	50	19	0
Chemical wastes	0	2	0	0
Scientific experiments	3	1	0	0
Fish wastes	1	0	0	0
Miscellaneous	2	2	0	0
Subtotal	94	54	19	0
Total..........				167

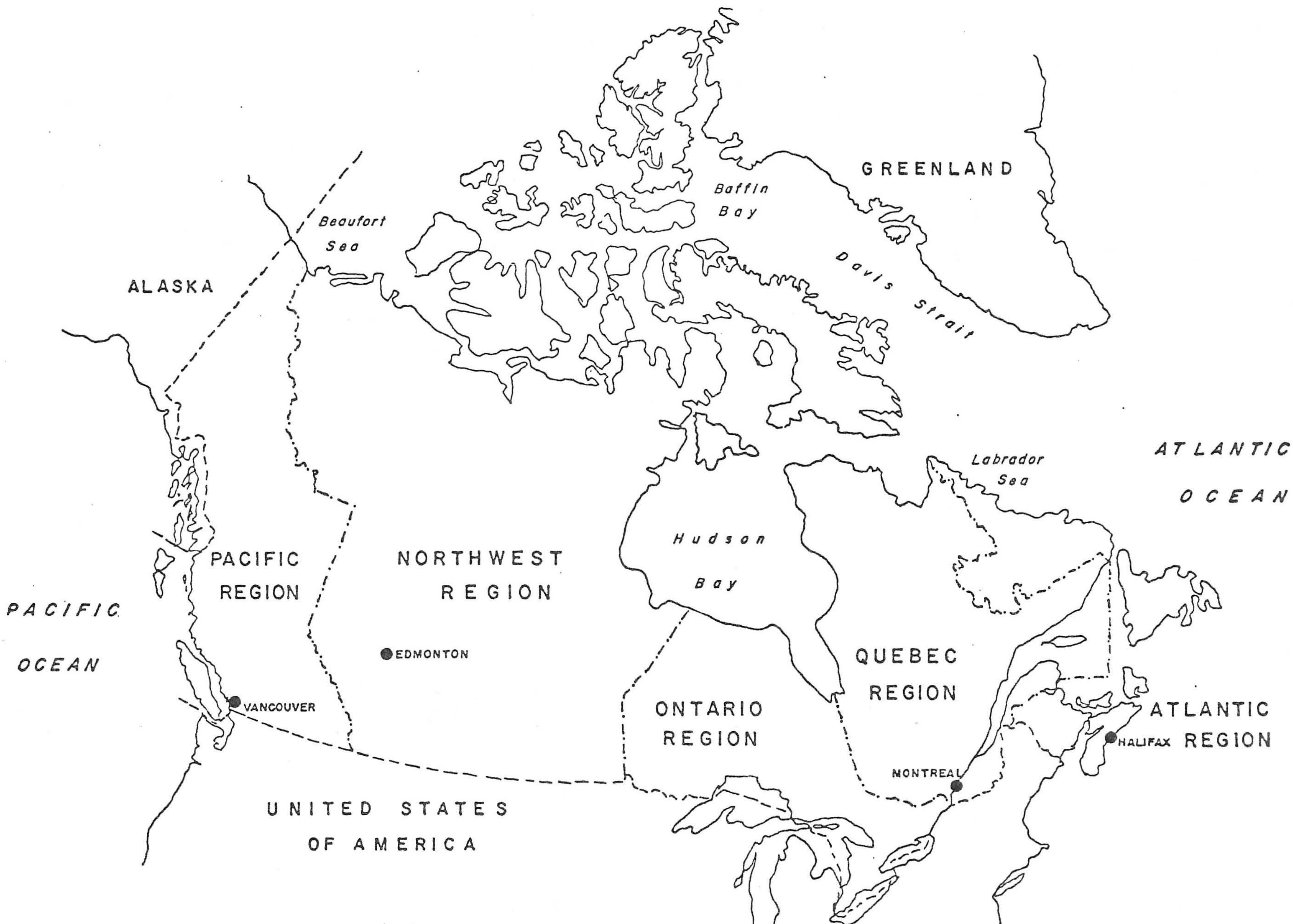

FIGURE I ADMINISTRATION CENTERS FOR THE OCEAN DUMPING CONTROL ACT

Of the total received, 157 applications or 94%, have involved the disposal of dredged materials. Most of the dredging requirements result from natural sedimentation processes and subsequent infilling of navigation channels, harbours, and dock areas.

However, particularly on the west coast, much of this material results from the deposition of wood wastes generated by the variety of activities associated with the forest products industry. In some cases these industries are located in areas already contaminated with other industrial wastes. The resultant dredgeates are generally found to be high in organic content, and are occasionally found in association with other pollutants, such as mercuric compounds and other heavy metals.

In order to assist in assessing and processing permit applications, Environment Canada has expended considerable effort evaluating the physical and chemical fates of dredgeates dumped into unconfined marine areas, and their subsequent effects upon the resident ecosystems. The main purposes of this discussion are to describe the problems of dredged material handling and disposal, particularly as applied to the west coast of Canada, and to review, in general terms, the nature, scope, and results obtained from certain studies undertaken by Environment Canada.

2 PROBLEM

Maintenance dredging of navigable waterways, harbours, docks, booming grounds, etc., is a continuing and essential requirement of most coastal areas. In British Columbia, dredging is carried out by all conventional types of equipment including pipeline suction plants, suction hoppers, clamshell dredges, and other bucket-dredge operations. At the present time, the use of suction-type equipment is generally restricted to the lower portions of the Fraser River and Vancouver harbour where the sediments are relatively homogeneous and, therefore, suitable for suction removal. This dredged material, comprised mostly of sand, is regularly spoiled to approved landfill sites for subsequent use as foundation fill. When deemed unsuitable or unnnecessary for this purpose, it is often discharged to deeper waters in the vicinity of the dredge site. With the advent of the Ocean Dumping Control Act, some of these latter activities are now regulated by the new legislation.

Clamshell and other bucket operations generally involve smaller volumes of material than those handled by suction methods and/or bottom sediments mixed with wood rubble and other forms of debris which make suction dredging difficult or impossible to carry out. Since the reach of the stationary cranes is generally not sufficient to permit side-casting into deeper water or onto land, the spoils are usually dumped into barges or scows for removal to a suitable location. Unfortunately, it is these materials, which frequently originate near wood products and other industries, that contain high levels of organic substances and, often, other pollutants as well.

This material is generally not suitable for construction purposes because of its chemical composition and unclassified nature. In British Columbia, the problem is compounded by the fact that land disposal sites are often simply not available owing to the rugged topography. Alternatively, where flat land near the shore is available it is often situated at the head of an estuary. Estuaries in general, and those of British Columbia in particular, are considered to be exceedingly critical to the wildlife, fisheries, and other natural resources of the coastal zone. In the past, and even now, significant areas of many of these estuaries are being covered over with dredge spoils, hogfuel, and general refuse, etc., in addition to sustaining other development pressures.

Investigations of some of the larger and/or more critical land-dump sites by Environment Canada, other regulatory agencies, and private industry have demonstrated that very few sites satisfy the basic criteria required to ensure minimal deleterious impact upon the terrestrial and adjacent aquatic environments and their associated ecosystems. With the shallow, often tidal, groundwater-table levels normally characteristic of the estuarine areas, and the high incidence of precipitation along the coast, the generation of highly toxic leachates has become a regular and continuing feature of many disposal sites. Compounding the problem is the fact that, more often than not, these leachates end up flowing into nearby shallow freshwater and/or intertidal marsh ecosystems which often harbour the most sensitive, critical life stages of many of the endemic natural resources.

With landfill options being therefore, very limited, it is not surprising that increased interest is being directed toward the marine environment as a potential receptor for dredged materials. In this regard, British Columbia appears to be in a relatively fortunate position. The same geological features that have limited land disposal possibilities provide a multitude of fjord-type marine inlets with water column depths in excess of 200 meters. Concurrently, the high levels of precipitation characteristic of the coastal zone are reflected in the large numbers of rivers and streams flowing into many of these inlets, thereby establishing and maintaining strong circulation patterns within the fjord systems. These conditions, where they exist, appear to provide suitable marine disposal options.

On the other hand, some of the fjords harbouring industries have shallow sills separating the open ocean from the inlets' heads, where the industries are generally located. Under these circumstances, water column circulation may often be restricted below sill depth in the inner basins, resulting in conditions which may not be conducive to the disposal of organic or other polluted waste, including dredge spoils.

Oceanographic and biological investigations have been carried out at a variety of geographical locations encompassing the range of physical oceanographic conditions encountered on the west coast of British Columbia. Experience has led researchers to conclude that the primary environmental requirements for mitigation of the key impact of organic waste disposal is a continual, sufficient supply of dissolved oxygen. The presence of sufficient oxygen usually permits the chemical oxidation and degradation of organics, while restricting the generation of hydrogen sulphide and other noxious compounds to below the sediment/water interface. The presence of oxygenated water above the sediment has also been found to permit colonization of exposed organic materials with fungal and/or bacterial growths, wood-boring bivalves, polychaetes, crustacea, etc. The ability of larger organisms to establish residence under these conditions promotes degradation processes, an attribute which is generally considered to be desirable.

When situations of poor circulation and low dissolved oxygen conditions (e.g., Alberni Inlet[1]) are compounded by the nearest potentially suitable marine disposal site being located at a considerable distance (>30 miles) from the dredge site, and land-disposal facilities being non-existent, serious environmental and/or economic repercussions may result. Under these conditions Environment Canada's approach has been to minimize the surface area exposed to the water column by confining the dumping ground to as small an area as possible. In addition, when it has been feasible (e.g., Howe Sound and Port Alberni, Figure 2), exposed organic material has been buried with clean dredge spoils, such as sand, gravel, etc. This procedure serves to seal polluted materials below a non-contaminated layer.[2]

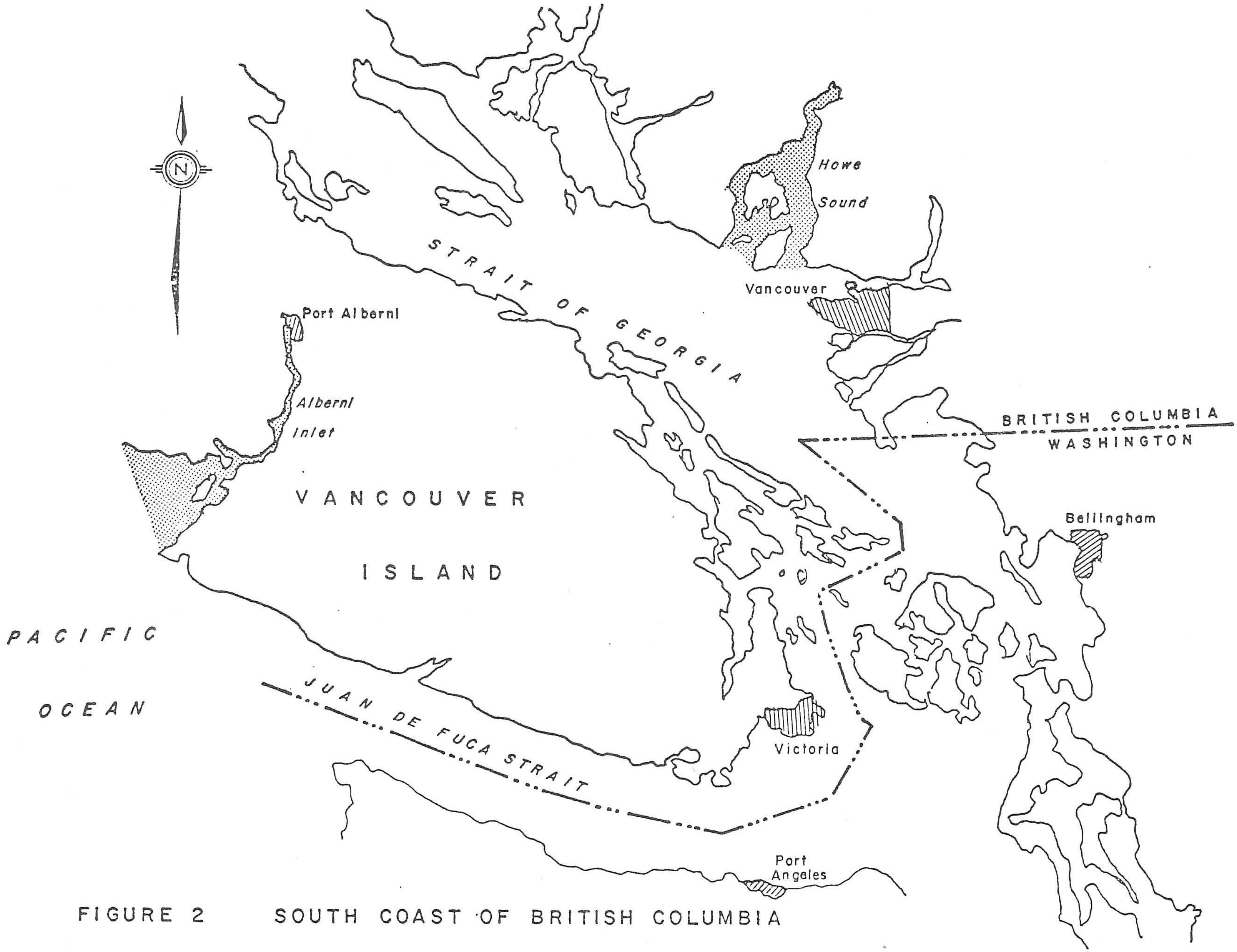

FIGURE 2 SOUTH COAST OF BRITISH COLUMBIA

3 RESEARCH ACTIVITIES

Prior to 1973, there was relatively little definitive information on the environmental impact of dredgeate disposal in unconfined marine areas. At about that time the U.S. Army Corps of Engineers was authorized by Congress to carry out a comprehensive nationwide program of research associated with all environmental aspects of the Corps dredging programs.[3] The 30 million dollar "Dredged Material Research Program" was assigned to the Waterways Experiment Station (Vicksburg, Mississippi). As a result of this major and most significant undertaking, tremendous research inroads have been made into the field of dredged material handling, disposal, reuse, etc.

Recognizing the nature and extent of the American program, but also realizing that certain aspects of the dredged material disposal problem in Canada were different, Environment Canada initiated a series of studies to investigate those problems which were unique to Canada's coasts or, which were in particular need of prompt resolution.

Initially, an extensive field program was carried out at one of British Columbia's largest active dump sites currently in use.[4] This particular location, Point Grey (Figure 3), had been used mainly for the disposal of dredged material from the lower Fraser River and Vancouver harbour. Currently, approximately 500,000 cubic yards (383,000 m^3) of material per year are deposited at this site, which has a mean water depth of 250 metres. The program investigated many components of the receiving environment, including the water column, the water-sediment interface, and the sediments, as well as examining the organisms inhabiting these zones. Water-bottle casts, benthic grab and core sampling, beam trawls, and manned submersible visual and photographic procedures were among the assessment techniques employed. The general results and preliminary conclusions of this work were presented at the 7th World Dredging Conference, San Francisco.[4] As would be expected, the main impact was on the bottom, through burial of benthic organisms and the introduction of new and different substrates, e.g., gravel, rock, wood debris, etc. Summarizing, the researchers concluded:

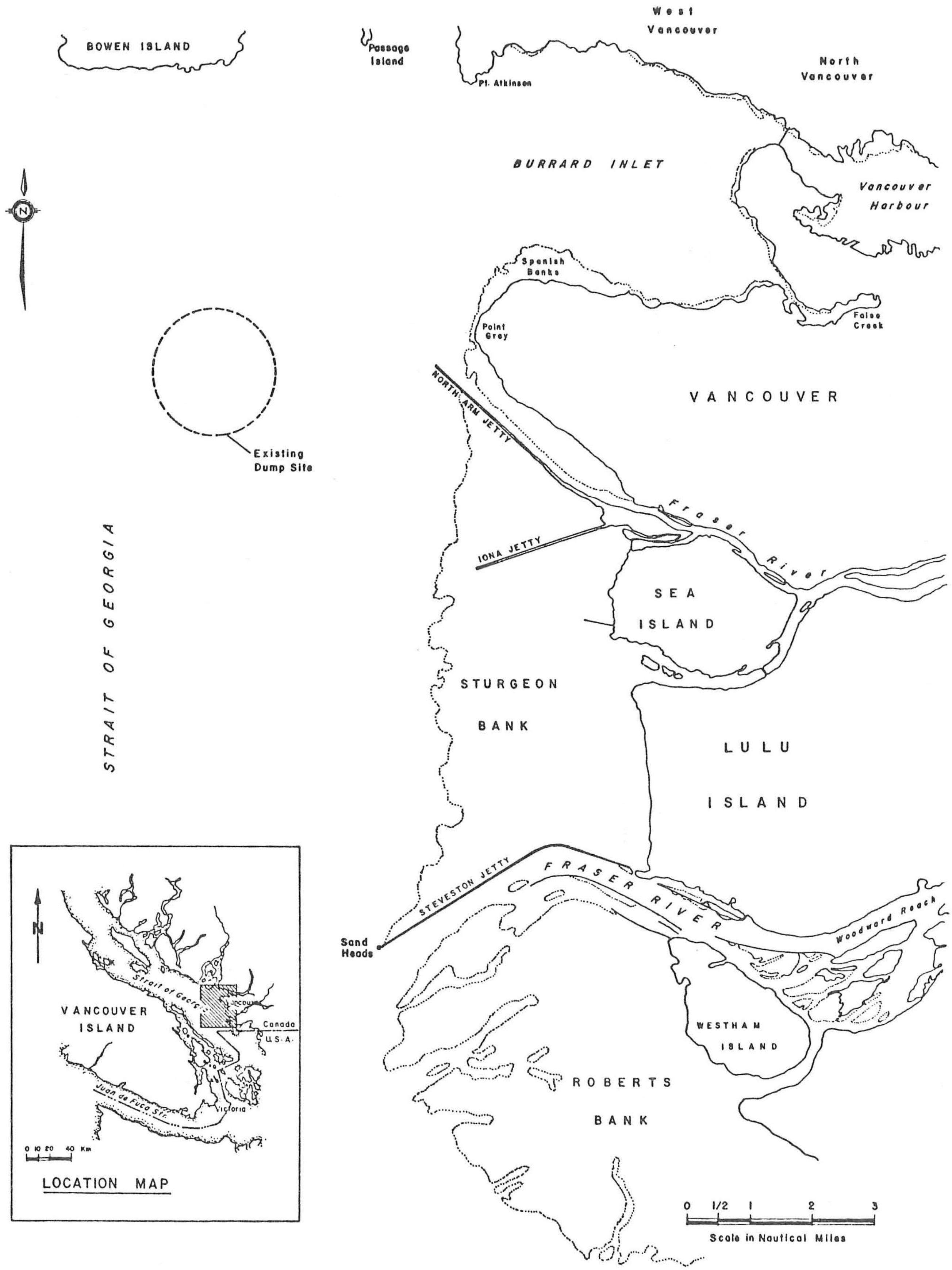

FIGURE 3 POINT GREY DUMP SITE

> *"that the site appeared to be suitable for the ocean disposal of the wastes in question, and that the deleterious impacts upon the resident biological communities were minimal. However, careful continued surveillance and monitoring of this area will be required in order to ensure that dumping is carried out where designated, since a valuable trawl fishery exists in the waters between the dumpsite and the City of Vancouver. It will also be necessary to ensure that levels of chemical contamination of the sediments and resident organisms remain at or below current levels".*

As a follow-up to this work and in order to determine the response of organisms to altered substrates, choice test experiments were carried out with eight species of benthic invertebrates.[5] The species tested included two echinoderms, *Brisaster latifrons* and *Chiridota laevis*; five crustaceans, *Cancer magister, Munida quadrispina, Pandalus danae, Crangon alaskensis, Corophium salmonis*; and the bivalve, *Macoma inconspicua*. The natural and altered substrates tested included mud, sand, rocks, wood chips, wood debris, and polluted sediments obtained from close to pulp mills. The study revealed that:

> *"The unnatural substrates were usually less preferred by burrowing animals, although in some cases no preferences were shown between artificial and natural substrates. Mobile epifauna were attracted toward hard surface (wood debris, rocks). Because of the preferences and field distributions, the results of the study indicated that large changes in the nature of a substrate as a result of dumping will affect the abundance and species composition of benthic communities."*[5]

These conclusions are consistent with *in situ* submersible observations of actual dumpsite conditions.

Sampling and chemical analysis of dredge spoils originating from industrialized areas such as False Creek (Vancouver harbour) and Squamish (Howe Sound) have resulted in further investigations into certain chemical and biochemical reactions in the dumpsite environment. From a strictly chemical standpoint, most of the recent research[6-7] has shown that metals, pesticide residues, and most other toxic components generally remain tightly bound to the sediment fractions, rather than being released to the water column. This has been particularly true under oxygenated conditions, which represent the normal circumstances experienced at most marine dump sites.

Environment Canada's chemical experiments utilized a modified form of the U.S. elutriate test.[8] Sediment samples, at a 1:2000 sediment-to-seawater ratio, were maintained under stirred and unstirred conditions for 17 days while subsamples were regularly withdrawn for trace-metal analysis, including lead, copper, zinc, cadmium, and mercury.[9] Sample processing and analyses were carried out in an ultra clean laboratory equipped with air-filtration, thereby minimizing the potential for contamination. The following summarizes the general results of this work which was carried out by Dr. C.S. Wong of the Fisheries and Marine Service:

> *"In general, all the metals examined appeared to behave quite independently of one another and underwent marked fluctuations over the study time period. Dissolved zinc showed a rapid initial temporary increase with a slower increase occurring after six hours. The stirred bottle appeared to give zinc concentrations an order of magnitude larger than the unstirred bottle. Copper concentration showed an initial spike similar to that of zinc, but within one day the levels had fallen below the initial values. A slow increase occurred over the remaining time period. Cadmium concentration showed an initial spike in both the blank and unstirred bottle. Lead behaved quite differently, exhibiting an initial fourfold increase in dropping back almost to the initial levels within a day. Mercury concentration also increased by a factor of four but appeared to take a day to do so. After six days, the levels had dropped back almost to the initial values. These and other metal release experiments have underlined the difficulties involved, and the attention that must be paid to other parameters such as salinity, temperature and pH. A great deal of care is required both in experiment design and interpretation."*[9]

Unfortunately, the specific concentrations of the various elements examined were not available for presentation at this time, but it is fair to say they they were generally minute (i.e., often in the part per trillion range). Work of this nature is continuing, but the preliminary results would tend to confirm the fact that direct chemical releases of trace metals to the receiving water do not present an immediate toxicological threat to marine organisms.

However, when considering the long term, ultimate fate of these pollutants, little research appears to have been conducted on the effects of biological action upon contaminated dredge spoils and/or the potential for bioaccumulation of toxicants within marine food chains. In this regard, under the direction of the Fisheries and Marine Service, several new studies have recently been initiated. One such program involves the collection of certain organisms from the Point Grey area and a "control" site located approximately 12 km north of the Point Grey dump site in the Strait of Georgia. Species included are the sea cucumbers, *Molpadia intermedia* and *chiridota laevis*; the heart urchin, *Brisaster latifrons*; and the polychaete, *Travisia brevis*. The primary objective of this survey will be to measure the levels of heavy metals (and possibly pesticide residues) in the tissues of the test species in an effort to determine bioaccumulation potentials.

Another project recently begun concerns the problem of mercury in dredged material. Historically, the upper end of Howe Sound became contaminated with mercury as a result of discharges from a chlor-alkali plant located there. Plant discharges are now significantly reduced, and, in fact, the results of environmental monitoring of the area indicate generally improved conditions (Environment Canada, unpublished data). However, dredging activities near the head of the inlet continue to expose and remove material containing substantial mercury concentrations.[10] In addition, the spoils are in a reduced state and are generally highly organic owing to the large input of wood wastes from adjacent forest products industries. Such conditions appear to be ideal for the evolution of methyl mercury. The experimental work will examine the chemical nature of the mercuric compounds in the dredged material, their potential for release and release pathways to the aquatic environment, and their possible impact upon resident benthic communities.

Finally, Environment Canada is involved in studying the whole problem of disposal of dredge spoils contaminated with forest-products industry wastes. These highly organic residues usually exhibit a substantial biochemical oxygen demand (BOD), and may, through the production of anoxic conditions, generate hydrogen sulphide, mercaptans, ammonia, and other organic compounds.

In an effort to identify more of the factors contributing to the degradation of organic materials, as well as establishing degradation rates for the various types of materials encountered and the breakdown products generated, several projects have been developed. The first will examine the ability of wood-boring molluscs to colonize and breakdown various woods. A second project will involve the chemical analysis of degradation products derived from a variety of dredged materials containing organic debris (e.g., bark, fibre, pulp mill sludges, etc.). This work will be done through the use of lysimeters designed to simulate as many of the *in situ* conditions as possible. A third project will evaluate the acute lethal responses of selected marine invertebrates (e.g., shrimp or polychaetes) to the leachates generated from the lysimeter experiments.

The results of all the aforementioned studies should contribute to Environment Canada's knowledge of the entire dredging picture. In particular, it is hoped that they will result in better assessments being made respecting the problems of organic-material disposal.

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